Hands-on Anatomy

Jacqueline Phillips and
Michael O'Hara

NORTH
BROAD
PRESS

Hands-on Anatomy

Hands-on Anatomy

Jacqueline Phillips and Michael O'Hara

NORTH
BROAD
PRESS

An Imprint of Temple University Press

Philadelphia Rome Tokyo

North Broad Press is a joint publishing project between Temple University Press and Temple University Libraries, publishing works of scholarship, both new and reissued, from the Temple University community. All North Broad Press titles are peer reviewed and freely available online. More information and all North Broad Press titles are available at https://temple.manifoldapp.org/projects/project-collection/north-broad-press.

This book has been peer reviewed by two subject experts from higher education institutions. We would like to thank them for their time, careful reading, and professional insights, all of which helped to make this a valuable resource for faculty and students.

Lindsey Saenger, DHSc, RDCS, Health Science Faculty, Sterling College, and Cardiovascular Department – Echocardiography, Hutchinson Regional Medical Center

Shaun Varrecchia, PT, DPT, Assistant Professor of Physical Therapy, Saint Joseph's University

Temple University Press

Philadelphia, Pennsylvania 19122

www.tupress.temple.edu

ISBN 9781439921234 (paperback); 9781439921241 (ebook)

Contents

Introduction

Human anatomy is the cornerstone of nearly all health professions. A sound understanding of visuospatial relationships between anatomical structures allows a surgeon to deftly transplant an organ, a nurse to draw blood, and a physical therapist to design an exercise program targeting a specific muscle group. In any discipline in which an individual provides patient care, the constructs that guide clinical practice are often rooted in the foundational coursework that launches their academic journey. This text aims to be part of this foundation and introduce students to clinical skills while helping them review musculoskeletal anatomy.

In *Hands-on Anatomy*, the authors present an entry-level guide for students who are beginning to apply their anatomical knowledge to the human body. It is intended as a student's initial exposure to clinical skills such as palpation and range of motion testing. It targets students in higher education, either at the undergraduate or graduate level, who have already had introductory anatomy courses. Through a regional approach, the most relevant skeletal landmarks, muscles, ligaments, and neurovascular structures are discussed, with a focus on how to palpate these structures. Additionally, guides on assessing the range of motion of joints are provided, along with descriptions of common clinical scenarios relating to each body area. *Hands-on Anatomy* intends to balance the depth of material provided in an introductory style for students and an approachable manner.

This textbook is divided into nine chapters. The first chapter contains background information on the topics covered throughout the text, as a refresh the student's memory on terminology they've most likely seen before, such as anatomical planes and directional movements. Additionally, within the first chapter there is some guidance on how to approach assessing range of motion and on how to palpate structures with the recognition that the is most likely the first exposure the reader has had to these skills. Chapters 2 to 9 are divided by body region, covering the upper quarter, spine, lower quarter, and head and neck. Each chapter features a consistent delivery of anatomical landmarks through each region along with directions on how to palpate each structure and how to assess range of motion for the relevant joints. Rich images complement the content throughout to aid the reader with their visualization and palpation of the structures. Clinical correlations are included in each of these chapters to tie academia to clinical practice through an appreciation

of human anatomy. Lastly, readers can test their retention of textbook content with summary questions that conclude each chapter.

No matter where you are on your academic journey, or what career trajectory you are on, the authors hope that *Hands-on Anatomy* will be a useful resource on your journey to becoming a health care professional.

1. Background Terminology and Information

Anatomical Terminology

Regional Terms

A sound understanding of terms associated with the different body regions will enable you to communicate more effectively. Additionally, if you have a firm knowledge of these terms, you'll be able to understand other anatomical terminology more quickly. For instance, knowing that the brachial region is the area of the upper arm will help you understand that the biceps brachii muscle, which contains the word stem brachii, is located within the brachial region.

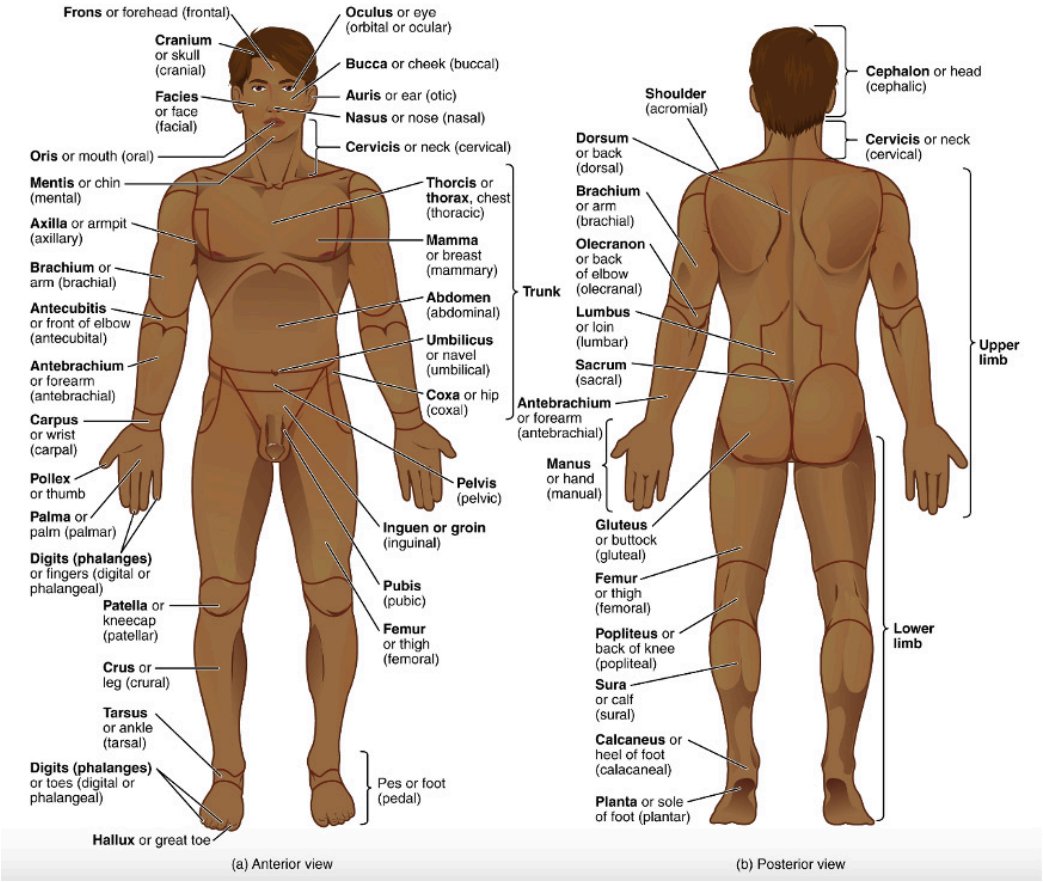


Figure 1.1. *Regions of the Body; Anterior and Posterior Views by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix is used under a CC BY 4.0 license.*

Directional Terms

When referencing a location on the body in relation to other landmarks, it's important to use directional terms. These terms ensure clear and standardized communication with others. However, it takes some practice to become comfortable with them. These terms will be used frequently throughout this text when providing instructions on how to locate and palpate a structure. Remember to always start from the anatomical position.

- **Anatomical position:** Standing tall, facing forward with palms also facing forward
- **Anterior (ventral):** The front side, or direction towards the front aspect.
- **Posterior (dorsal):** The back side, or direction towards the back aspect.
- **Superior:** Above or higher than another body part.
- **Inferior:** Below or lower than another body part.
- **Medial:** Towards the midline of the body with midline referring to an imaginary line that can be visualized in the middle of the person, from the most superior to inferior aspect
- **Lateral:** Away from the midline of the body.
- **Proximal:** Closer to the point of origin, or to the trunk of the body.
- **Distal:** Further away from the point of origin, or the trunk of the body.
- **Superficial:** Closer to the surface of the body.
- **Deep:** Further away from the surface of the body.

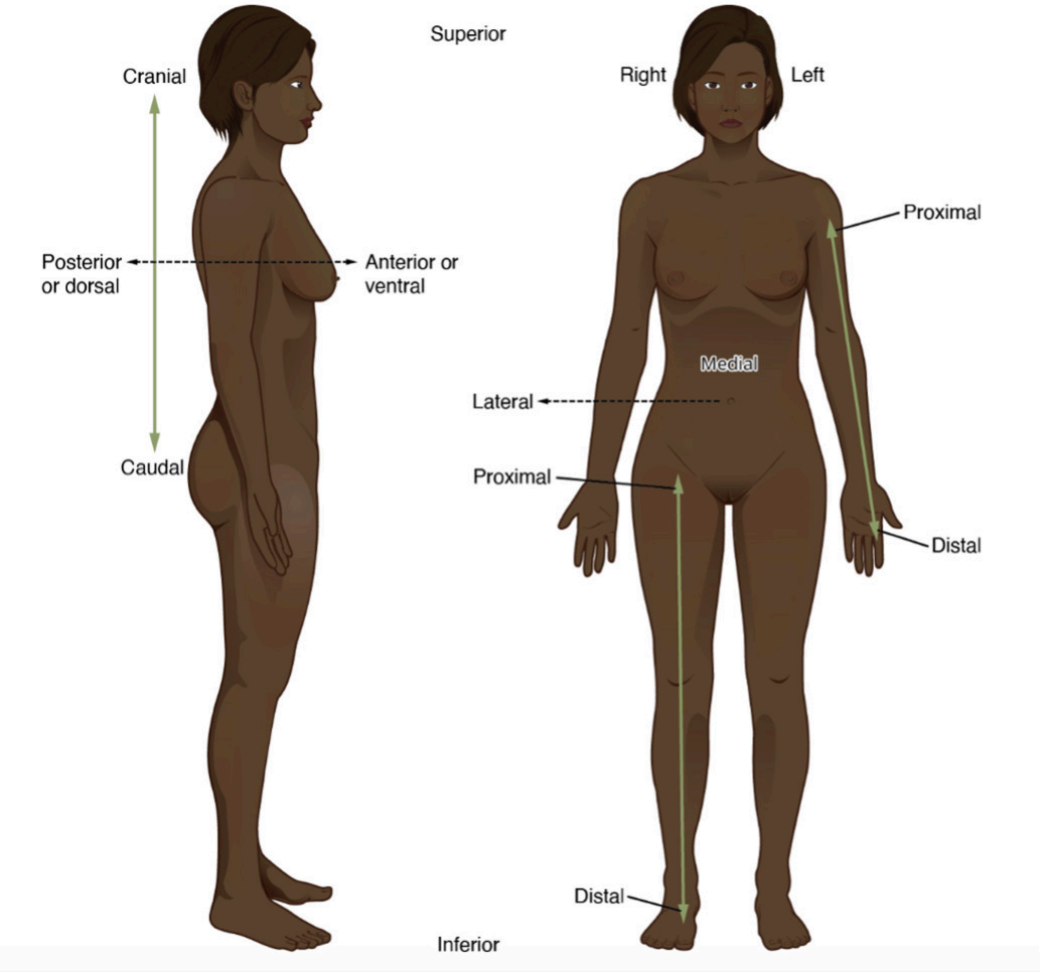


Figure 1.2. *Directional Terms; Sagittal and Anterior Views by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix is used under a CC BY 4.0 license.*

Anatomical Planes

An anatomical plane is an imaginary plane that travels through the body, dividing the body into two portions based on its orientation. Many of the pictures you see in anatomical texts show a certain view, or plane, of the structure or body part.

Anatomical planes are also used to describe the direction, or plane, in which movements occur.

- Flexion and extension occur along the sagittal plane.
- Abduction and adduction occur along the frontal plane.
- Rotation occurs along the transverse plane.

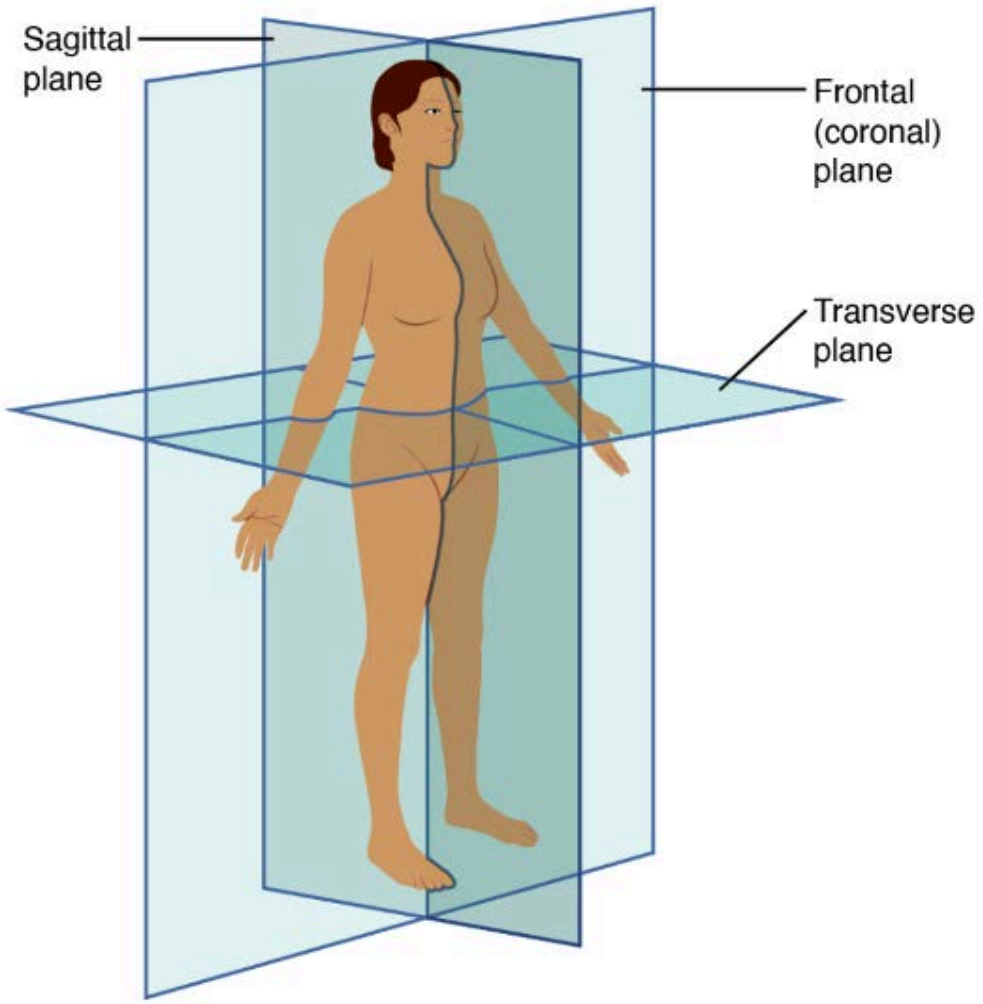


Figure 1.3. *Anatomical Planes by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix is used under a CC BY 4.0 license.*

Body Positions

When discussing an area of the body, it is important to clearly communicate the

exact position you are referencing. First, remember that when referencing the right or left side of the body or structure, the **anatomical right** or **anatomical left** refers to the patient's (or person's) right or left, not yours. Next, the starting position for a body's orientation is **anatomical position**. This position involves the person standing straight and looking forward, with their palms also facing forward.

When working through the activities in this textbook, you will need to position your partner in different ways to make certain structures more accessible. The following are common body positions that will assist you.

- **Supine:** The person faces upward.
- **Prone:** The person faces downward.
- **Side-lying:** The person lies on their right or left side, possibly in a "hook-lying" position, where their hips and knees are bent.
- **Long-sitting:** The person sits upright with their legs extended in front of them.
- **Short-sitting:** The person sits up at the edge of a table or chair with their lower legs hanging off.

Figure 1.4. *Anatomical position by Dan Silver is used under a CC BY 4.0 license.*

Figure 1.5. *Supine position by Dan Silver is used under a CC BY 4.0 license.*

Figure 1.6. *Prone position by Dan Silver is used under a CC BY 4.0 license.*

Figure 1.7. *Side-Lying Position by Dan Silver is used under a CC BY 4.0 license.*

Figure 1.8. *Long-Sitting Position by Dan Silver is used under a CC BY 4.0 license.*

Figure 1.9. *Short-sitting Position by Dan Silver is used under a CC BY 4.0 license.*

Skeletal Terminology: Bone Markings

All bones have similar projections, depressions, and tunnels on or within them. Learning the appropriate terms for these markings will be valuable when you begin to identify and palpate these skeletal landmarks. Below is a list of common markings that can be found on different bones throughout the body, categorized according to the type of marking.

- **Projections**
    - **Condyle:** Rounded surface
    - **Crest:** Ridge
    - **Process:** Any prominence
    - **Spine:** Sharp process
    - **Tuberosity:** Rough surface created by a muscle pulling on the area of the bone
    - **Tubercle:** Small rounded surface
- **Depressions**
    - **Fossa:** Large depression
    - **Sulcus:** Groove
    - **Fissure:** Deep groove
- **Openings**
    - **Meatus:** Opening into a canal
    - **Foramen:** Hole
    - **Sinus:** Air-filled cavity or space

Musculature Terminology

- **Attachments**
    - **Tendons vs. Aponeurosis:** Skeletal muscles, which are the focus of this text, can indirectly attach to bones via two different structures: a tendon or an aponeurosis. A **tendon** is a cord-like structure composed of connective tissue, like what is seen at either end of the biceps brachii. An **aponeurosis** is also made of connective tissue; however, instead of a cord-like structure it is a flat sheet of tissue. There is an expansive example of this in the lower back called the thoracolumbar aponeurosis (also

sometimes called the thoracolumbar fascia).
    - **Origin vs. Insertion:** With muscles having two ends, or two attachment points, we use the language of origin and insertion to identify which end of the muscle we are referring to. An **origin** is the end of the muscle that is more fixed, typically where the muscle does not act to move a joint. Usually, this is the more proximal end of the muscle, so sometimes the term proximal attachment is used interchangeably with the term origin. The **insertion** is the end of the muscle where more motion occurs. Usually, this is the more distal end of the muscle, so sometimes the term distal attachment is used interchangeably with the term insertion.

Muscle Actions

With every joint action there are muscles that help perform the action and muscles that act to resist the motion. Furthermore, there may be more than one muscle that helps perform a specific joint action. To identify these roles of muscles, we use the following terminology.

- **Agonist:** A muscle that is an agonist is the prime mover of the joint action, meaning it produces the most force to enable the action to occur.
- **Antagonist:** A muscle that performs the opposite joint action of the one identified is labeled the antagonist. For example, if referring to the motion of shoulder extension, a muscle that flexes the shoulder would be an antagonist.
- **Synergist:** Often there are several muscles that help perform the same joint action. A muscle that aids the agonist is called a synergist.

Anatomical Movements and Range of Motion

Joint Actions

Joints throughout the body have varying degrees of mobility; however, the same terminology is used to describe the motions that can occur. The following terms describe these motions.

- **Flexion:** From anatomical position, bending a joint away from anatomical position
- **Extension:** Straightening a joint toward anatomical position
- **Abduction:** Moving away from the midline
- **Adduction:** Moving toward the midline
- **Horizontal Abduction:** Abduction of a limb within the transverse plane
- **Horizontal Adduction:** Adduction of a limb within the transverse plane
- **Medial Rotation (internal rotation):** When the long bone of the joint rotates by turning on its long axis toward the midline
- **Lateral Rotation (external rotation):** When the long bone of the joint rotates by turning on its long axis away from the midline
- **Supination:** Rotation of the forearm so that the palm of the hand turns upward
- **Pronation:** Rotation of the forearm so that the palm of the hand turns downward
- **Dorsiflexion:** Flexion of the dorsal surface of the foot
- **Plantarflexion:** Flexion of the plantar surface of the foot
- **Inversion:** Turning the plantar surface of the foot toward the midline
- **Eversion:** Turning the plantar surface of the foot away from the midline
- **Protraction:** Moving forward in the transverse plane
- **Retraction:** Moving backward in the transverse plane

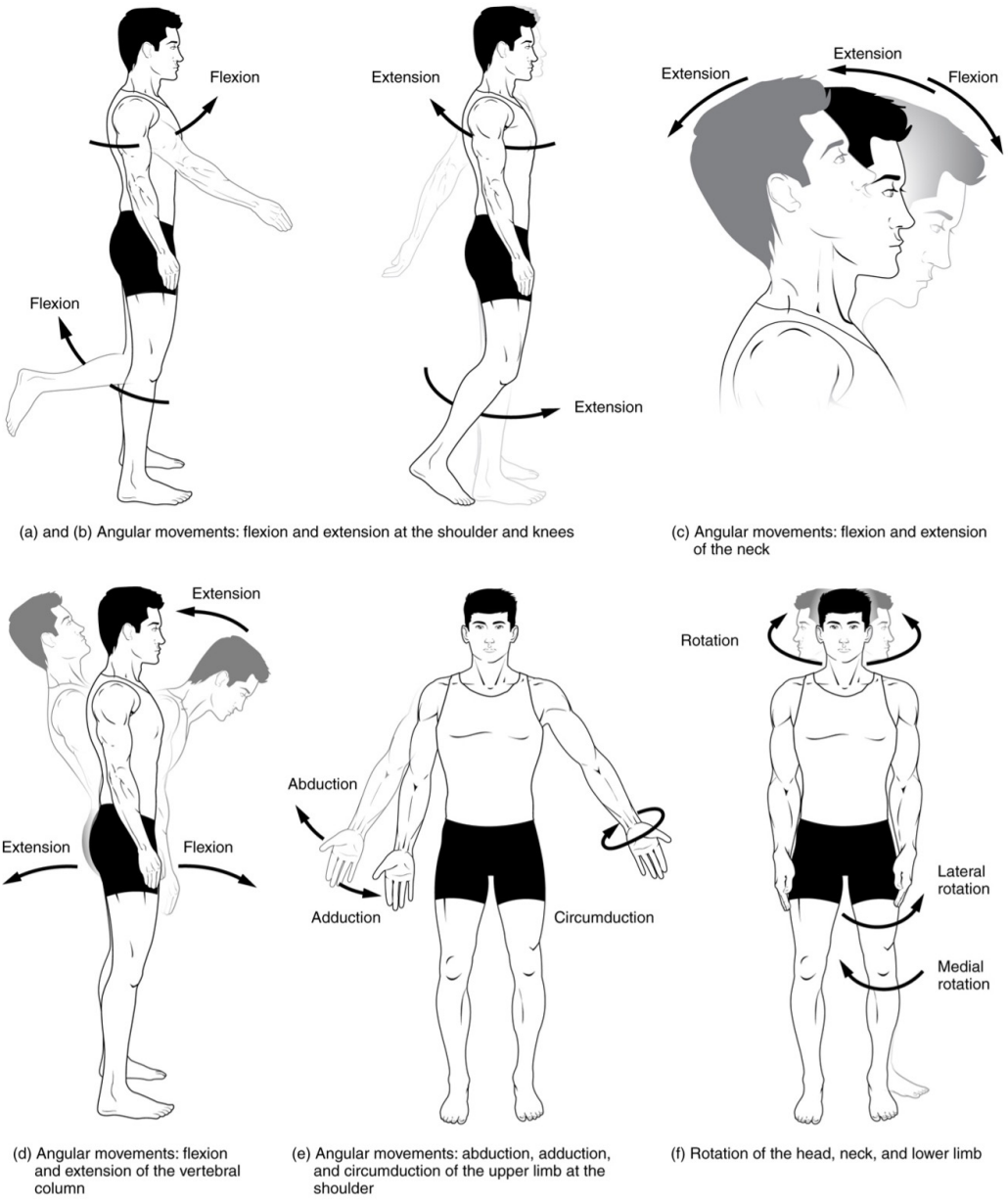


Figure 1.10. *Anatomical Movements by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix is used under a CC BY 4.0 license.*

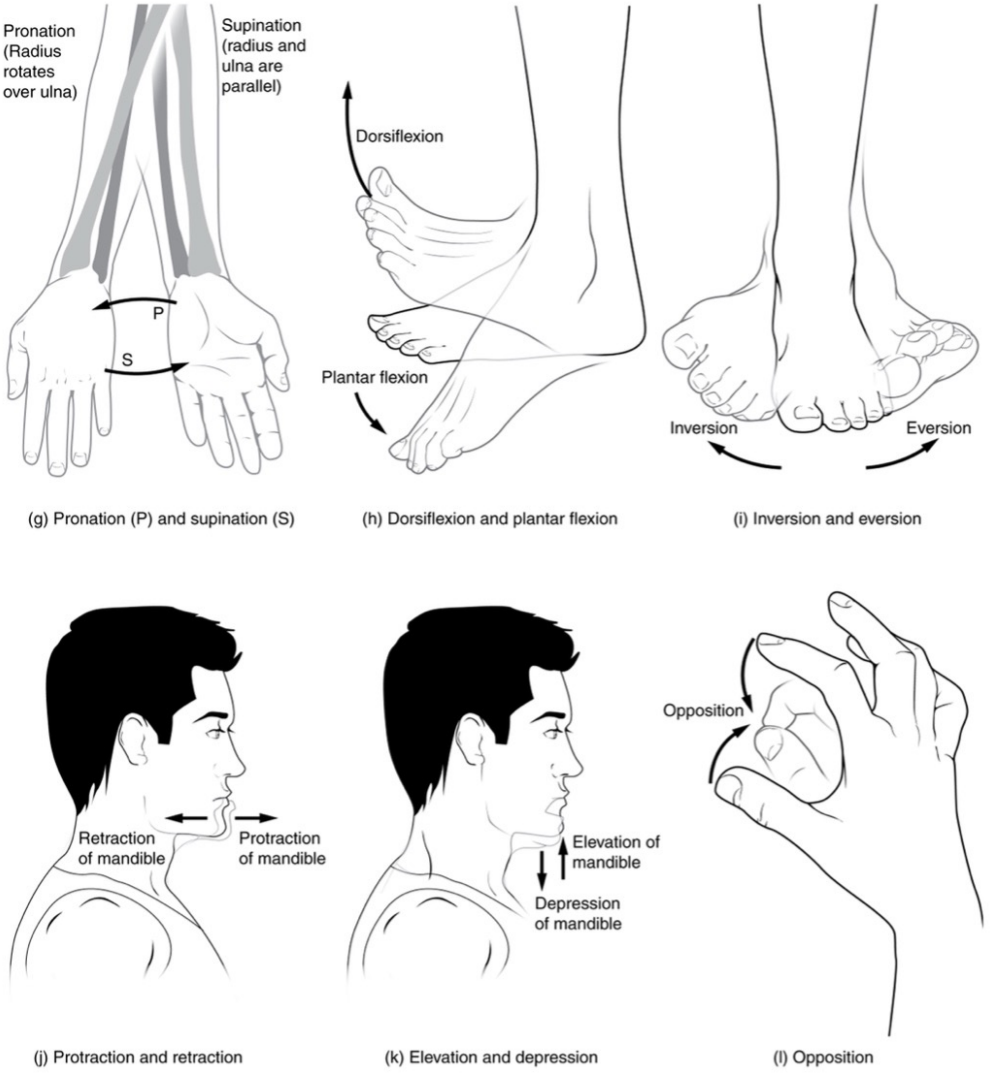


Figure 1.11. *Anatomical Movements Continued by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix is used under a CC BY 4.0 license.*

Range of Motion

Range of motion (ROM) is defined as the extent of movement of a joint through a given motion. There are different ways to examine an individual's capability to move a joint through a given motion. These methods can be applied to identify the ROM they have or what may be limiting the ROM. Complete ROM depends on the

healthy articulation of skeletal surfaces of the joint, along with mobility of soft tissue surrounding the joint. A thorough range of motion assessment is one piece of the clinical picture of a patient.

- **Range of Motion Assessment:** Each movement of a joint can be assessed in three ways: actively, passively, and resistively.
    - **Active Range of Motion (AROM):** Active range of motion is assessed by having the patient perform the action without any assistance through their entire range of motion. This assessment provides an idea of the individual's willingness to move through the given range.
    - **Passive Range of Motion (PROM):** Passive range of motion is assessed by having the clinician completely guide the patient through the range while the patient is totally relaxed. This assessment provides an idea of the individual's available ROM, beyond their willingness to move, while also providing insight into the structural limitations at their end range.
    - **Resistive Range of Motion (RROM):** Resistive range of motion is assessed by having the patient perform the action against resistance provided by the clinician. This range of motion provides insight into the strength an individual has throughout a range of motion.

- **Factors affecting ROM**
    - **Normal Ranges:** With any assessment, it is first important to remember that variability exists among individuals. There are normative ranges for all joints and actions. However, a normal range for one individual may be less or greater than the normal range for another individual. To help identify if a range is normal for an individual, all measurements should be compared bilaterally to assess for symmetry. Furthermore, goniometry skills should be practiced and standard procedures should be followed to ensure accuracy.
    - **Abnormal Ranges:** There are many possibilities as to why an individual may have excessive or limited range of motion at a given joint. When an individual presents with a limited range of motion, the origin may be related to a skeletal or soft tissue injury. For example, swelling, which can occur secondary to many types of injury, can cause limitations in movement due to the increased fluid volume within a given tissue surrounding a joint.

Palpation of Anatomical Structures

Why Palpate?

Palpation is a useful clinical tool for a variety of healthcare professionals. It is often utilized to assist in the differential diagnosis process during the physical examination. Palpation may also be required to orient intervention strategies, such as manual therapy and soft tissue mobilization. However, palpation is not without limitations. Numerous research studies have demonstrated findings that question the validity and reliability of palpation. As this text describes, clinical practice should not rely solely on palpation. Additional examination procedures, such as range of motion and manual muscle testing, should also be considered as part of the examination process. As with all clinical skills, efficiency and effectiveness of palpation benefits from routine practice.

Consent to Touch

Physical touch of another requires consent to touch. Consent must be obtained before placing your hands on your partner. With palpation of every body structure, particularly those adjacent to sensitive areas, the examiner should clearly explain what they plan to do and confirm permission to proceed.

The Skill of Palpating

Surface palpation skills are developed over time through practice and guided feedback. The following are tips on how to approach different structures and what to be mindful of along the way.

- **Soft Hands:** Proceed gently with your palpation, and if needed gradually increase the pressure of your touch. Always gauge your partner's response to palpation by looking for visual cues such as grimacing in addition to asking for verbal feedback on how you are doing.

- **One or Five Fingers?** If you are having trouble locating a landmark, utilize multiple fingers simultaneously to expand your palpation area. This will increase the likelihood of locating the structure of interest. For smaller structures it may be necessary to navigate the area with only one finger.
- **Use Your Anatomy Knowledge!** When palpating be mindful of the spatial orientation of anatomical landmarks. These landmarks, such as a skeletal protuberance, can be used to navigate from one location to another. Using your knowledge will also help you understand the depth of structures relative to each other (e.g., the rhomboid muscles are deep to the trapezius muscle).
- **Practice:** Practicing with a wide variety of partners will give you a better appreciation for different body types and will help you master your skills.
- **Seek Feedback:** Ask for feedback from your partner and instructor on the accuracy and approach of your palpations. This is how we improve our skills!

Figure 1.12. *Palpation by Dan Silver is used under a CC BY 4.0 license.*

The Importance of Anatomy

An understanding of human anatomy is a foundational cornerstone of clinical practice for healthcare professionals. To provide a clinical framework for this exploration of anatomy, a series of clinical correlations will be presented. The primary aim of clinical correlations is to demonstrate the relationship between functional anatomy and various diagnoses, examination procedures, and intervention strategies typically encountered in contemporary healthcare settings.

Variability of Anatomy

A great deal of variability exists between the surface anatomy of two individuals. As you attempt to identify body structures, it is important to consider that there may be slight differences from one partner to the next and that relevant instructions to assist in locating landmarks may not always be applicable. By appreciating these differences and understanding that there are many roads to the same destination, you will be able to navigate the same anatomical structure in different bodies.

2. The Shoulder and Arm

Skeletal Landmarks with Palpation Instructions

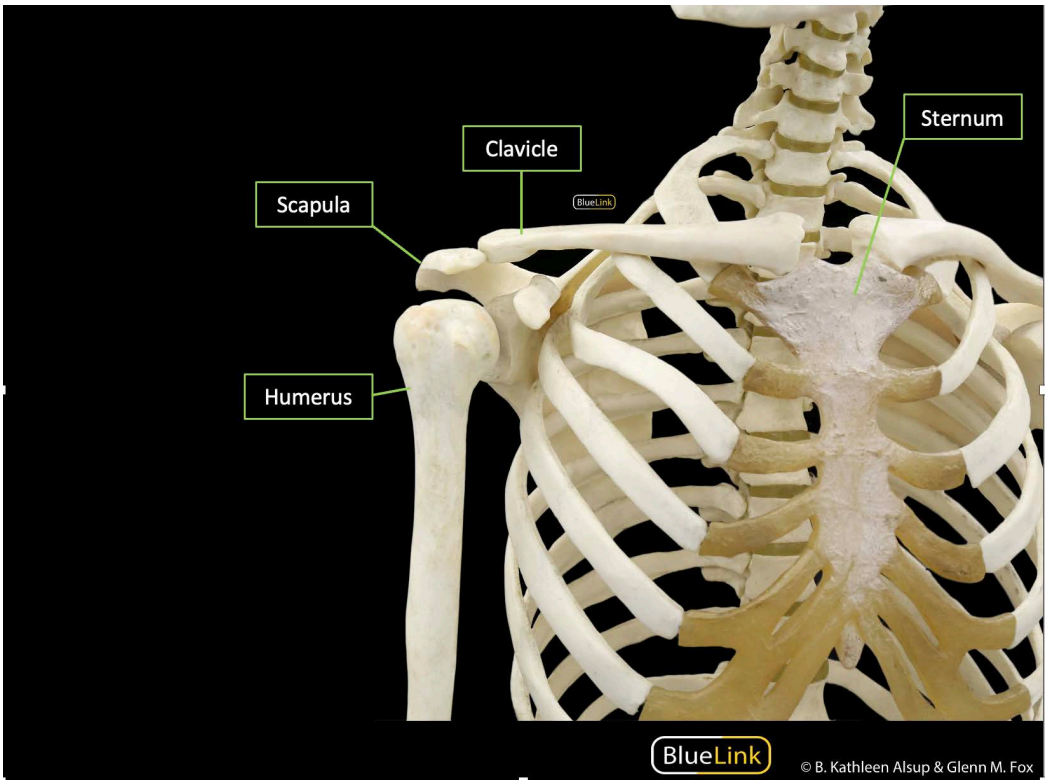


Figure 2.1. *Bones of the Shoulder; Anterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

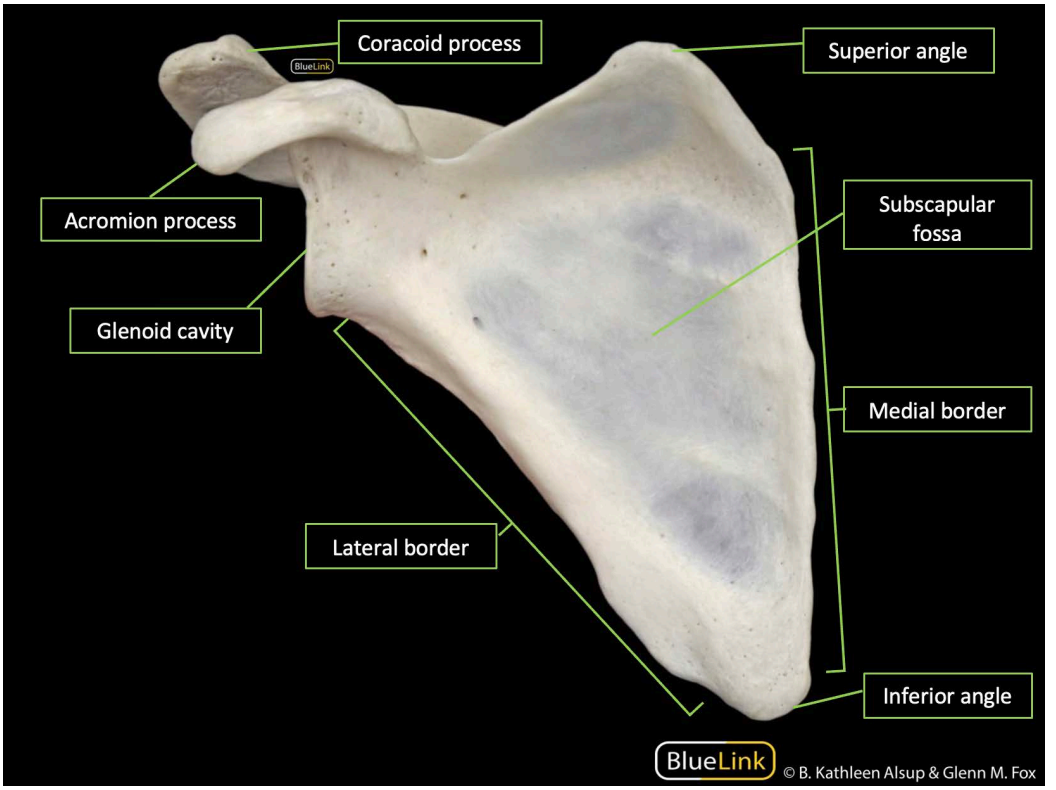


Figure 2.2. *Skeletal Landmarks of the Scapula; Anterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

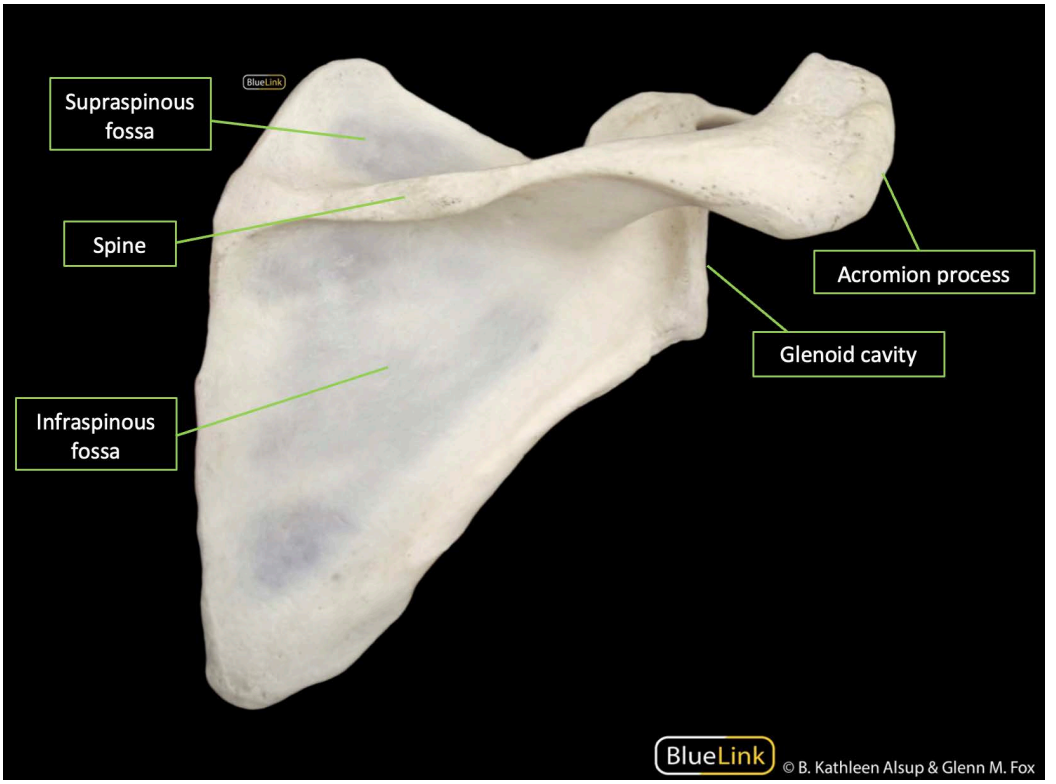


Figure 2.3. *Skeletal Landmarks of the Scapula; Posterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Scapula

- **Spine**
  - **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Although the spine of the scapula is covered by musculature, it is very prominent in comparison to the surrounding fossae. Begin by placing your partner in prone position. Make sure they are relaxed so that the muscles that cover the scapula are not engaged, as this would make it more difficult to feel any landmarks deep to those muscles. Feel toward the more superior aspect of the scapula. The spine will feel like a ledge that spans the scapula, from one side to the other, in a diagonal manner. Note in Figure 2.2 the orientation in which the diagonal travels.

- **Muscles That Attach Here:** Deltoid and trapezius
- **Fossae:** Supraspinous fossa
    - **How to Palpate**
        - **Position of Partner:** Prone, sitting
        - **Directions:** After identifying the spine of the scapula, move superior to where a less prominent depression, or drop off, can be felt. Make sure to stay on the scapula while locating this depression.
    - **Muscles That Attach Here:** Supraspinatus
- **Infraspinous Fossa**
    - **How to Palpate**
        - **Position of Partner:** Prone, sitting
        - **Directions:** Move inferior to the spine while staying within the borders of the scapula. This large expanse constitutes the infraspinous fossa.
    - **Muscles That Attach Here:** Infraspinatus
- **Subscapular Fossa**
    - **How to Palpate**
        - **Position of Partner:** Supine
        - **Directions:** Begin with your partner in a supine position with their shoulder flexed above their head. Cradle their arm so they can relax. This will make it easier for you to access this area. Begin palpating the scapula as it wings out laterally from the thorax. Concentrate on palpating the anterior aspect, which is where the subscapular fossa is located.
    - **Muscles That Attach Here:** Subscapularis

- **Borders and Angles**
    - **Inferior Angle**
        - **How to Palpate**
            - **Position of Partner:** Standing, sitting, prone
            - **Directions:** Place your partner's arm behind their back so that their hand is resting on their low back. This will help move the scapula into a position that pops the inferior angle out. Palpate toward the most inferior point of the scapula, where the medial and lateral borders converge to a point.

        - **Muscles That Attach Here:** Teres major
    - **Lateral Border**
        - **How to Palpate**
            - **Position of Partner:** Standing, sitting, prone
            - **Directions:** Starting at the inferior angle, travel up the lateral side of the scapula until the scapula can no longer be felt. Eventually, as you move toward the shoulder, this border becomes difficult to palpate because of the increase in musculature in this area.
        - **Muscles That Attach Here:** Teres minor
    - **Medial Border**
        - **How to Palpate**
            - **Position of Partner:** Standing, sitting, prone
            - **Directions:** Start again at the inferior angle and travel up the medial side of the scapula until the border ends.
        - **Muscles That Attach Here:** Rhomboids and serratus anterior
    - **Superior Angle**
        - **How to Palpate**
            - **Position of Partner:** Standing, sitting, prone
            - **Directions:** Follow the medial border superiorly until this angle change is felt. Palpating this angle can be difficult because thick musculature may exist in this area. Take time to ensure you have reached the superior angle, and not just the midpoint of the spine. If you have reached the superior spine you should be able to palpate inferiorly along the medial border from that point.
        - **Muscles That Attach Here:** Levator scapulae

- **Acromion Process**
    - **How to Palpate**
        - **Position of Partner:** Prone, sitting
        - **Directions:** This process of the scapula can be palpated in two ways. First, while your partner is lying prone, palpate the spine of the scapula. Travel all the way to the most lateral aspect of the spine until you are at the top of the shoulder at the acromion process. If you feel a depression where the acromion meets the clavicle, you have gone a little too far. The second approach to finding the acromion process is to face your partner while they are seated facing you. Start by

palpating the clavicle and proceed to palpate toward the lateral end of the bone. Palpate past the clavicle, where you will feel a divot and then the start of the acromion.
    - **Muscles That Attach Here:** Deltoid and trapezius
    - **Structures That Attach Here:** Acromioclavicular ligament, coracoacromial ligament

- **Coracoid Process**
    - **How to Palpate**
        - **Position of Partner:** Sitting
        - **Directions:** While facing your partner, first visualize where the acromion and humeral head are. Begin to palpate by locating the coracoid, inferior to the acromion and medial to the humeral head. Pressure may need to be applied to feel this hook-like prominence floating in this area. Be careful not to palpate too hard and hurt your partner.
    - **Muscles That Attach Here:** Coracobrachialis, biceps brachii (short head), pectoralis minor
    - **Structures That Attach Here:** Coracoclavicular ligament, coracohumeral ligament

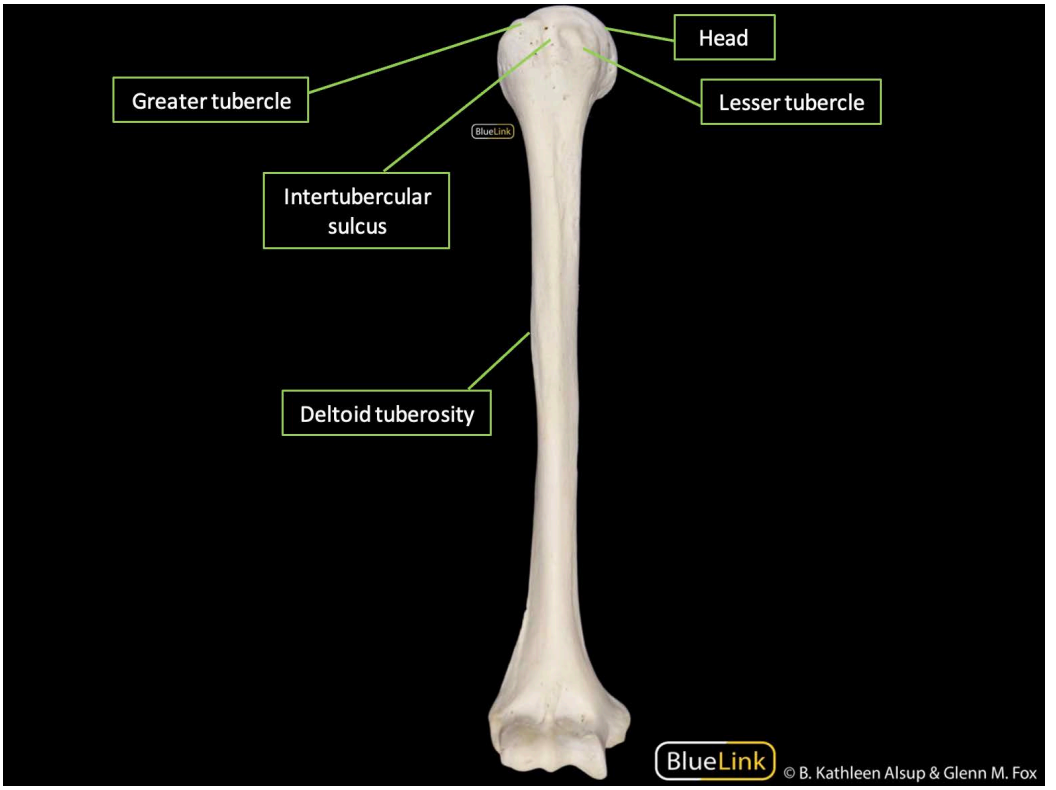


Figure 2.4. *Skeletal Landmarks of the Proximal Humerus; Anterior View by Kathleen Alsup & Glenn M. Fox is used with permission of the author.*

Humerus

- **Greater and Lesser Tubercles**
  - **How to Palpate**
    - **Position of Partner:** Sitting, standing, supine
    - **Directions:** While facing your partner, begin by palpating the anterior aspect of the humeral head. Find the medial aspect of the humeral head where the tubercles are. These two tubercles are next to each other. The greater tubercle is slightly larger, slightly more superior, and lateral to the lesser tubercle. To ensure you are at the right location, flex your partner's elbow to 90 degrees and then medially and laterally rotate their shoulder. This will move the humeral head underneath your thumb or fingers. You should feel the tubercles moving side to side as you move your partner in these directions.

- **Muscles That Attach to the Greater Tubercle:** Supraspinatus, infraspinatus, teres minor
- **Muscles That Attach to the Lesser Tubercle:** Teres major, subscapularis

- **Intertubercular Sulcus**
  - **How to Palpate**
    - **Position of Partner:** Sitting, standing, supine
    - **Directions:** The intertubercular sulcus is a small groove located between the greater and lesser tubercles. When sliding from one tubercle to the other, you may feel as though you are moving a piece of tissue. This is the long head of the biceps brachii, which runs through this sulcus as it ascends to the glenoid cavity of the scapula.
  - **Muscles That Attach Here:** Latissimus dorsi, teres major
  - **Structures Located Here:** The long head of the biceps brachii runs through this groove.

- **Deltoid Tuberosity**
  - **How to Palpate**
    - **Position of Partner:** Sitting, standing, supine
    - **Directions:** Although you will not feel a prominence or skeletal landmark when feeling for this insertion of the deltoid muscle, you can determine you are in the correct location by finding the tapering of the deltoid muscle at its distal attachment here. Have your partner abduct their shoulder against resistance to engage the muscle and better define its borders. This will make it easier to find the location of the deltoid tuberosity.
  - **Muscles That Attach Here:** Deltoid

- **Clavicle**
  - **How to Palpate**
    - **Position of Partner:** Sitting, standing, supine
    - **Directions:** The clavicle is a prominent bone that can be identified with the unaided eye. Palpate the entire clavicle, taking note of the curvature of the bone and the end points at either end.
  - **Muscles That Attach Here:** trapezius, deltoid, pectoralis major, sternocleidomastoid, subclavius
  - **Structures That Attach Here:** Acromioclavicular ligament, coracoclavicular

ligament, sternoclavicular ligament, costoclavicular ligament

Musculature with Palpation Instructions

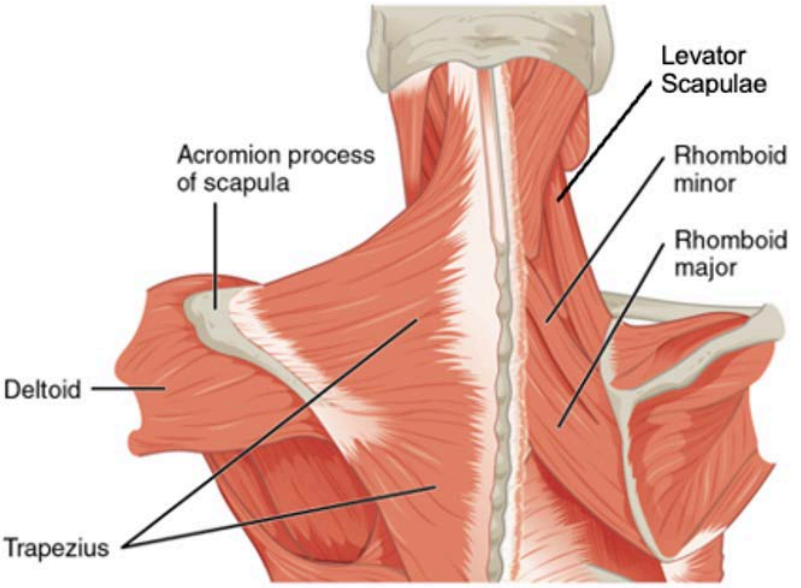


Figure 2.5. *Large Muscles of the Posterior Shoulder by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

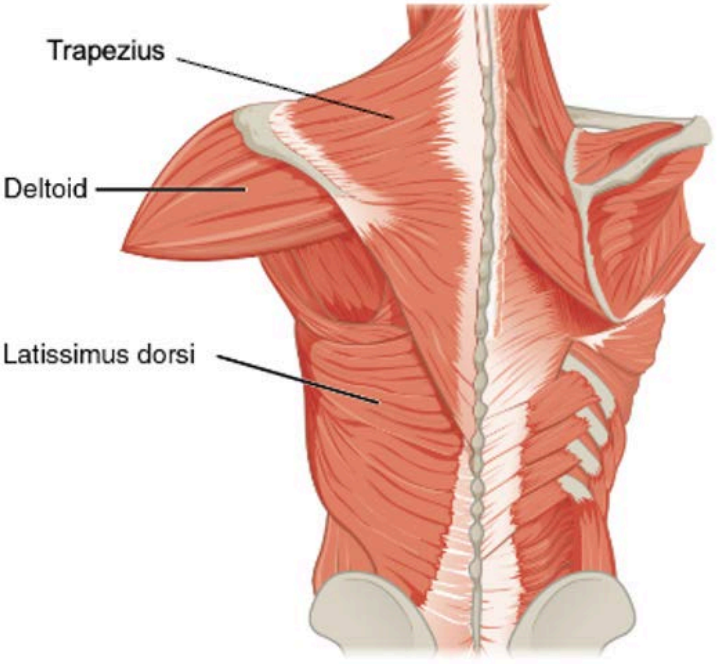


Figure 2.6. *Deep Muscles of the Posterior Shoulder by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

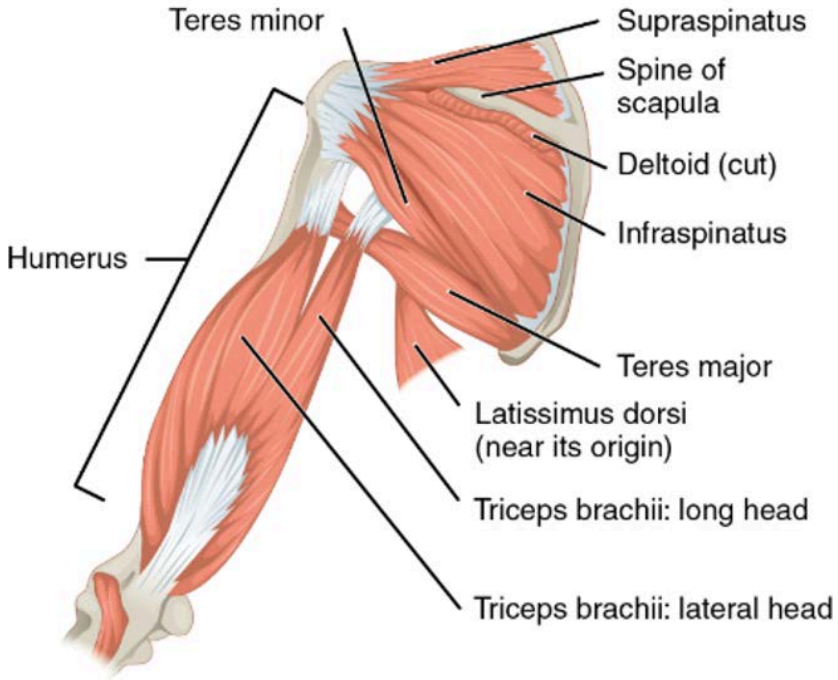


Figure 2.7. *Muscles of the Posterior Scapula by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

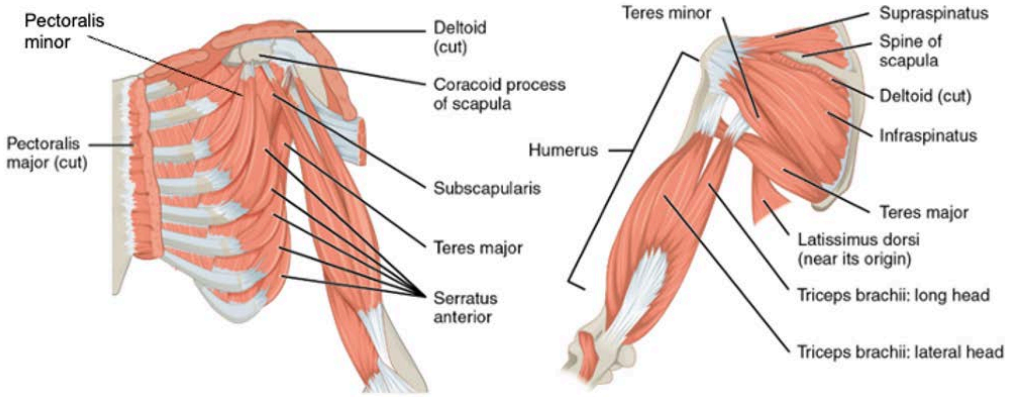


Figure 2.8. *Deep Muscles of the Anterior Shoulder; Deep Muscles of the Posterior Shoulder by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

Trapezius

- **Origin(s)**
  - **Upper Trapezius:** occipital bone (external occipital protuberance and nuchal line), ligamentum nuchae
  - **Middle Trapezius:** thoracic spinous processes
  - **Lower Trapezius:** thoracic spinous processes
- **Insertion(s)**
  - **Upper Trapezius:** clavicle
  - **Middle Trapezius:** acromion and spine of scapula
  - **Lower Trapezius:** spine of scapula
- **Action(s)**
  - **Upper Trapezius:** elevates the scapula
  - **Middle Trapezius:** retracts the scapula
  - **Lower Trapezius:** depresses the scapula
- **Innervation(s):** Spinal accessory nerve (CN XII)
- **How to Palpate**
  - **Position of Partner:** Prone, sitting
  - **Directions:** Approach this expansive muscle by breaking it down into its three regions. Note the fiber direction of each region and try to palpate in these orientations as you work your way through the tissue. For each section, simply work your way from the origin to the insertion, or insertion to the origin.

Latissimus Dorsi

- **Origin(s):** Thoracic spinous processes, thoracolumbar fascia, iliac crest, ribs 10–12
- **Insertion(s):** Intertubercular sulcus of humerus
- **Action(s):** Extension, adduction, and medial rotation of the shoulder
- **Innervation(s):** Thoracodorsal nerve
- **How to Palpate**
  - **Position of Partner:** Prone, sitting
  - **Directions:** Begin by palpating the origin of this muscle as it begins near

the iliac crest and thoracolumbar fascia. Work your way diagonally to the lower ribs, moving on the continued diagonal around the thorax. Have your partner abduct and medially rotate their shoulder so that you can feel the latissimus dorsi posterior to the shoulder as it creates the posterior border to the axilla.

Deltoid

- **Origin(s)**
    - **Anterior:** clavicle
    - **Middle:** acromion process of the scapula
    - **Posterior:** spine of the scapula
- **Insertion(s):** Deltoid tuberosity
- **Action**
    - **Anterior:** flexion and medial rotation of the shoulder
    - **Middle:** abduction of the shoulder
    - **Posterior:** extension and lateral rotation of the shoulder
- **Innervation(s):** Axillary nerve
- **How to Palpate**
    - **Position of Partner:** Sitting, supine, prone
    - **Directions:** Because this muscle is so expansive, it is important to break it up into regions even for palpation purposes.
        - Beginning with the anterior portion, palpate from just inferior to the mid-clavicle and work your way laterally until you find yourself at the humeral head. Then descend with the fibers toward the deltoid tuberosity.
        - For the middle portion, begin at the acromion process and work your way laterally and eventually descend to the deltoid tuberosity.
        - Finally, for the distal portion of the deltoid, begin by palpating the spine of the scapula. Then work your way laterally to the posterior aspect of the shoulder and then descend to the deltoid tuberosity.

Levator Scapulae

- **Origin(s):** Cervical transverse processes
- **Insertion(s):** Superior angle of the scapula
- **Action(s):** Elevation and downward rotation of the scapula
- **Innervation(s):** Dorsal scapular nerve
- **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** For this small muscle, simply palpate from its origin to insertion or vice versa. Although this muscle is deep to the trapezius at its inferior attachment, it is the most superficial muscle along its orientation within the neck. When palpating the border of the upper trapezius within this region, the levator scapulae can be directly palpated anterior to this border in the cervical region.

Rhomboid Minor and Major

- **Origin(s)**
    - **Minor:** nuchal ligament, cervical spinous processes
    - **Major:** cervical spinous processes

- **Insertion(s)**
    - **Minor:** spine of the scapula
    - **Major:** medial border of the scapula
- **Action(s):** Retraction and downward rotation of the scapula
- **Innervation(s):** Dorsal scapular nerve
- **How to Palpate**
    - **Position of Partner:** Prone, sitting
    - **Directions:** Although the rhomboids are located deep to the trapezius, you can palpate them by pressing deep on the trapezius along the origin and insertion of the rhomboid minor and major, respectively. Palpate from their origin to insertion, or vice versa, and recognize that the rhomboid minor is superior to the rhomboid major, but that these muscles otherwise have similar fiber orientation.

Supraspinatus

- **Origin(s):** Supraspinous fossa of the scapula
- **Insertion(s):** Greater tubercle of the humerus
- **Action(s):** Abduction
- **Innervation(s):** Suprascapular nerve
- **How to Palpate**
    - **Position of Partner:** Prone, sitting
    - **Directions:** Begin by locating the spine of the scapula. Next, move superiorly while remaining on the scapula, and palpate this portion of the bone, the supraspinous fossa, where the muscle is located.

Infraspinatus

- **Origin(s):** Infraspinous fossa of the scapula
- **Insertion(s):** Greater tubercle of the humerus
- **Action(s):** Lateral rotation of the shoulder
- **Innervation(s):** Suprascapular nerve
- **How to Palpate**
    - **Position of Partner:** Prone, sitting
    - **Directions:** After locating the spine of the scapula, move inferiorly while remaining on the scapula and palpate this portion of the bone, the infraspinous fossa, where the muscle is located.

Teres Minor

- **Origin(s):** Lateral border of the scapula
- **Insertion(s):** Greater tubercle of the humerus
- **Action(s):** Lateral rotation of the shoulder
- **Innervation(s):** Axillary nerve
- **How to Palpate**
    - **Position of Partner:** Prone, sitting
    - **Directions:** First, locate the infraspinatus muscle. Next, move slightly

inferiorly and laterally until you are palpating the lateral border of the scapula. This is where the muscle begins. Continue to move laterally over the thorax while ascending to the shoulder. Eventually this muscle, along with the latissimus dorsi, will form the posterior wall of the axilla and become more difficult to trace.

Teres Major

- **Origin(s):** Inferior angle of the scapula
- **Insertion(s):** Intertubercular sulcus of the humerus
- **Action(s):** Medial rotation and adduction of the shoulder
- **Innervation(s):** Lower subscapular nerve
- **How to Palpate**
    - **Position of Partner:** Prone, sitting
    - **Directions:** First, locate the origin of this muscle at the inferior angle of the scapula. Next, palpate the belly of the muscle by moving laterally toward the shoulder. Eventually this muscle becomes hard to trace as it dives anteriorly to insert on the humerus.

Subscapularis

- **Origin(s):** Subscapular fossa of the scapula
- **Insertion(s):** Lesser tubercle of the humerus
- **Action(s):** Medial rotation of the shoulder
- **Innervation(s):** Upper and lower subscapular nerves
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Begin with your partner in a supine position with their shoulder flexed above their head. Cradle their arm so that they can relax. This will make it easier for you to access the area of this muscle. Begin palpating the scapula as it wings out laterally from the thorax. Concentrate on palpating the anterior aspect, which is where the subscapularis is located.

Pectoralis Major

- **Origin(s)**
  - **Clavicular Head:** clavicle
  - **Sternocostal Head:** sternum, first six costal cartilages, and aponeurosis of external oblique muscle
- **Insertion(s):** Intertubercular sulcus of the humerus
- **Action(s):** Adduction, flexion, and medial rotation of the shoulder; protraction of the scapula
- **Innervation(s):** Lateral and medial pectoral nerves
- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Because this muscle is in a potentially sensitive area, it's especially important to have consent to palpate and to also discuss with your partner what you are doing while palpating this area. Begin by palpating the areas of the origin of this muscle, from the clavicle to the sternum, and then working your way laterally to its insertion on the humerus.

Pectoralis Minor

- **Origin(s):** Ribs 3–5
- **Insertion(s):** Medial border and coracoid process of the scapula
- **Action(s):** Depression, protraction, and downward rotation of the scapula
- **Innervation(s):** Medial pectoral nerve
- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Because of the location and positioning of this muscle below the pectoralis major, it's difficult to palpate. To tackle this muscle through palpation, begin at the coracoid process and work your way down to the upper ribs. To help provide you with the best ability to palpate this muscle, place your partner's shoulder in a slightly protracted position to ensure relaxation of the pectoralis major.

Serratus Anterior

- **Origin(s):** Ribs 1–9
- **Insertion(s):** Medial border of the scapula
- **Innervation(s):** Long thoracic nerve
- **Action(s):** Protraction and upward rotation of the scapula
- **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** First, find the lateral border of the scapula. Although the serratus anterior does not have an attachment to the lateral border, this is where you can begin to feel the muscle after it has journeyed under the scapula from its insertion on the medial border of the scapula. Continue to palpate the muscle around the thorax until it blends into the ribs. Simultaneous palpation of the muscle during manually resisted scapular protraction and/or upward rotation may accentuate the ability to appreciate this structure.

Biceps Brachii

- **Origin(s)**
    - **Long Head:** supraglenoid tubercle of the scapula
    - **Short Head:** coracoid process of the scapula
- **Insertion(s):** Radial tuberosity
- **Action(s):** Elbow flexion and supination, shoulder flexion
- **Innervation(s):** Musculocutaneous nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Beginning with the proximal portion of the muscle, palpate the long head of the biceps brachii within the intertubercular sulcus. Descend the long head until you've approached the muscle belly. Next, travel back to the other origin of the biceps brachii at the coracoid process, where the short head of the biceps brachii originates. Descend to the muscle belly and continue toward the insertion at the proximal radius. Alternatively, you may instruct your partner to perform active elbow flexion against resistance to better appreciate the observation and borders of the muscle

bellies.

Coracobrachialis

- **Origin(s):** Coracoid process of the scapula
- **Insertion(s):** Humerus
- **Action(s):** Flexion and adduction of the shoulder
- **Innervation(s):** Musculocutaneous nerve
- **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** Have your partner in supine position. Start your palpation journey at the coracoid process and then descend the brachial region while taking care to remain medial to the muscle belly of the biceps brachii. The coracobrachialis ends around mid-humerus, as should your palpation of this muscle. Instructing the patient to perform active shoulder flexion and adduction against resistance may provide necessary nuance to appreciate the muscle from adjacent structures.

Brachialis

- **Origin(s):** Humerus
- **Insertion(s):** Coronoid process of the ulna and ulnar tuberosity
- **Action(s):** Elbow flexion
- **Innervation(s):** Musculocutaneous nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin about mid-humerus on the lateral side of the arm. Try to palpate between the biceps brachii and the humerus. This muscle is deep to the biceps brachii, so you will be able to palpate only the small portion of the muscle belly that is accessible on the lateral side.

Triceps Brachii

- **Origin(s)**
    - **Long Head:** infraglenoid tubercle of the scapula
    - **Lateral Head:** humerus
    - **Medial Head:** humerus
- **Insertion(s):** Olecranon process of the ulna
- **Action(s):** Elbow extension; shoulder extension
- **Innervation(s):** Radial nerve
- **How to Palpate**
    - **Position of Partner:** Sitting, prone
    - **Directions:** Have your partner in seated or prone position. Beginning with the proximal end of the muscle, start around the posterior shoulder and descend with your palpations. Cover the whole posterior aspect of the brachial region and end at the point of your elbow, at the olecranon process.

Other Anatomical Landmarks

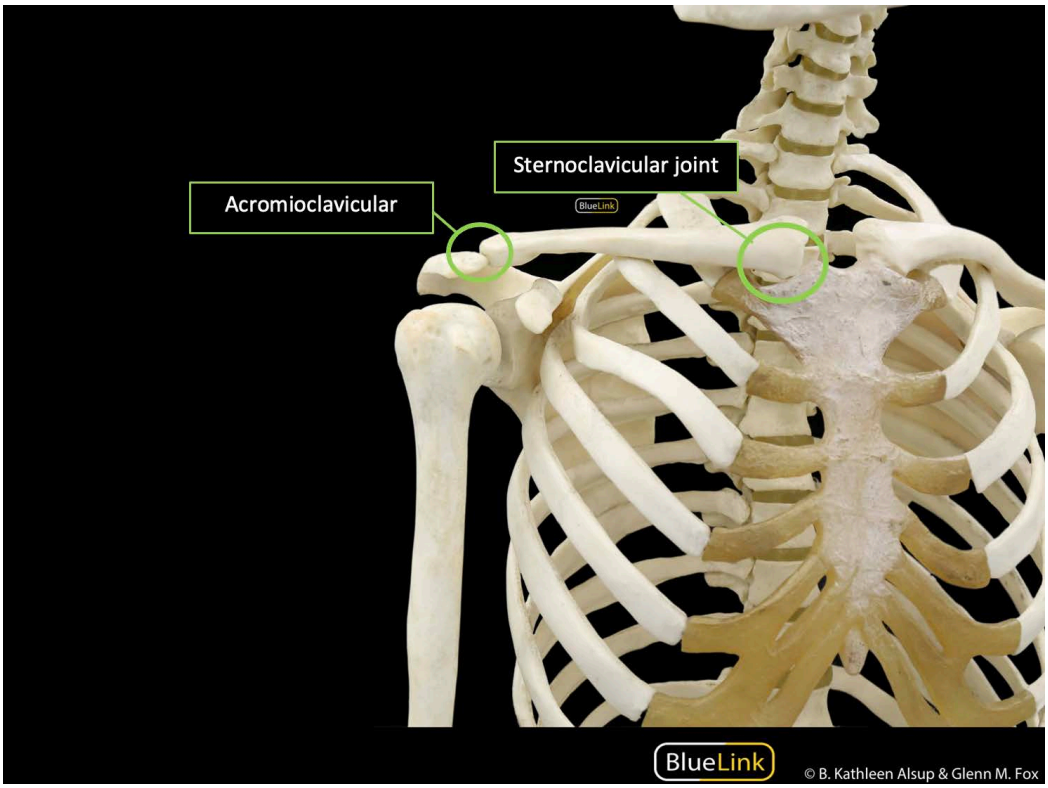


Figure 2.9. *Acromioclavicular and Sternoclavicular Joints by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

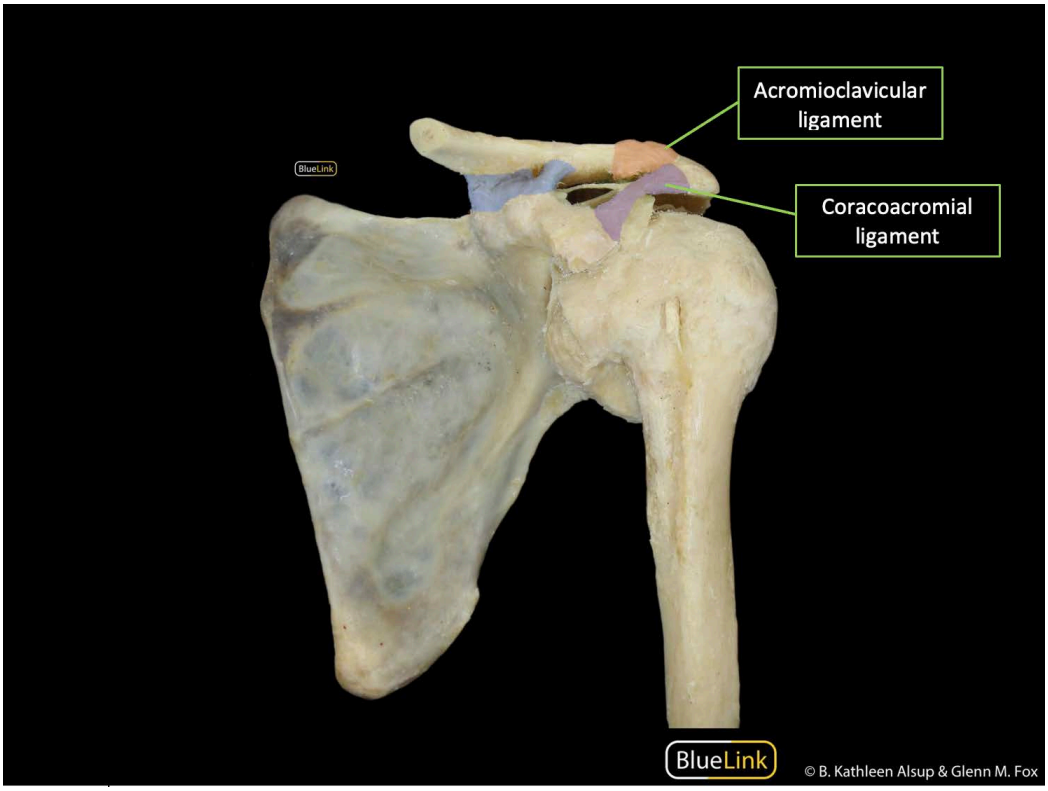


***Figure* 2.10.** *Acromioclavicular and Coracoacromial Ligaments by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

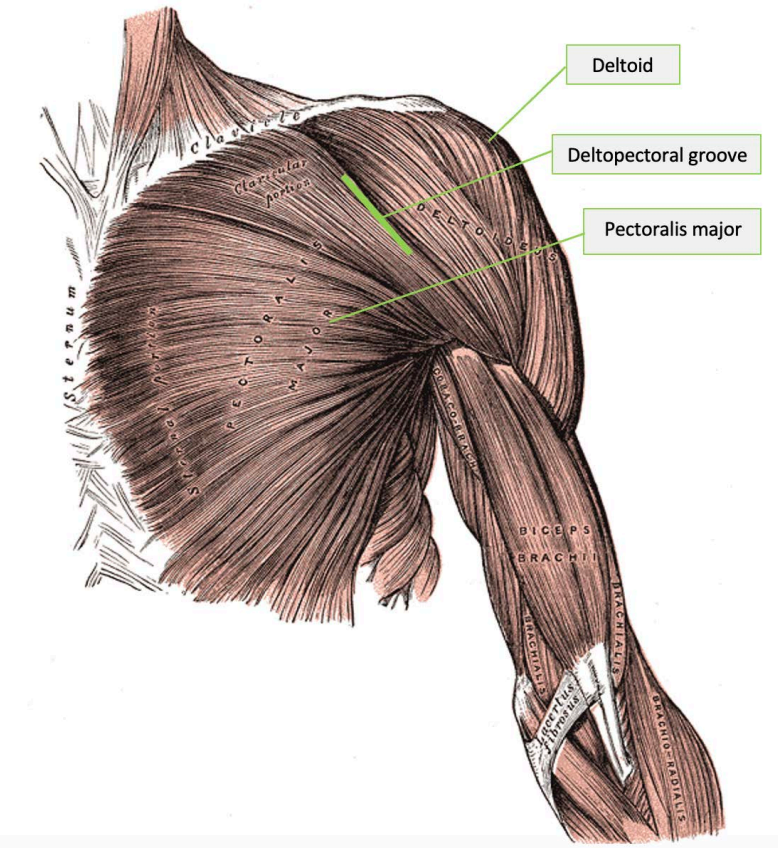


Figure 2.11. *Deltopectoral Groove by Henry Vandyke Carter and Henry Gray has been modified (altered) and is in the public domain.*

Sternoclavicular Joint

- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Start at the medial end of the clavicle and palpate toward the sternum. A step-off will be palpable as you move from the rounded end of the clavicle toward the flat manubrium of the sternum. In this area of indentation is where the sternoclavicular joint exists.

Acromioclavicular Joint

- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Begin by palpating either the distal end of the clavicle or the acromion process. Travel toward the other bone until you feel a difference in curvature of the bones. This joint may be visually identified before even palpating because of its prominence.

Acromioclavicular Ligament

- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** As you palpate the acromioclavicular joint, you are subsequently palpating the acromioclavicular ligament, which bridges the two articulating bones. The ligament itself, like many ligaments, will not be distinct, so it is important to make sure you are palpating the correct location, based on your anatomical knowledge.

Coracoacromial Ligament

- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Simply palpate between the two articulating bones, the coracoid, and the acromion process, to palpate the connecting ligament.

Deltopectoral Groove

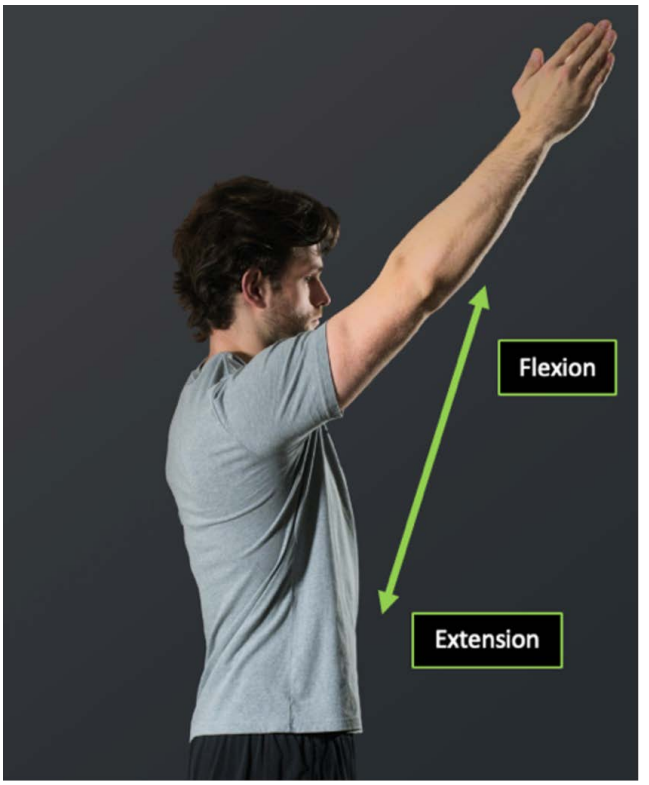
- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** This groove can be felt between the borders of the deltoid and

pectoralis major muscles. Find the anterior border of the anterior deltoid and palpate along this ridge. To make this border more prominent, you can have your partner perform shoulder flexion while you provide resistance.

- **Note:** This is where the cephalic vein runs superficially.

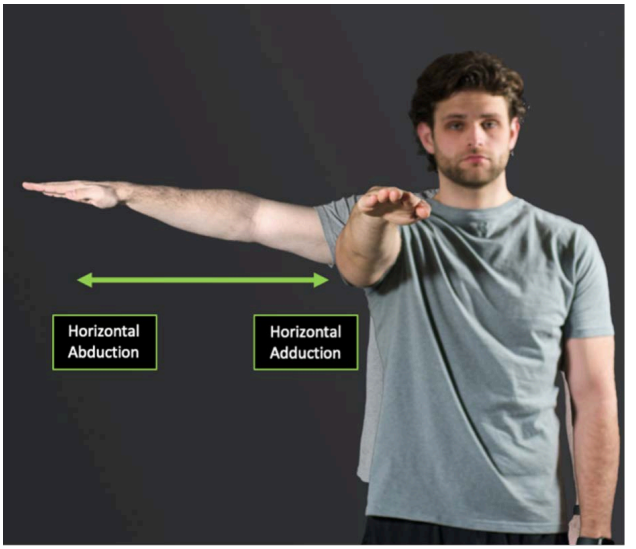
Range of Motion

Table 2.1 Range of Motion

Shoulder Joint Actions	**Tips for ROM Assessment**	**Picture of Joint Action**
Flexion and Extension	For passive and resistive ranges, ensure the patient is seated or lying down in a manner that provides you with a vantage point with overhead positions of their arm.	

Shoulder Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Abduction and Adduction	As with flexion and extension ranges, ensure the patient is situated in a position that provides you with the ability to work with their arm overhead.	

Shoulder Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Lateral (External) Rotation and Medial (Internal) Rotation	There are many ways in which these ranges can be performed and assessed. Consistency with how your assessment is performed is important to ensure reliability and an accurate assessment.	

Shoulder Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Horizontal Abduction and Adduction	Make sure your patient has their shoulder flexed to 90 degrees and extended straight out in front of them as they move it in the transverse plane while not rotating their shoulder and remaining neutral.	

Figures 2.12-2.16 by Dan Silver are used under a CC BY 4.0 License.

Clinical Correlations

Acromioclavicular Joint Sprain

- **Background:** A sprain is an injury to a ligament at a joint. There are different levels of severity of a sprain ranging from grade 1 to grade 3. A grade 1 sprain occurs when the fibers of the ligament simply become stretched, while a grade 2 sprain involves a partial tear of the ligament. A grade 3 sprain is the most severe type of sprain: the ligament becomes fully torn.
- A sprain to the acromioclavicular ligament of the acromioclavicular joint can occur when someone falls on their shoulder or when they fall on their outstretched arm. Depending on the severity of the sprain, sometimes a visible deformity can be observed at the joint. This would indicate there has been

separation of the acromion from the clavicle.

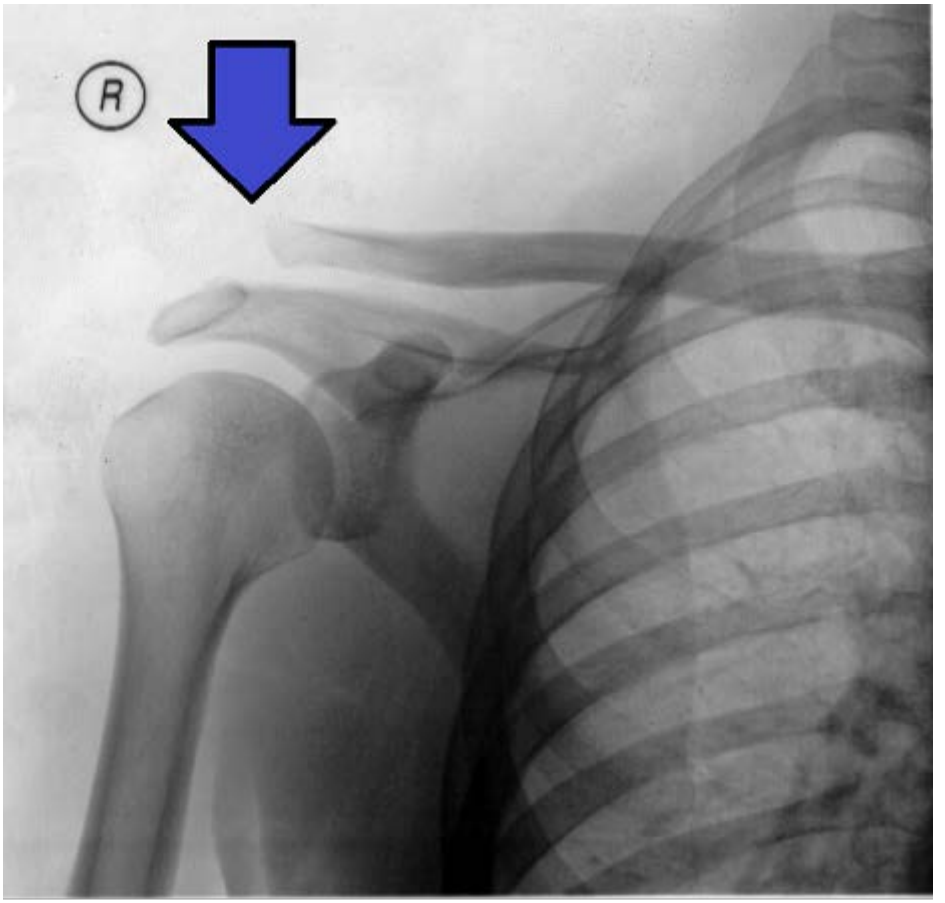


Figure 2.17. *Acromioclavicular Joint Sprain by Jay F. Cox is used under a CC BY 2.5 license.*

Rotator Cuff Impingement

- **Background:** Inflammation of a tendon is referred to as tendonitis. Typically, tendonitis coincides with overuse of the affected muscle through repetitive motions, which can result in inflammation, pain, and weakness of the muscle.
- This injury can occur at the proximal end of the muscle through repetitive overhead motions of the arm. As the shoulder flexes or abducts, the long head of the biceps brachii can become impinged upon in the space underneath the subacromial arch. Underneath this arch is a small area in which several

structures, including the long head of the biceps brachii, the supraspinatus tendon, and the subacromial bursa, are packed beneath the acromion process and distal end of the clavicle. When the arm moves into an overhead position, this space becomes smaller, and the structures that run through it can be impinged.

SLAP Tear

- **Background:** Damage to the glenoid labrum, within the shoulder complex, can occur over time with repetitive motions, or acutely in a traumatic incident.
- A superior labrum anterior posterior tear (SLAP) is a common glenoid labral tear in individuals with a primary complaint of shoulder pain. This type of labrum tear may present with an array of different symptoms, including clicking, locking, or pain with shoulder movement, along with a decrease in strength of surrounding muscles. Both conservative and surgical treatment options are available for this injury.

Review Questions: Skeletal Landmarks of the Shoulder and Arm

1. When palpating the medial border, what skeletal structure can be felt if you move to the superior end of the border?
2. Which structure is more lateral, the greater or lesser tubercle of the humerus?
3. The subscapular fossa is located on the (anterior / posterior / superior) side of the scapula.
4. How is the landmark of a "tuberosity" created (e.g., deltoid tuberosity)?
5. Which ligament spans the acromioclavicular joint?
6. The _____ fossa is found superior to the spine of the scapula.
7. When palpating the spine of the scapula toward its lateral end, what other skeletal structure can be felt?

8. The clavicle articulates with two bones: the (sternum / scapula) toward its medial end, and the (sternum / scapula) toward its lateral end.
9. The _____ can be found between the greater and lesser tubercles on the humerus.
10. Describe what a fossa looks and/or feels like on a bone.

Review Questions: Musculature of the Shoulder and Arm

1. Identify three muscles that attach to the coracoid process.
2. The biceps brachii inserts on the _____.
3. Which tendon can be found running through the intertubercular sulcus?
4. True/False: The upper fibers of the trapezius are antagonistic to the lower fibers of the trapezius.
5. The rhomboid minor and major muscles are deep to which muscle?
6. The anterior deltoid _____ rotates the shoulder.
7. Identify all the flexors of the shoulder.
8. Which muscle originates at the infraglenoid tubercle of the scapula?
9. The medial pectoral nerve is the only nerve that innervates the (pectoralis minor / pectoralis major / coracobrachialis).
10. The middle deltoid acts to _____ the shoulder and originates at the _____.

3. The Elbow and Forearm

Skeletal Landmarks with Palpation Instructions

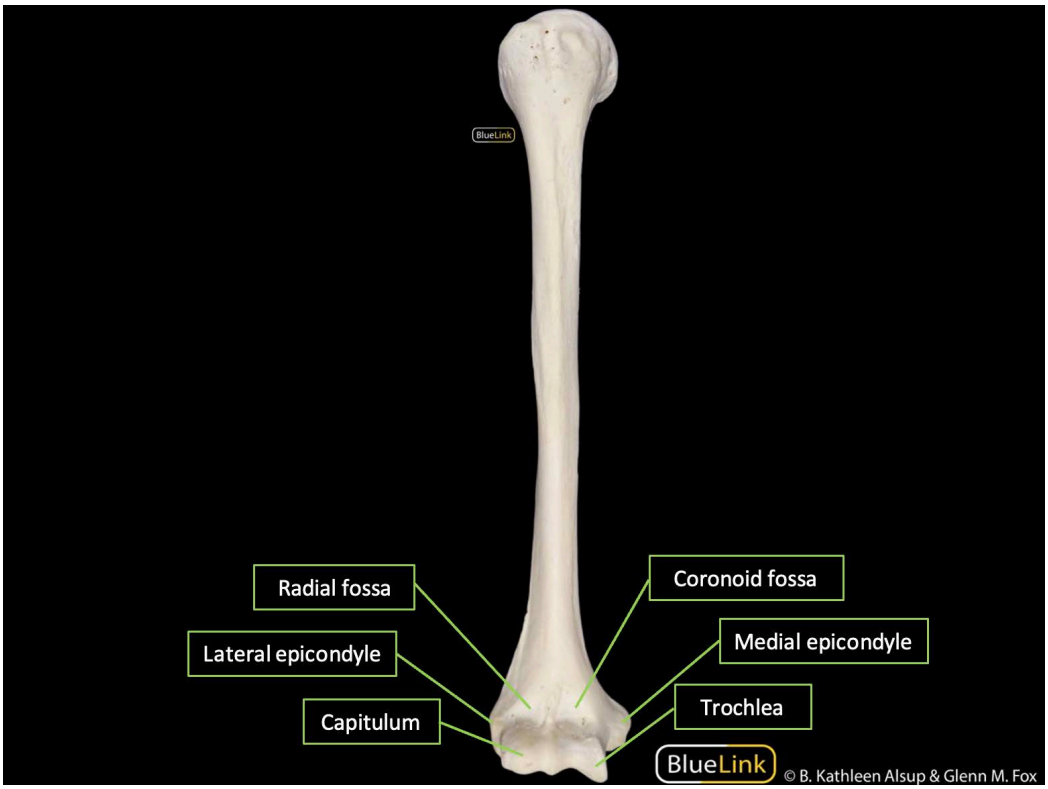


Figure 3.1. *Skeletal Landmarks of the Distal Humerus; Anterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

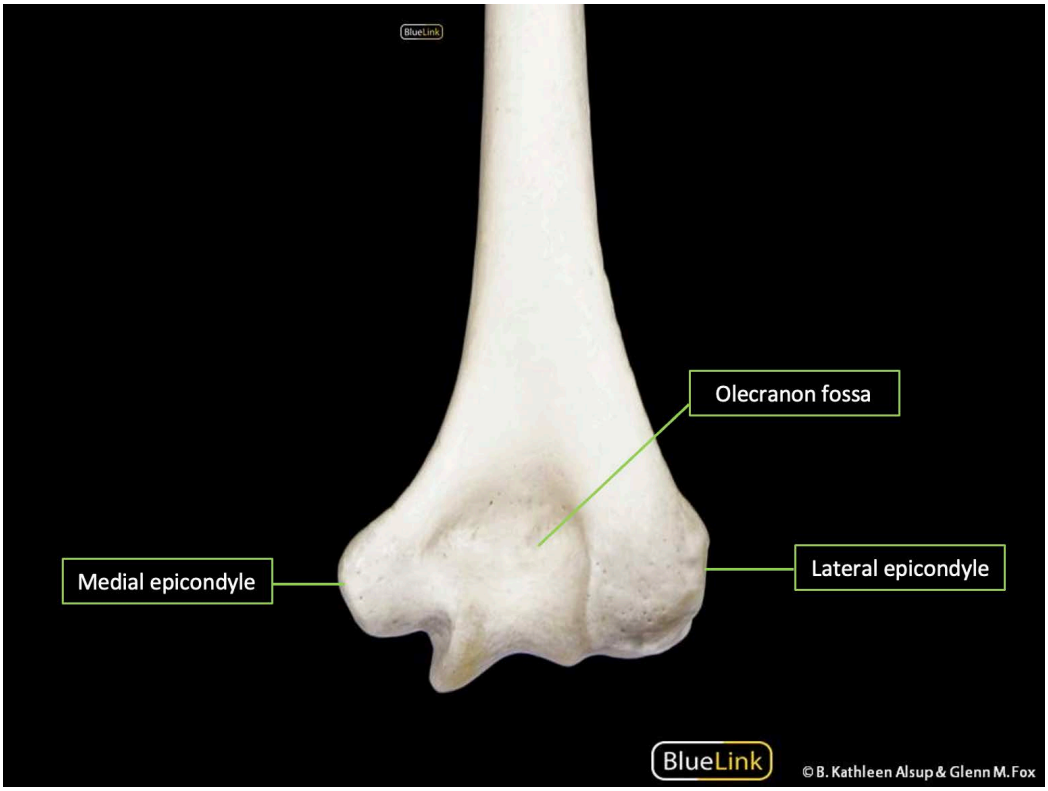


***Figure* 3.2.** *Skeletal Landmarks of the Distal Humerus; Posterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

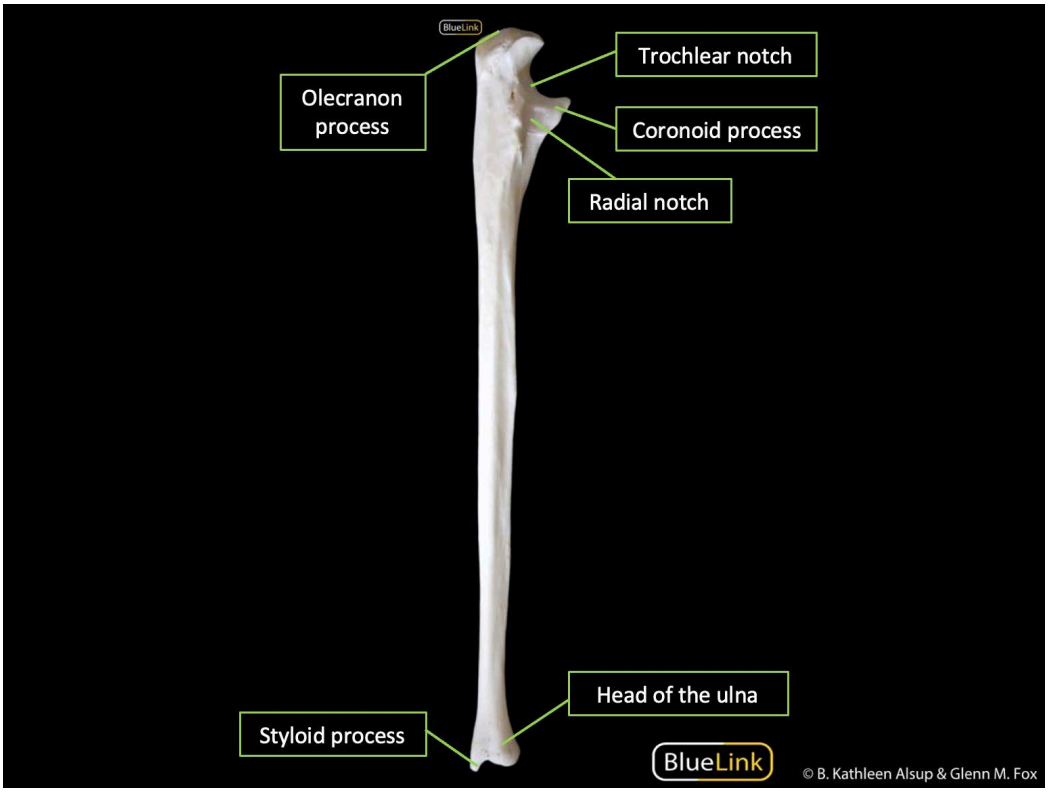


Figure 3.3. *Skeletal Landmarks of the Ulna by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

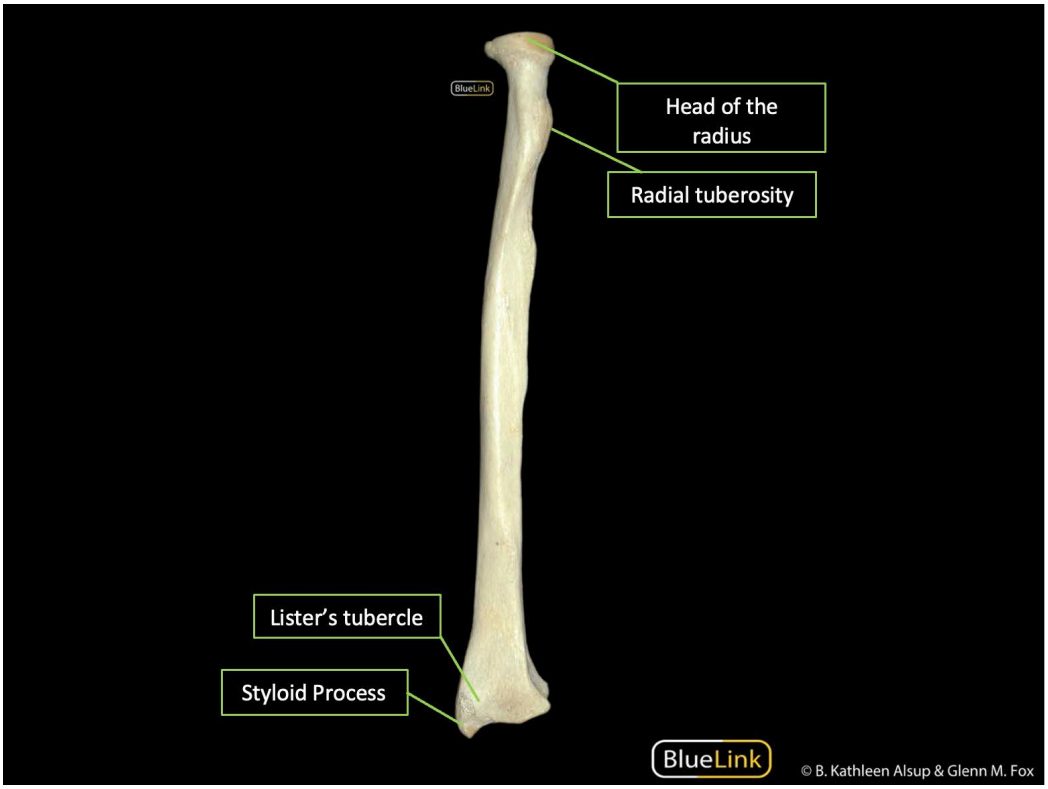


Figure 3.4. *Skeletal Landmarks of the Radius by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Humerus

- **Olecranon Fossa**
  - **How to Palpate**
    - **Position of Partner:** Sitting, standing
    - **Directions:** Begin by fully flexing your partner's elbow. Palpate the distal posterior aspect of the humerus, honing in on the depression, which is the olecranon fossa. Recognize that the triceps brachii tendon covers this depression.
- **Medial Epicondyle**
  - **How to Palpate**
    - **Position of Partner:** Sitting, standing, supine
    - **Directions:** With your partner's arm either flexed or extended, palpate

the medial aspect of the distal humerus. The medial epicondyle will be the most outward boney projection on this side of the elbow.
    - **Muscles That Attach Here:** Wrist flexors (flexor carpi radialis, palmaris longus, flexor carpi ulnaris, and flexor digitorum superficialis) and pronator teres
    - **Structures That Attach Here:** Medial collateral ligament

- **Lateral Epicondyle**
    - **How to Palpate**
        - **Position of Partner:** Sitting, standing, supine
        - **Directions:** This structure is palpated in the same way as the medial epicondyle, except that it's found on the lateral side of the distal humerus.
    - **Muscles That Attach Here:** Wrist extensors (extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum, extensor carpi ulnaris, and extensor digiti minimi), supinator, and anconeus.
    - **Structures That Attach Here:** Lateral collateral ligament

Ulna

- **Olecranon Process**
    - **How to Palpate**
        - **Position of Partner:** Sitting
        - **Directions:** Fully flex your partner's elbow to view their posterior elbow. A point should be visible, which is the olecranon process of the elbow.
    - **Muscles That Attach Here:** Triceps brachii, anconeus, and flexor carpi ulnaris.

Radius

- **Radial Head**
    - **How to Palpate**

- **Position of Partner:** Sitting
- **Directions:** Flex your partner's elbow to 90 degrees and then palpate the lateral epicondyle. Keep the elbow flexed and slide distally toward the hand about a half inch. You may feel a small depression as you move from the humerus to the radius. Confirm you have landed on the head of the radius by having your partner supinate and pronate their forearm. This will rotate the head of the radius underneath your fingertips.

◦ **Structures Located Near this Landmark:** The annular ligament wraps around the head of the radius.

Musculature with Palpation Instructions

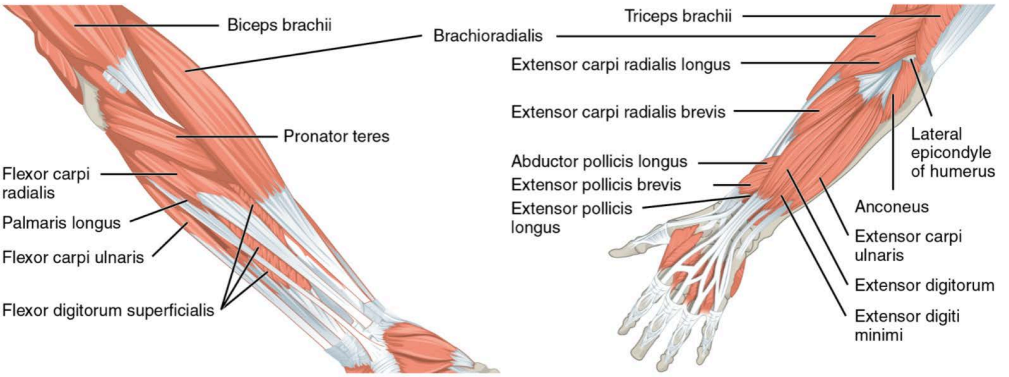


***Figure* 3.5.** *Muscles of the Anterior Forearm; Muscles of the Posterior Forearm* by *Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix* *has been modified (cropped) and is used with permission of the author.*

Brachialis

- **Origin(s):** Mid-anterior humerus.
- **Insertion(s):** Coronoid process and tuberosity of the ulna
- **Action(s):** Elbow flexion
- **Innervation(s):** Musculocutaneous nerve
- **How to Palpate**

- **Position of Partner:** Sitting
- **Directions:** The brachialis lies deep to the biceps brachii. The best way to access this specific muscle is to find the border of the biceps brachii on either the medial or lateral side of its belly and palpate beneath the border toward the anterior humerus.

Brachioradialis

- **Origin(s):** Lateral supracondylar ridge
- **Insertion(s):** The styloid process of the radius
- **Action(s):** Elbow flexion
- **Innervation(s):** Radial nerve
- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** Have your partner flex their elbow to 90 degrees with their forearm in a neutral position where their thumb points upward. Palpate along the muscle belly of the brachioradialis, which lies along the length of the radius. To make this muscle more prominent, in this position place resistance on your partner's distal forearm as they try to flex their elbow.

Supinator

- **Origin(s):** Lateral epicondyle of the humerus and supinator crest of the ulna
- **Insertion(s):** Shaft of the radius
- **Action(s):** Supinate the forearm
- **Innervation(s):** Deep branch of the radial nerve
- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** The depth and location of this muscle limit the specification of its palpation. Use the origin and insertion of the muscle to guide your palpation.

Pronator Teres

- **Origin(s):** Medial epicondyle of the humerus
- **Insertion(s):** Shaft of the radius
- **Action(s):** Pronation of the forearm
- **Innervation(s):** Median nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin at the medial epicondyle, where this muscle originates and travels diagonally across the proximal forearm to the radius. Palpate this muscle along its diagonal orientation. Applying manual resistance to the action of the muscle may assist in differentiating the muscle from others attaching at the common flexor proximal attachment.

Flexor Carpi Radialis

- **Origin(s):** Medial epicondyle of the humerus
- **Insertion(s):** 2nd and 3rd metacarpals
- **Action(s):** Flexion of the wrist and radial deviation
- **Innervation(s):** Median nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin at the medial epicondyle and travel down the anterior forearm toward the radius, staying on the lateral side, all the way to the wrist. Applying manual resistance to the action of the muscle may assist in differentiating the muscle from others attaching at the common flexor proximal attachment.

Palmaris Longus

- **Origin(s):** Medial epicondyle of the humerus
- **Insertion(s):** Flexor retinaculum of the hand
- **Action(s):** Flexion of the wrist

- **Innervation(s):** Median nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin at the medial epicondyle and travel down the anterior forearm, down its midline, all the way to the wrist.

Flexor Carpi Ulnaris

- **Origin(s):** Medial epicondyle of the humerus
- **Insertion(s):** Pisiform, hook of the hamate, and 5th metacarpal
- **Action(s):** Flexion of the wrist and ulnar deviation
- **Innervation(s):** Ulnar nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin at the medial epicondyle and travel down the anterior forearm toward the ulna, staying on the medial side of the forearm, all the way to the wrist. Applying manual resistance to the action of the muscle may assist in differentiating the muscle from others attaching at the common flexor proximal attachment.

Flexor Digitorum Superficialis

- **Origin(s):** Medial epicondyle of the humerus
- **Insertion(s):** Middle phalanxes of digits 2–5
- **Action(s):** Flexion of the proximal interphalangeal joints of digits 2–5
- **Innervation(s):** Median nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** This muscle is located deep to the palmaris longus, so it will be palpated in a similar manner. Begin at the medial epicondyle and travel down the anterior forearm, down its midline, all the way to the wrist.

Flexor Digitorum Profundus

- **Origin(s):** Ulnar and interosseous membrane
- **Insertion(s):** Distal phalanxes of digits 2–5
- **Action(s):** Flexion of the distal interphalangeal joints of digits 2–5
- **Innervation(s):** Ulnar nerve (medial half of muscle) and anterior interosseous nerve (lateral half of muscle)
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** The depth and location of this muscle limits the specification of its palpation. Use the origin and insertion of the muscle to guide your palpation.

Extensor Carpi Radialis Longus and Brevis

- **Origin(s):** Lateral epicondyle of the humerus
- **Insertion(s):** 2nd and 3rd metacarpal
- **Action(s):** Wrist extension and radial deviation
- **Innervation(s):** Radial nerve (extensor carpi radialis longus) and the deep branch of the radial nerve (extensor carpi radialis brevis)
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin at the lateral epicondyle and travel down the posterior forearm along the length of the radius, staying on the lateral side of the forearm, all the way to the wrist. Applying manual resistance to the muscle's action may help differentiate this muscle from others attaching at the common extensor proximal attachment.

Extensor Digitorum

- **Origin(s):** Lateral epicondyle of the humerus
- **Insertion(s):** Extensor expansions of digits 2–5
- **Action(s):** Extension of the wrist and fingers

- **Innervation(s):** Posterior interosseous nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin at the lateral epicondyle and travel down the posterior forearm, along its midline, all the way to the wrist.

Extensor Digiti Minimi

- **Origin(s):** Lateral epicondyle of the humerus
- **Insertion(s):** Extensor expansion of digit 5
- **Action(s):** Extend the wrist and digit 5
- **Innervation(s):** Posterior interosseous nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin at the lateral epicondyle and travel down the posterior forearm, aiming for the 5th digit, all the way to the wrist.

Extensor Carpi Ulnaris

- **Origin(s):** Lateral epicondyle of the humerus
- **Insertion(s):** 5th metacarpal
- **Action(s):** Extension of the wrist and ulnar deviation
- **Innervation(s):** Deep branch of the radial nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin at the lateral epicondyle and travel down the posterior forearm, staying on the medial side of the forearm, toward the ulna, all the way to the wrist. Applying manual resistance to the action of the muscle may assist in differentiating this muscle from others attaching at the common flexor proximal attachment.

Pronator Quadratus

- **Origin(s):** Distal ulna
- **Insertion(s):** Distal radius
- **Action(s):** Pronation of the forearm
- **Innervation(s):** Anterior interosseous nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** This muscle runs very deep and transverses the distal wrist. Palpation of the muscle should involve focusing on this area while feeling between the radius and ulna.

Other Anatomical Landmarks

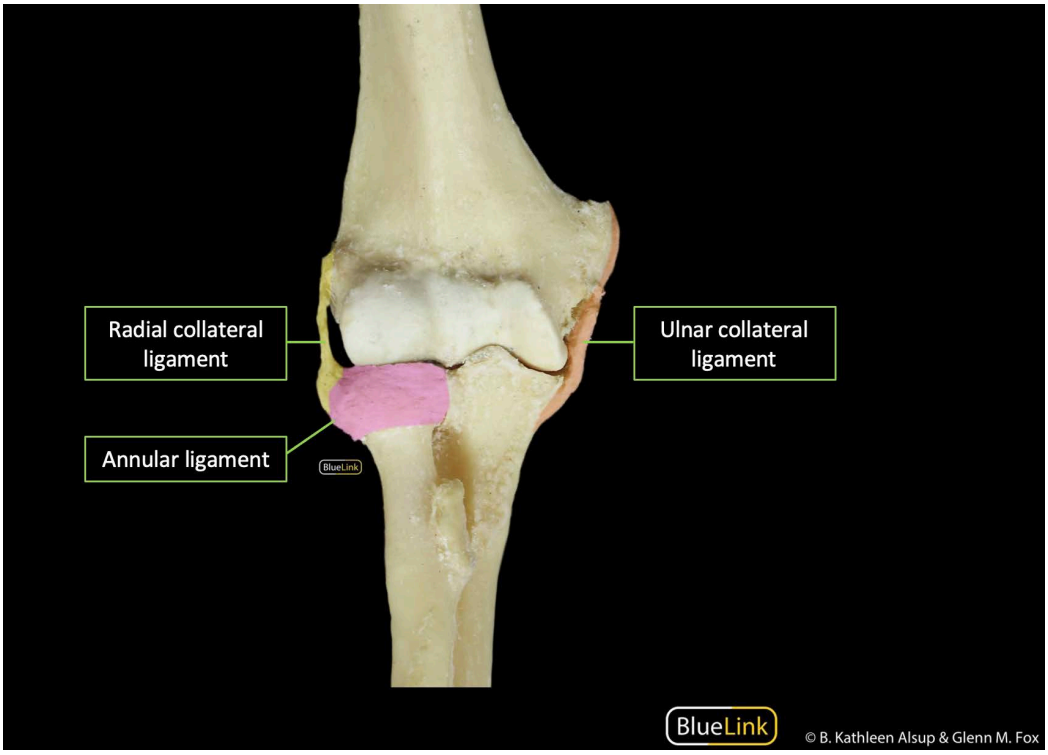


Figure 3.6. *Ligaments of the Elbow by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Annular Ligament

- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** This ligament wraps around the head of the radius, so simply palpate the head of the radius, and you will also be palpating this structure, which is superficial to the head.

Ulnar Collateral Ligament

- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** This ligament runs from the medial epicondyle of the humerus to the proximal ulna. Travel from one of those structures to the other to palpate this ligament.

Radial Collateral Ligament

- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** This ligament runs from the lateral epicondyle of the humerus to the radial head. Travel from one of those structures to the other to palpate this ligament.

Ulnar Nerve

- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** This nerve runs down the length of the arm, traveling most superficially in the area of the elbow. Find the groove, between the olecranon process of the ulna and medial epicondyle of the humerus,

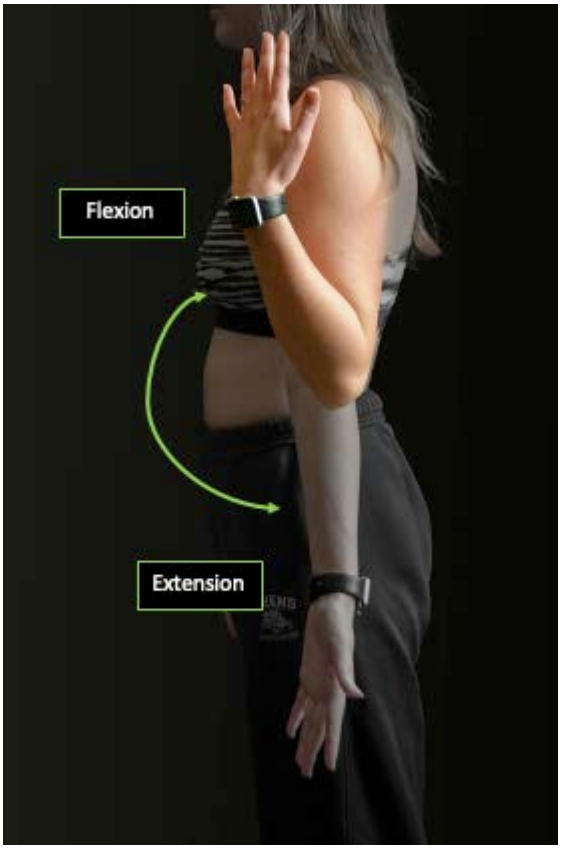
where this nerve runs. Be sure not to palpate with too much pressure as you locate this structure on your partner.

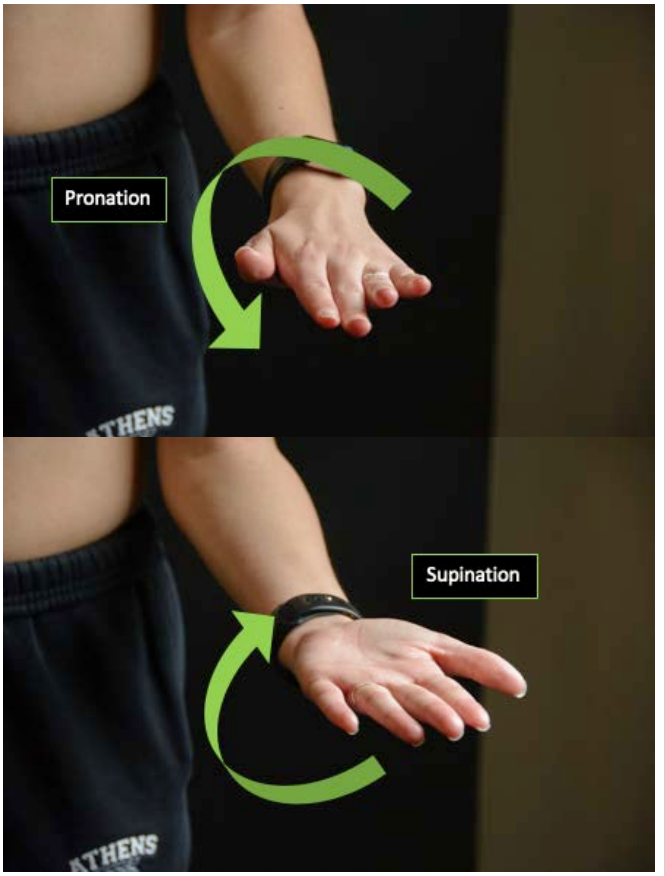
Brachial Artery

- **How to Palpate**
  - **Position of Partner:** Sitting, supine
  - **Directions:** Begin by locating the tendon of the biceps brachii, then move superomedially across the elbow approximately two to three finger breadths. Gradually sink your fingers into the tissue to palpate the brachial artery.

Range of Motion

Table 3.1 Joint Actions

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Elbow Flexion and Extension	These actions are simple to do, but don't forget to encourage your partner to execute the full range of motion when assessing active and resistive ranges.	

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Forearm Supination and Pronation	When assessing the resistive ranges of these motions, the best hand placement is at the forearm. This ensures you are resisting the radius as its distal end rotates around the ulna. If you grab the wrist or hand, you are more likely to engage accessory motions.	

Figures 3.7-3.9 by Dan Silver are used under a CC BY 4.0 License.

Clinical Correlations

Medial and Lateral Epicondylitis

- **Background:** The term *epicondylitis* refers to inflammation affecting the structures that attach to an epicondyle. Medial epicondylitis specifically refers to inflammation of the wrist flexor tendons attaching to the medial epicondyle.

Similarly, lateral epicondylitis is the inflammation of the wrist extensor tendons where they attach to the lateral epicondyle. Repetitive wrist flexion or extension movements over time cause these injuries at the proximal aspect of the associated muscles.

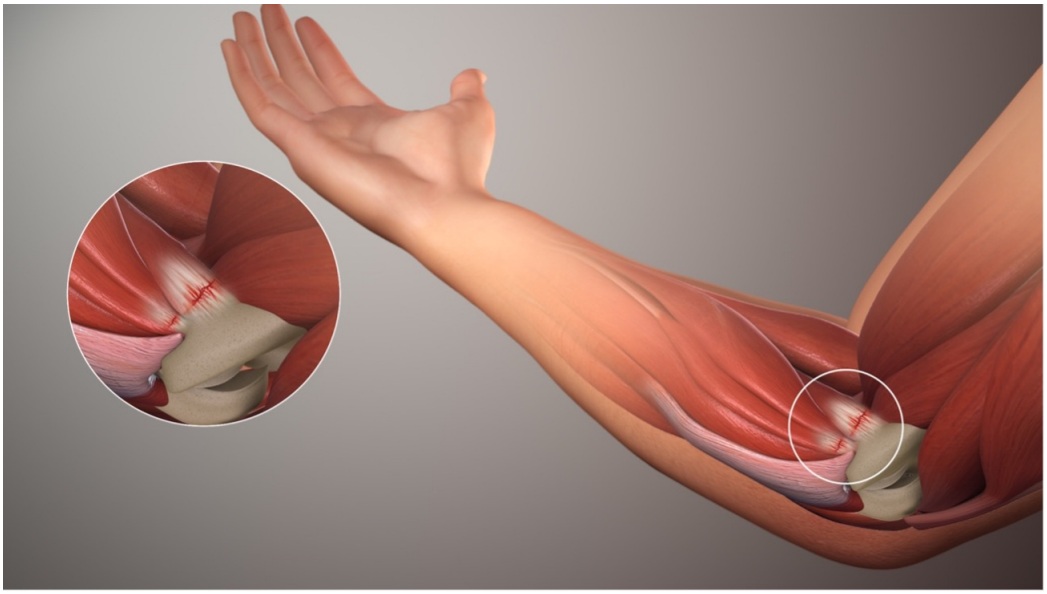


Figure 3.10. *Medial Epicondylitis by Scientific Animations is used under a CC BY-SA 4.0 license.*

Cubital Tunnel Syndrome

- **Background:** *Cubital tunnel* refers to the superficial tunnel where the ulnar nerve runs at the elbow between the olecranon process of the ulna and the medial epicondyle of the humerus. Compression of the nerve at this point can cause radiating neurological signs down the rest of the extremity. This may include muscle weakness and/or numbness and tingling of the area the ulnar nerve innervates, at the hand and fingers.

Review Questions: Skeletal Landmarks of the Elbow and Forearm

1. The olecranon process of the ulna articulates with the _____ of the humerus.
2. The _____ ligament wraps around the head of the radius.
3. The trochlea of the humerus is (medial / lateral), while the capitulum is (medial / lateral).
4. The ulnar nerve can be found between what two palpable skeletal landmarks of the elbow?
5. The areas above each epicondyle of the humerus are called _____ ridges.
6. The radial notch of the ulna is found on the (proximal / distal) end of the ulna.
7. The (radius / ulna) articulates with the humerus to create a hinge joint.
8. The olecranon fossa is found on the (anterior / posterior) side of the humerus.
9. The radius is the (medial / lateral) bone of the forearm, while the ulna is the (medial / lateral) bone of the forearm.
10. When the elbow is flexed, the radial head moves into the _____ of the humerus.

Review Questions: Musculature of the Elbow and Forearm

1. The extensor carpi radialis performs which two joint actions?
2. The _____ inserts on the olecranon process of the ulna.
3. The radial tuberosity serves as the insertion site for the _____.
4. The wrist extensors originate on the (medial epicondyle / lateral epicondyle), while the wrist flexors originate on the (medial epicondyle / lateral epicondyle).
5. Name two muscles that are synergists to the biceps brachii in flexing the elbow.

6. The pronator quadratus is located at the (proximal / distal) forearm, while the pronator teres is located at the (proximal / distal) forearm.

7. The flexor digitorum acts on which numbered digits of the hand?

8. The palmaris longus is located on the (anterior / posterior) side of the forearm.

9. The flexor digitorum superficialis inserts on the (proximal / middle) phalanx, while the flexor digitorum profundus inserts on the (proximal / middle) phalanx of the associated digits.

10. The triceps brachii acts to _____ the elbow.

4. The Wrist and Hand

Skeletal Landmarks with Palpation Instructions

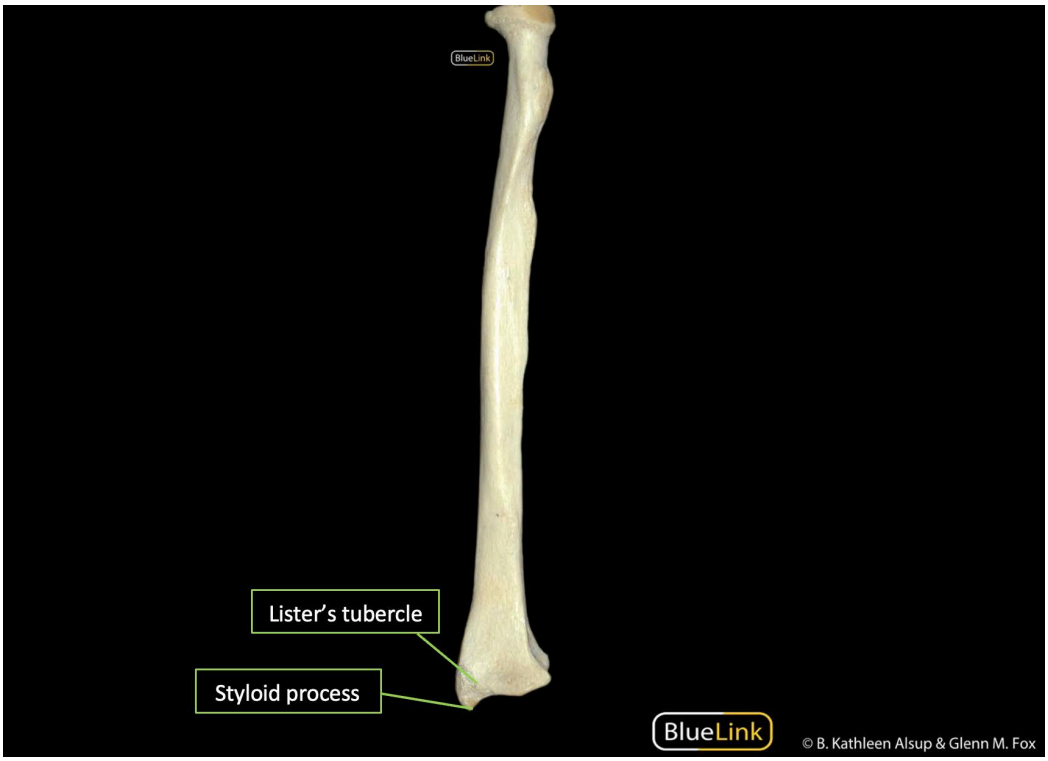


Figure 4.1. *Skeletal Landmarks of the Distal Radius by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

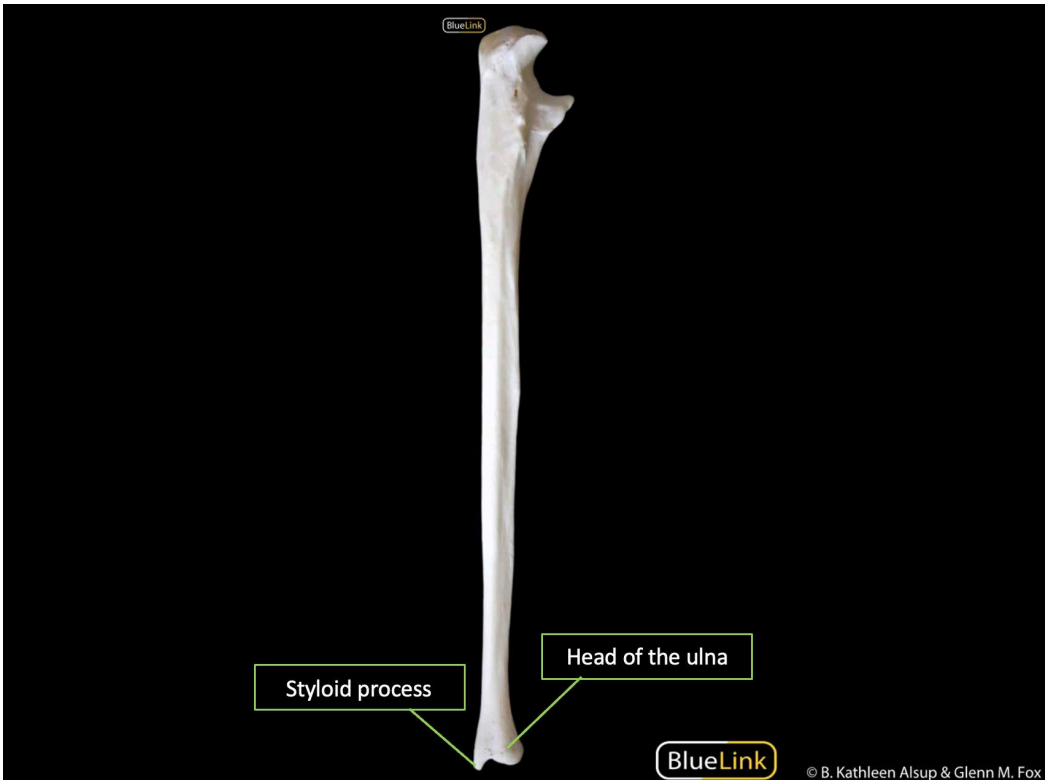


Figure 4.2. *Skeletal Landmarks of the Distal Ulna by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

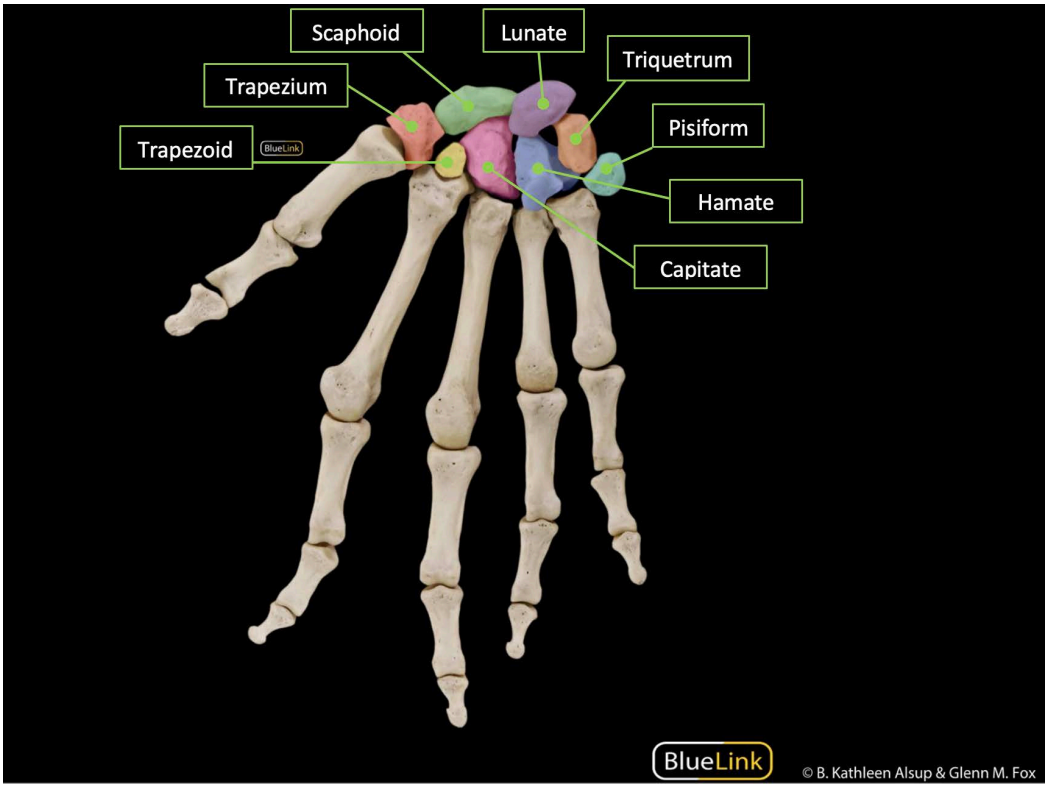


Figure 4.3. *Carpal Bones; Palmar View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

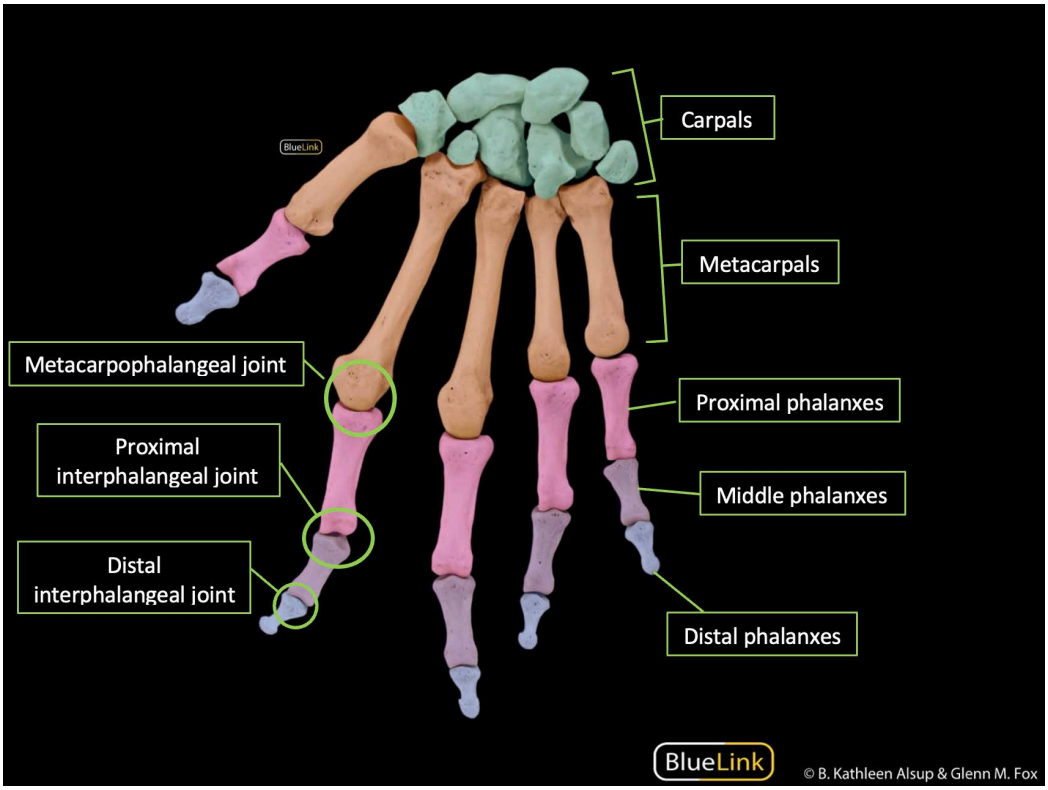


Figure 4.4. *Bones and Joints of the Hand; Palmar View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Radius

- **Styloid Process of the Radius**
  - **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** The styloid process is a small protrusion of the bone at its distal end. To palpate, begin at the distal lateral aspect of the radius and simply feel the very end of the radius.
  - **Muscles That Attach Here:** Brachioradialis

- **Dorsal Tubercle of the Radius (Lister's Tubercle)**
  - **How to Palpate**
    - **Position of Partner:** Sitting with a pronated forearm

        - **Directions:** Begin by palpating the posterior side of the distal aspect of the radius. Feel for a small bump located midway across the radius. Note that if you have gone to the middle of the wrist, you have gone too far.
    - **Structure Located Near this Landmark:** The tendon of the extensor pollicis longus muscle hinges around this skeletal landmark.

Ulna

- **Head of the Ulna**
    - **How to Palpate**
        - **Position of Partner:** Sitting with a pronated forearm
        - **Directions:** Locate the posterior side of the distal aspect of the ulna. The head of this bone is the large bulbous area at the distal end. The head is often visible prior to palpation.

- **Styloid Process of the Ulna**
    - **How to Palpate**
        - **Position of Partner:** Sitting
        - **Directions:** The styloid process is a small protrusion of the bone at its distal end. To palpate, begin at the distal lateral aspect of the ulna and simply feel the very end of the ulna.

Carpals

- **Scaphoid**
    - **How to Palpate**
        - **Position of Partner:** Sitting with a pronated forearm
        - **Directions:** Begin by viewing the dorsal side of your partner's hand. The best way to access the scaphoid bone is to feel the floor of the anatomical snuffbox. To locate this area, have your partner extend their thumb. View the tendon of the extensor pollicis longus, which is now popping out, along with the more lateral tendons of the extensor

pollicis brevis and abductor pollicis longus. Palpate between these two sets of tendons to feel the floor of the snuffbox, where the scaphoid sits.
    - **Muscles That Attach Here:** Abductor pollicis brevis
    - **Other Structures That Attach Here:** Transverse carpal ligament

- **Lunate**
    - **How to Palpate**
        - **Position of Partner:** Sitting with a pronated forearm
        - **Directions:** Locate the extensor creases of the skin on the dorsal side of your partner's wrist. Palpate immediately distal to these creases at the midline of the wrist, in line with the 3rd digit. While your partner's wrist is extended, the lunate is not very palpable; however, when their wrist is flexed, this bone becomes easier to access and feel.

- **Pisiform**
    - **How to Palpate**
        - **Position of Partner:** Sitting with a supinated forearm
        - **Directions:** Begin by viewing the palmar side of your partner's hand. Identify the flexor creases of the skin along the wrist. Palpate immediately distal to these creases on the medial side of the hand. Essentially aim for palpating the very corner of the hand. The pisiform will feel like a very small ball-like structure.
    - **Muscles That Attach Here:** Flexor carpi ulnaris, abductor digiti minimi, and adductor digiti minimi
    - **Other Structures That Attach Here:** Transverse carpal ligament

- **Triquetrum**
    - **How to Palpate**
        - **Position of Partner:** Sitting
        - **Directions:** The triquetrum is located deep to the pisiform so it can be palpated at the medial border of the hand, between the palmar and dorsal surfaces of the hand.

- **Trapezium**
    - **How to Palpate**

        - **Position of Partner:** Sitting with a pronated forearm
        - **Directions:** This bone is located distal to the scaphoid, so begin by palpating the scaphoid on the dorsal side of the hand. Move distal from the scaphoid until you feel a change in bony landmarks. The other way to approach this bone is to first palpate the 1st metacarpal until you reach the proximal end of this bone and begin to approach the trapezium.
    - **Muscles That Attach Here:** Abductor pollicis brevis, flexor pollicis brevis, and opponens pollicis
    - **Other Structures That Attach Here:** Transverse carpal ligament

- **Trapezoid**
    - **How to Palpate**
        - **Position of Partner:** Sitting with a pronated forearm
        - **Directions:** Locate the trapezium first, and then move medially to reach the area of this carpal bone, which lies between the capitate and trapezium. Keep in mind this carpal bone is more in alignment with the 2nd metacarpal when you perform your palpation.
    - **Muscles That Attach Here:** Adductor pollicis

- **Capitate**
    - **How to Palpate**
        - **Position of Partner:** Sitting with a pronated forearm
        - **Directions:** This bone is located immediately distal to the lunate, so begin by finding the lunate from the dorsal side of the hand and move immediately distal to the bone. Stay in line with the 3rd metacarpal when moving distally, and once you have landed on a dome-shaped bone, you have found the capitate.
    - **Muscles That Attach Here:** Adductor pollicis

- **Hamate**
    - **How to Palpate**
        - **Position of Partner:** Sitting with a supinated forearm
        - **Directions:** Begin by palpating the pisiform on the palmar side of the palm. Move about ½–1 inch on a diagonal to the 2nd digit. Press firmly into the hand to feel the hook of the hamate, which is a palpable protrusion of the bone.

- **Muscles That Attach Here:** Flexor carpi ulnaris, flexor digiti minimi brevis, and opponens digiti minimi
- **Other Structures that Attach Here:** Transverse carpal ligament

Metacarpals

- **How to Palpate:** The metacarpals can be accessed most easily from the dorsal side. Begin at the head of an individual metacarpal and palpate, moving proximally until a change in the skeletal anatomy can be felt, indicating you are now palpating a carpal bone.
- **Muscles That Attach Here:**
  - **All Metacarpals:** Palmar and dorsal interossei
  - **1st Metacarpal:** Abductor pollicis longus and opponens pollicis
  - **2nd Metacarpal:** Flexor carpi radialis, extensor carpi radialis longus, and brevis and abductor pollicis
  - **3rd Metacarpal:** Flexor carpi radialis, extensor carpi radialis longus and brevis, and abductor pollicis
  - **5th Metacarpal:** Flexor carpi ulnaris, extensor carpi ulnaris, and opponens digiti minimi
  - **Palmar and dorsal Interossei** also attach to different areas of the digits.

Phalanges

- **How to Palpate:** Prior to palpating the proximal, middle, or distal phalanx of a digit, view Figure 4.4 of the skeletal anatomy of the hand. Ensure your ability to name and locate the phalanges, and then palpate the general area of each individual bone.
- **Muscles That Attach Here:**
  - **Distal Phalanx of Digit 1:** Extensor pollicis longus, flexor pollicis longus
  - **Proximal Phalanx of Digit 1:** Extensor pollicis brevis, abductor pollicis brevis, flexor pollicis brevis, adductor pollicis
  - **Distal Phalanges of Digits 2–5:** Flexor digitorum profundus
  - **Middle Phalanges of Digits 2–5:** Flexor digitorum superficialis
  - **Proximal Phalanx of Digit 5:** Abductor digiti minimi, flexor digiti minimi

brevis, and adductor digiti minimi
    - **Palmar and dorsal Interossei** also attach to different areas of the digits.

Joints

- **How to Palpate:** The individual metacarpophalangeal and interphalangeal joints can be palpated. First, using Figure 4.4, identify which joint to palpate and feel around the joint surfaces from all accessible points.

Musculature with Palpation Instructions

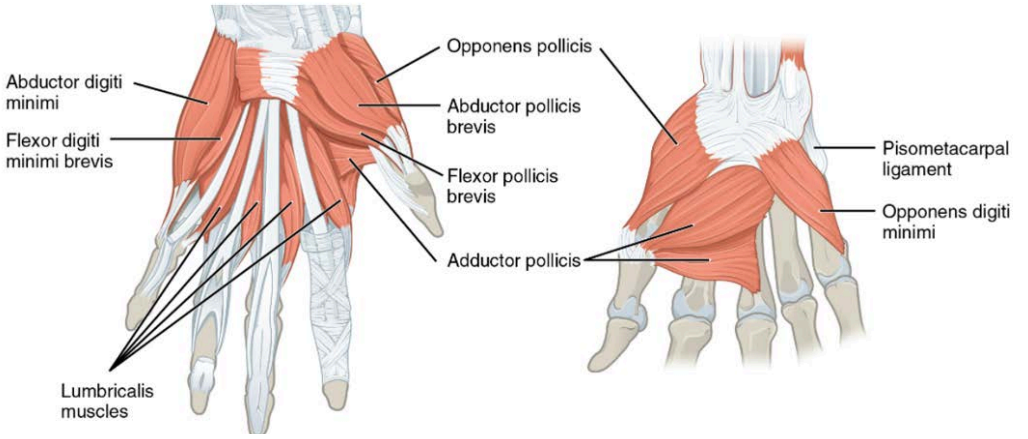


Figure 4.5. *Muscles of the Hand; Palmar Views of Superficial and Deep Layers by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

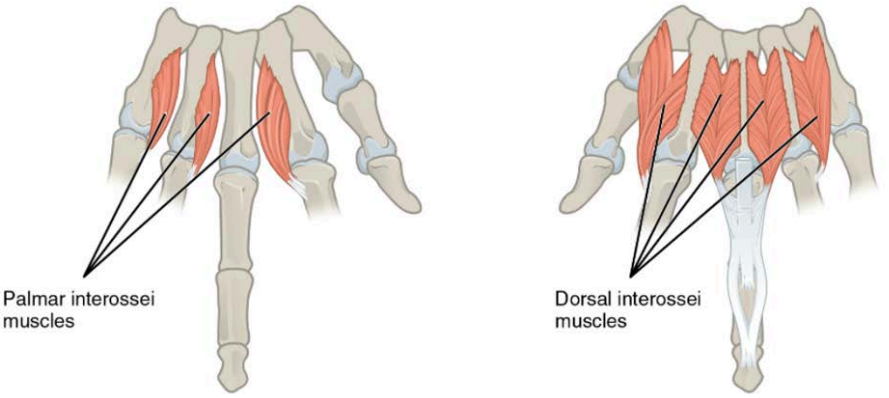


Figure 4.6. *Interossei Muscles of the hand; Palmar View and Dorsal View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

Abductor Pollicis Longus

- **Origin(s):** Ulna, radius, and interosseous membrane
- **Insertion(s):** 1st metacarpal
- **Action(s):** Abduction and extension of the 1st digit
- **Innervation(s):** Posterior interosseous nerve
- **How to Palpate**
    - **Position of Partner:** Sitting with a neutral or pronated forearm
    - **Directions:** This smaller muscle can be difficult to distinguish from surrounding musculature but can be palpated as it wraps over the distal radius. Have your partner extend their thumb to make the tendons of the anatomical snuffbox more apparent. This muscle tendon helps create the lateral border of this landmark and can be a guide to palpating the distal end of this muscle.

Extensor Pollicis Brevis

- **Origin(s):** Radius and interosseous membrane
- **Insertion(s):** Proximal phalanx of the 1st digit

- **Action(s):** Extension of the 1st digit
- **Innervation(s):** Posterior interosseous nerve
- **How to Palpate**
    - **Position of Partner:** Sitting with a neutral or pronated forearm
    - **Directions:** The orientation of this muscle is similar to the abductor pollicis longus. It begins in the posterior forearm and then wraps around the radius. Its distal tendon is the other tendon helping create the lateral border of the anatomical snuffbox. Begin your palpation midway in the posterior forearm, and then follow the direction of the muscle to insertion.

Extensor Pollicis Longus

- **Origin(s):** Ulna and interosseous membrane
- **Insertion(s):** Distal phalanx of the 1st digit
- **Action(s):** Extension of the 1st digit
- **Innervation(s):** Posterior interosseous nerve
- **How to Palpate**
    - **Position of Partner:** Sitting with a neutral or pronated forearm
    - **Directions:** Because of the depth and size of this muscle, it proves difficult to palpate. When attempting to do so, travel from the origin of the distal posterior forearm to the end of the first digit. The tendon of this muscle creates the medial border of the anatomical snuffbox.

Flexor Pollicis Longus

- **Origin(s):** Radius and interosseous membrane
- **Insertion(s):** Distal phalanx of the 1st digit
- **Action(s):** Flexion of the 1st digit
- **Innervation(s):** Anterior interosseous nerve
- **How to Palpate**
    - **Position of Partner:** Sitting with a neutral or pronated forearm
    - **Directions:** Because this muscle is located deep to the anterior forearm musculature, it can be very difficult to palpate. When attempting to do so, begin midway on the anterior forearm on the radial side. Then travel down

the forearm to the end of the 1st digit.

Thenar Muscles

- **Abductor Pollicis Brevis**
  - **Origin(s):** Scaphoid and trapezium
  - **Insertion(s):** Proximal phalanx of the 1st digit
  - **Action(s):** Abduction of the 1st digit
  - **Innervation(s):** Recurrent branch of the median nerve
- **Flexor Pollicis Brevis**
  - **Origin(s):** Trapezium and flexor retinaculum
  - **Insertion(s):** Proximal phalanx of the 1st digit
  - **Action(s):** Flexion of the 1st metacarpophalangeal joint
  - **Innervation(s):** Recurrent branch of the median nerve
- **Opponens Pollicis**
  - **Origin(s):** Trapezium and transverse carpal ligament
  - **Insertion(s):** 1st metacarpal
  - **Action(s):** Opposition
  - **Innervation(s):** Recurrent branch of the median nerve
- **Adductor Pollicis**
  - **Origin**
    - **Transverse Head:** 3rd metacarpal
    - **Oblique Head:** 2nd and 3rd metacarpals, trapezoid, and capitate
  - **Insertion(s):** 1st proximal phalanx
  - **Action(s):** Adduction of the 1st digit
  - **Innervation(s):** Deep branch of the ulnar nerve
- **How to Palpate the Thenar Muscles:**
  - **Position of Partner:** Sitting with a supinated forearm
  - **Directions:** To palpate this group of muscles, first identify the soft tissue pad at the base of the thumb called the thenar eminence. Palpate this bulge of soft tissue to collectively examine these muscles.

Hypothenar Muscles

- **Abductor Digiti Minimi**
  - **Origin(s):** Pisiform and flexor retinaculum
  - **Insertion(s):** Proximal phalanx of the 5th digit
  - **Action(s):** Abduction of the 5th digit
  - **Innervation(s):** Deep branch of the ulnar nerve
- **Flexor Digiti Minimi Brevis**
  - **Origin(s):** Hamate
  - **Insertion(s):** Proximal phalanx of the 5th digit
  - **Action(s):** Flexion of the 5th digit
  - **Innervation(s):** Deep branch of the ulnar nerve
- **Opponens Digiti Minimi**
  - **Origin(s):** Hamate and flexor retinaculum
  - **Insertion(s):** 5th metacarpal
  - **Action(s):** Opposition
  - **Innervation(s):** Deep branch of the ulnar nerve
- **Adductor Digiti Minimi**
  - **Origin(s):** Pisiform and flexor retinaculum
  - **Insertion(s):** Proximal phalanx of the 5th digit
  - **Action(s):** Abduction of the 5th digit
  - **Innervation(s):** Deep branch of the ulnar nerve
- **How to Palpate the Hypothenar Muscles:**
  - **Position of Partner:** Sitting
  - **Directions:** To palpate this group of muscles, first identify the soft tissue pad at the base of the pinkie called the hypothenar eminence. Palpate this bulge of soft tissue to collectively examine these muscles.

Lumbricals

- **Origin(s):** Flexor digitorum profundus
- **Insertion(s):** Extensor expansion
- **Action(s):** Flexion of metacarpophalangeal joints and extension of interphalangeal joints

- **Innervation(s):** Median nerve (1st and 2nd lumbrical) and deep branch of the ulnar nerve (3rd and 4th lumbrical)
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Because these muscles are located very deep, they can be very difficult to palpate. When attempting to do so, follow from the origin of the flexor digitorum profundus tendons and work your way distally to their insertions on the extensor expansion of the digits.

Palmar and Dorsal Interossei

- **Origin(s):** Metacarpals
- **Insertion(s):** Proximal phalanxes and extensor expansions
- **Action**
    - **Palmar Interossei:** Adduction
    - **Dorsal Interossei:** Abduction
- **Innervation(s):** Deep branch of ulnar nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Because these muscles are located very deep, they can be very difficult to palpate. When attempting to do so, follow their origin along the metacarpals to the proximal phalanxes and extensor expansions. The first dorsal interossei is the most prominent of all these muscles as it's located between the 1st and 2nd digit on the dorsal side between the metacarpal bones.

Other Anatomical Landmarks

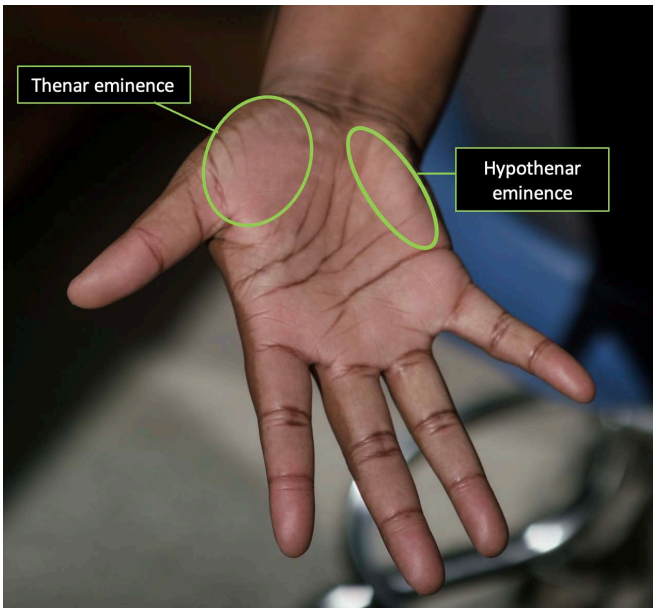


Figure 4.7. *Thenar and Hypothenar Eminences; Palmar View by Dan Silver is used under a CC BY 4.0 license.*

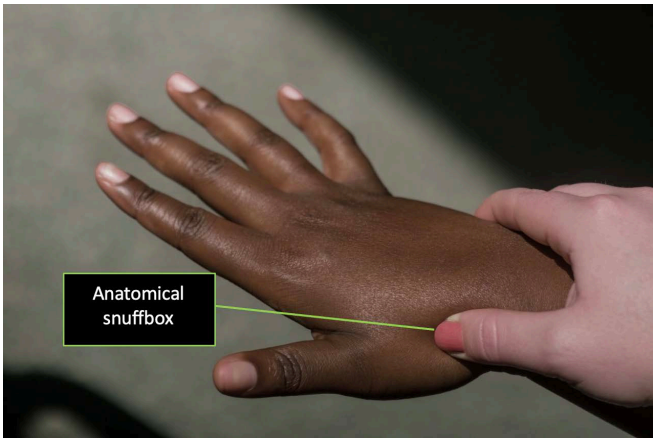


Figure 4.8 *Anatomical Snuffbox; Dorsal View by Dan Silver is used under a CC BY 4.0 license.*

Thenar Eminence

- **How to Palpate**
  - **Position of Partner:** Sitting with a supinated forearm
  - **Directions:** The thenar eminence is the enlarged mound of soft tissue at the base of the thumb on the palmar side. This enlarged area of soft tissue is created by the muscle bellies of some of the smaller thumb muscles. To palpate, simply identify this enlarged area on the palmar side of the hand and fully palpate the region.

Hypothenar Eminence

- **How to Palpate**
  - **Position of Partner:** Sitting with a supinated forearm
  - **Directions:** Similar to the thenar eminence, this area is created by muscle bellies of some of the smaller pinkie muscles. Identify the enlarged mound of soft tissue at the base of the pinkie on the palmar side and palpate fully.

Anatomical Snuffbox

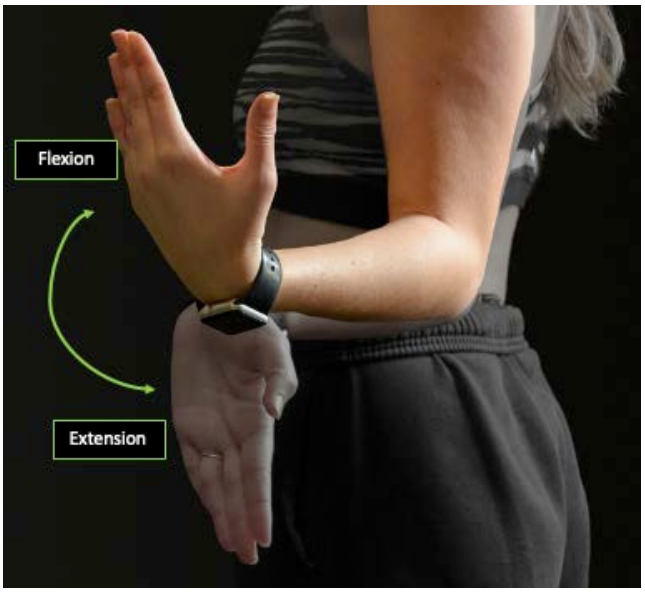
- **How to Palpate**
  - **Position of Partner:** Sitting with a pronated forearm
  - **Directions:** This depression is found on the dorsal side of the hand, at the base of the thumb, between several tendons of the hand. Medially, the extensor pollicis longus creates a border while the lateral border is created by the extensor pollicis brevis and abductor pollicis longus. While moving the thumb in the appropriate directions, these tendons will become activated and more apparent while creating a soft tissue depression between them, which is the anatomical snuffbox. When palpating into the snuffbox, the scaphoid can be felt.

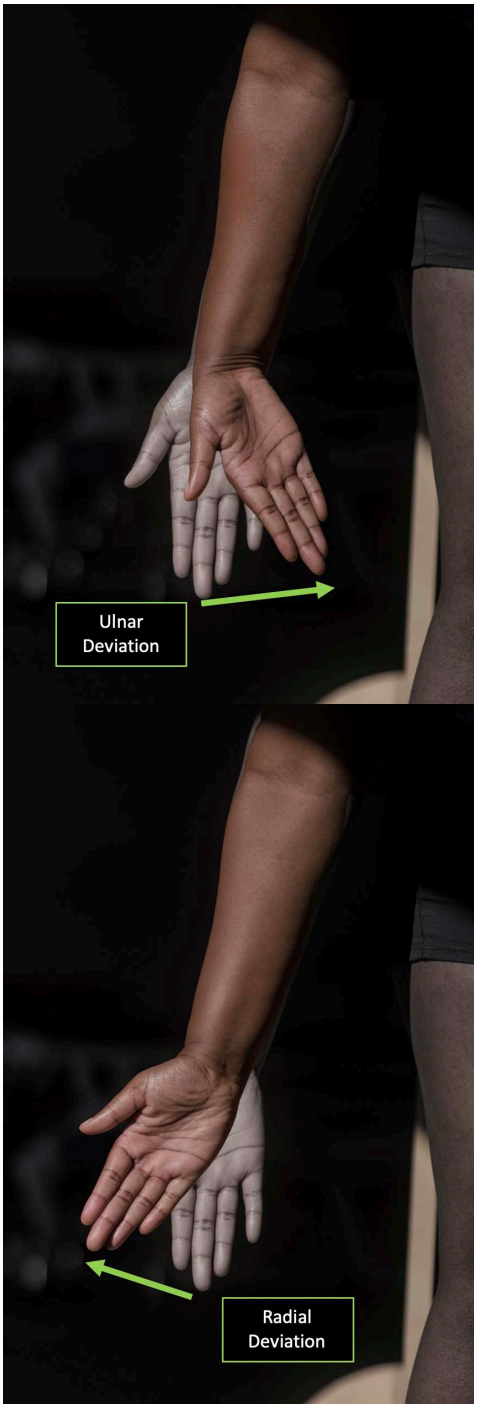
Radial Artery

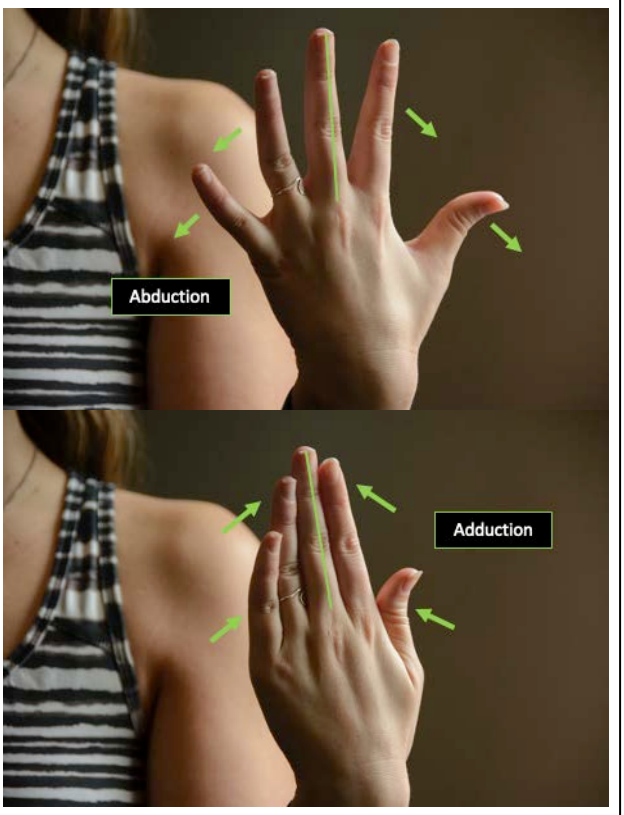
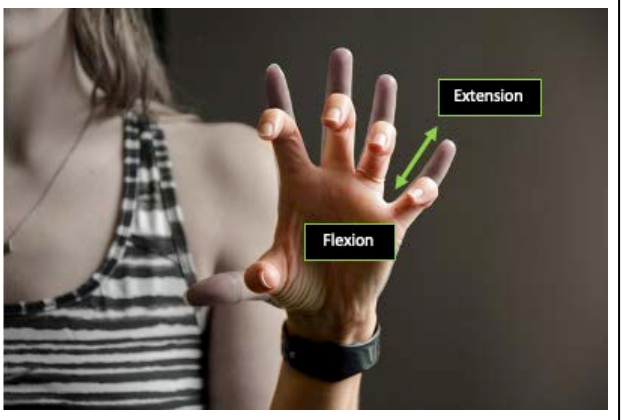
- **How to Palpate**
  - **Position of Partner:** Sitting with a supinated forearm
  - **Directions:** Locate the most superficial point of the radial artery, which runs along the anterior side of the wrist toward the lateral side. Palpate over the flexor creases of the hand at the most lateral aspect of the anterior wrist with your 2nd and 3rd digits to feel the pulse of this artery.

Range of Motion

Table 4.1 Range of Motion of the Wrist & Hand

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Wrist Flexion and Extension	Try to isolate these movements as much as possible when assessing these ranges to ensure they're not compensating with the use of other arm musculature.	

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Ulnar Deviation and Radial Deviation	When assessing these ranges, it's important to recognize they are very limited and it's normal to have a small range of motion for both radial and ulnar deviation. It's also important to make sure the hand is moving in the frontal plane and that there is no rotation of the forearm, or flexion and extension of the wrist, occurring when performing these movements.	

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Abduction and Adduction of the Fingers	Abduction and adduction of the fingers occurs at the metacarpophalangeal joints. The midline for these motions is defined as being through the third finger, and the other fingers either move toward this midline (adduction) or away from this midline (abduction).	
Flexion and Extension of the Fingers	Flexion and extension can be performed at the metacarpophalangeal or interphalangeal joints. These ranges can be assessed one digit and even one joint at a time or all together. The goal or purpose of the assessment will determine your approach. Either way, it's important to always maintain a neutral wrist during these ranges to ensure no extra tension is being placed on some of these muscles.	

Clinical Correlations

Carpal Tunnel Syndrome

- **Background:** The carpal tunnel is a small area within the wrist that is enclosed by surrounding carpal bones and ligaments. Located within the narrow tunnel are several tendons along with the median nerve.
- When the tendons within the tunnel become inflamed, due to overuse of the muscle, the median nerve can become compressed. Carpal tunnel syndrome refers to the compression of this nerve, along with the many symptoms that result from the nerve not properly functioning, such as numbness and weakness of the innervated areas of the hand.

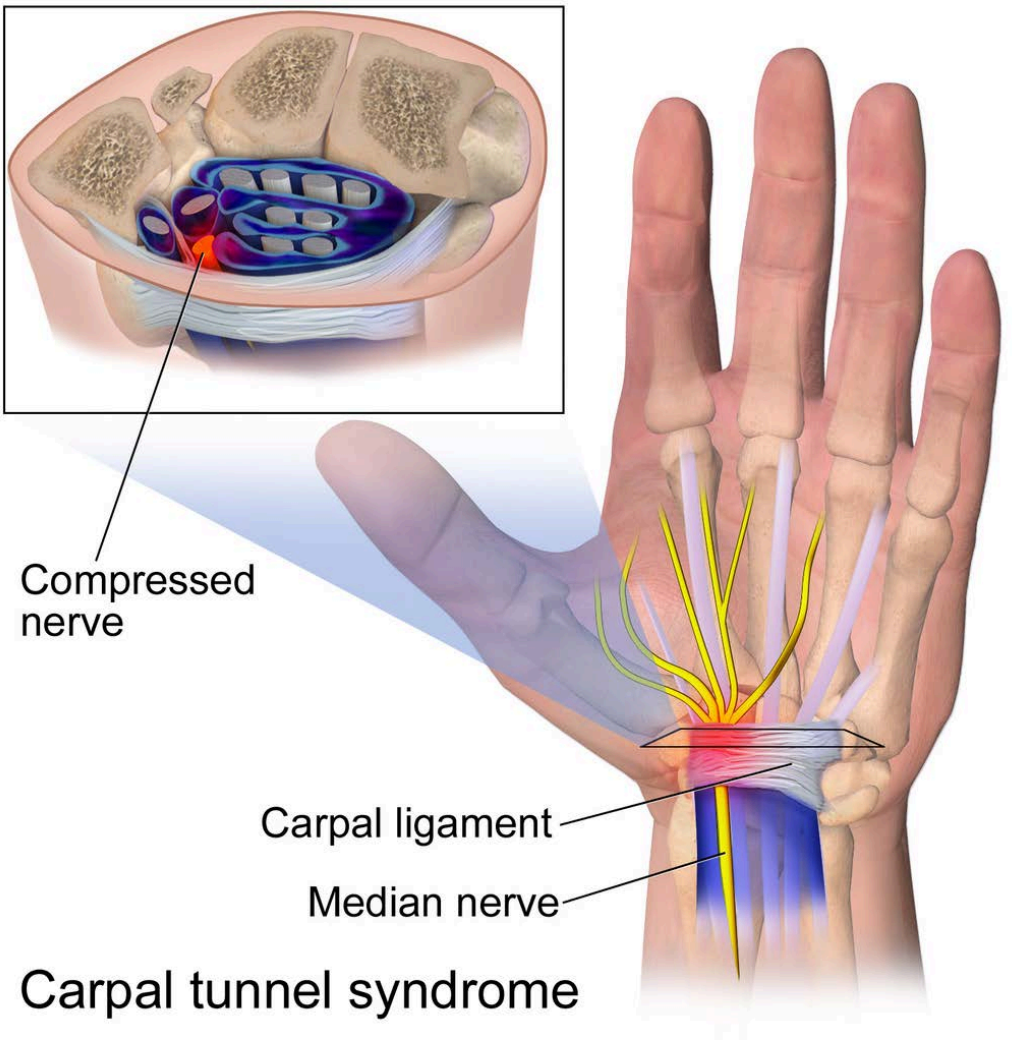


Figure 4.15. *Carpal Tunnel Syndrome by Blausen.com staff is used under a CC BY 4.0 license.*

Ulnar Nerve Palsy

- **Background:** The term palsy refers to the paralysis, or loss of ability to move, of the muscles innervated by a provided nerve.
- A common site of damage to the ulnar nerve occurs within the hand where the ulnar nerve runs through a small tunnel around the area of the hypothenar eminence. Prolonged pressure on this area of the hand can cause transient, and sometimes more severe, neurological dysfunction, including numbness and tingling along with weakness of the muscles this nerve innervates.

Jersey Finger

- **Background:** There are several tendons located along the palmar and dorsal sides of the fingers. Excessive movements of finger joints can cause injury to these tendons.
- When an athlete grabs the jersey of a player who is getting away, their distal interphalangeal joint can be pulled into hyperextension, causing damage to the flexor digitorum profundus tendon, which is located on the palmar side of the finger. A notable decrease or lack of ability to flex the distal interphalangeal joint is a sign this injury has occurred.

Review Questions: Skeletal Landmarks of the Wrist and Hand

1. The dorsal tubercle of the radius is located on the (anterior / posterior) side of the wrist.
2. A proximal phalanx articulates with a _____ bone proximally.
3. A distal interphalangeal is located between two bones, a _____ and a _____.
4. Which two carpal bones can be found in line with the 3rd digit?
5. The scaphoid bone should be accessed on the (palmar / dorsal) side of the hand when palpating.
6. The head of the radius is (proximal / distal) while the head of the ulna is (proximal / distal).
7. The fifth digit is more commonly referred to as the _____.
8. Which two carpal bones are found at the base of the thumb?
9. The head of a metacarpal is located at the (proximal / distal) end, while the base is located at the (proximal / distal) end.
10. What mnemonic helps you remember the order of the carpal bones in the wrist?

Review Questions: Musculature of the Wrist and Hand

1. The lumbricals act to _____ the metacarpophalangeal joints and _____ _____ the interphalangeal joints.
2. The extensor indicis muscle is located on the (anterior / posterior) side of the forearm.
3. The term pollicis refers to which numbered digit?
4. The thenar eminence is located at the base of the (5th digit / 1st digit), while the hypothenar eminence is located at the base of the (5th digit / 1st digit).
5. Which digit serves as the midline of the hand?
6. A muscle with the term digitorum in the name acts on which digits of the hand?
7. Describe the action of opposition.
8. The palmar interossei act to _____ the fingers, while the dorsal interossei act to _____ the fingers.
9. Which muscle of the thumb has both a transverse and an oblique head?
10. The abductor digiti minimi originates on which carpal bone?

5. The Spine, Thorax, and Abdomen

Skeletal Landmarks with Palpation Instructions

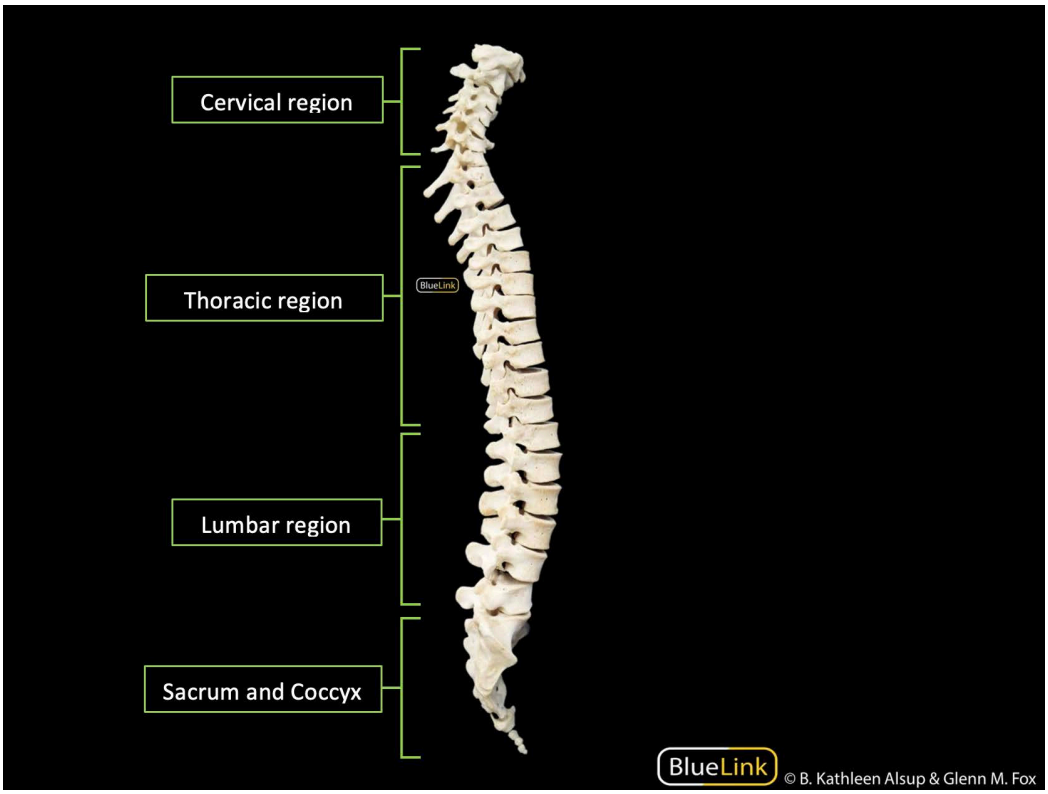


Figure 5.1. *Regions of the Spine; Sagittal View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

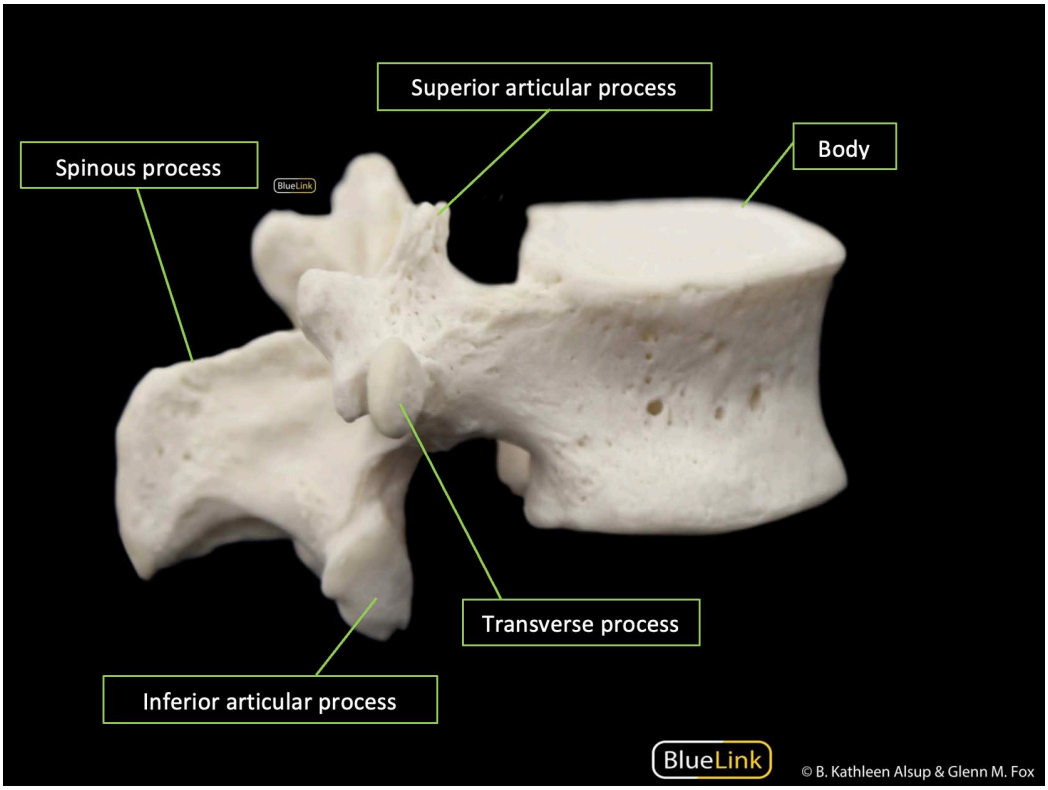


Figure 5.2. *Skeletal Landmarks of a Vertebra; Sagittal View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

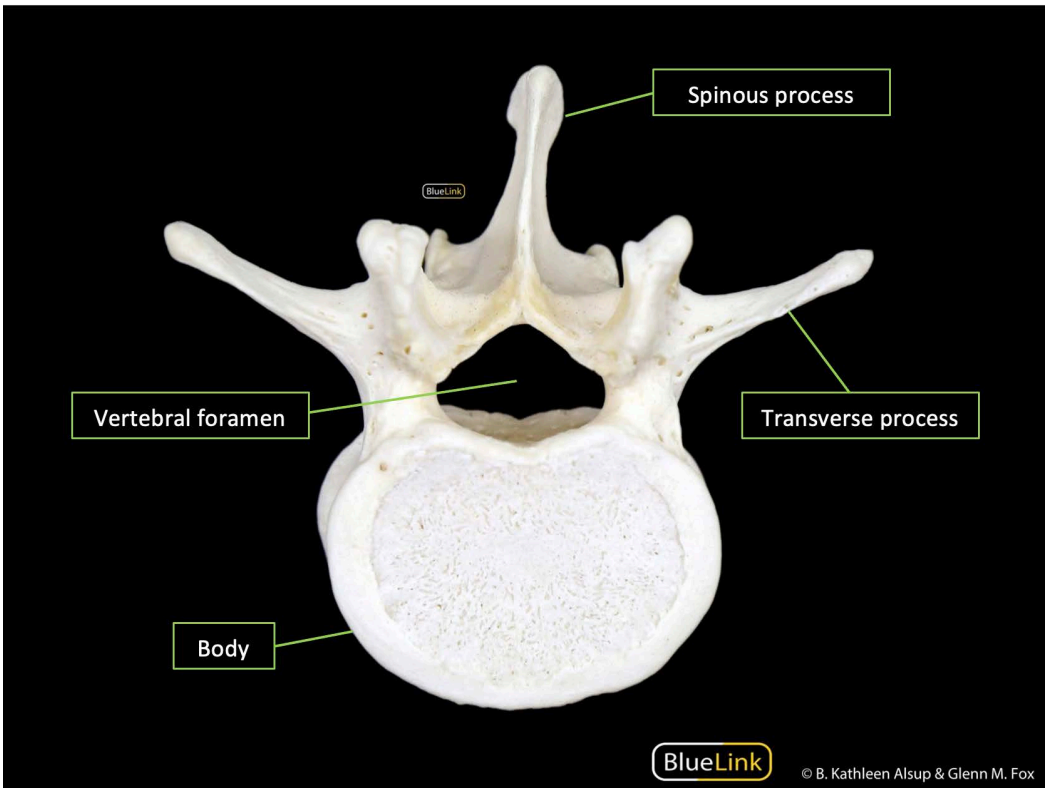


***Figure* 5.3.** *Skeletal Landmarks of a Vertebra; Superior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

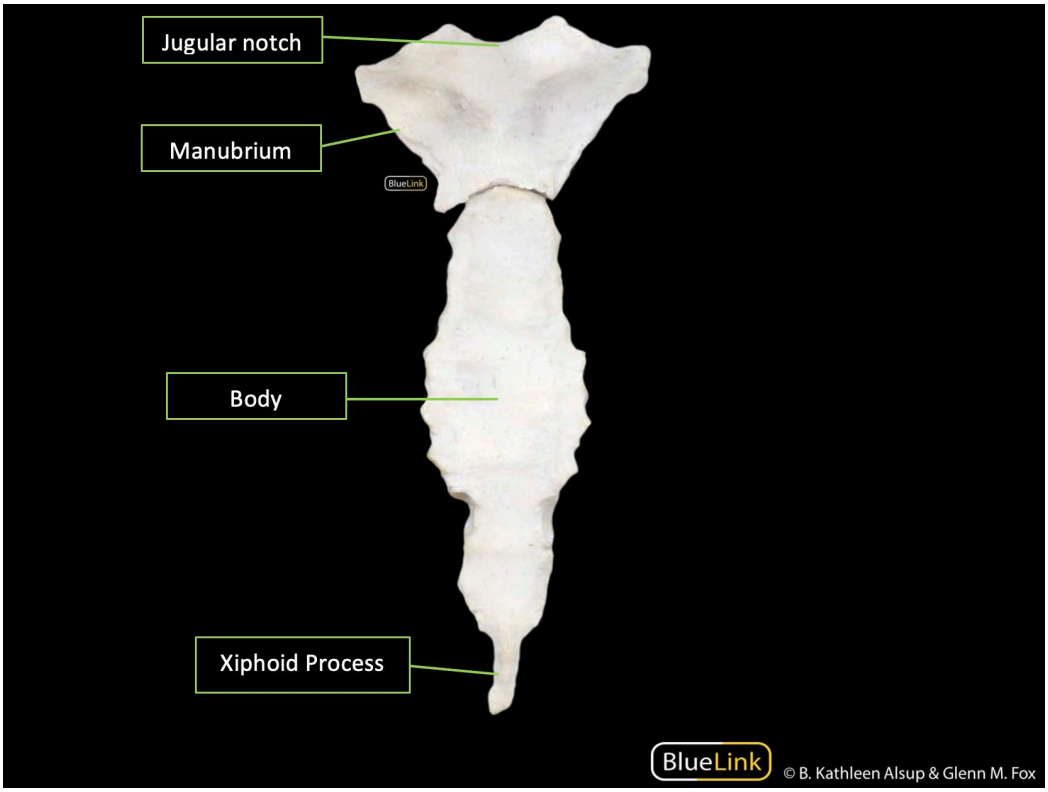


Figure 5.4. *Skeletal Landmarks of the Sternum by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

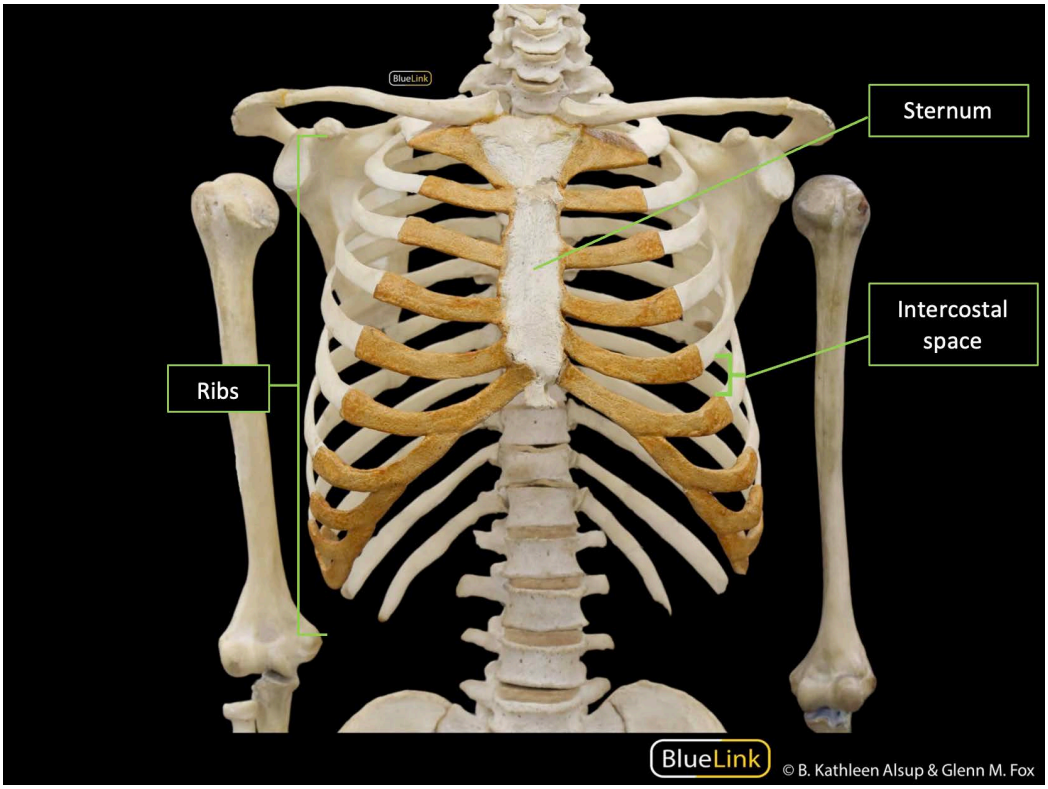


Figure 5.5. *The Thorax by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Spinous Processes of the Vertebrae

- **How to Palpate**
  - **Position of Partner:** Prone, standing, sitting
  - **Directions:** Find the midline of the back and palpate down this line. The point of each spinous process will be very palpable along with a depression of soft tissue between each spinous process as you move, either superiorly or inferiorly, from one process to the next.
  - The spinous processes of the following vertebrae can be located by first identifying skeletal landmarks that are at the same horizontal level as these vertebrae. Once you have found the associated skeletal landmark, work your way medially to find the indicated spinous process.
    - C7: base of the neck
    - T2: superior angle of the scapula

        - T7: inferior angle of the scapula
        - T12: 12th rib
        - L4: superior aspect of the iliac crest
- **Structures That Attach Here:** The spinous processes serve as the proximal or distal attachments for numerous muscles and ligaments in each region. For example, muscles of the superficial back, such as the rhomboid major and minor; muscles of the intermediate back, such as the spinalis of erector spinae; and muscles of the deep back, such as semispinalis, multifidus, and rotatores, attach to this landmark. The reader is encouraged to explore corresponding content on the spine for greater depth and breadth of knowledge of the structures that attach to this location.

Transverse Processes of the Vertebrae

- **How to Palpate**
    - **Position of Partner:** Prone, standing, sitting
    - **Directions:** It's important to first visualize a vertebra and recognize the distance between a spinous process and the transverse processes of the same vertebrae. Once you have found and palpated a spinous process, move laterally to either side about ½ to 1 inch to feel a transverse process. These processes are not nearly as pronounced as spinous processes, so more pressure will be needed; however, they are palpable.
- **Structures That Attach Here:** The transverse processes serve as the proximal or distal attachments for numerous muscles and ligaments in each region. For example, muscles of the superficial back, such as levator scapulae; muscles of the intermediate back, such as longissumus of erector spinae; and muscles of the deep back, such as transversospinalis group and splenius cervicis; attach to this landmark. The reader is encouraged to explore corresponding content on the spine for greater depth and breadth of knowledge of the structures that attach to this location.

Jugular Notch

- **How to Palpate**
  - **Position of Partner:** Supine, sitting, standing
  - **Directions:** Face your partner and begin by locating the medial ends of the clavicles. Palpate between the ends of the clavicles and just superior to the top of the sternum to feel the jugular notch, or the depression between these bones.

Sternum

- **How to Palpate**
  - **Position of Partner:** Supine, sitting, standing
  - **Directions:** Once you have identified the jugular notch, begin to palpate inferiorly where the manubrium of the sternum is located. The manubrium composes the top portion of the sternum. Being mindful not to palpate too laterally where the costochondral cartilage can be felt, continue to palpate inferiorly to the body of the sternum, all the way to the xiphoid process.
- **Muscles That Attach Here:** Sternocleidomastoid, pectoralis major, transversus thoracis, sternohyoid, and sternothyroid
- **Structures That Attach Here:** Sternoclavicular ligament, and costosternal ligament

Ribs

- **How to Palpate**
  - **Position of Partner:** Supine, prone, sitting, standing
  - **Directions:** Most ribs can be palpated fully from the sternum to their articulation with the thoracic vertebrae posteriorly. Simply pick a particular rib and palpate it fully by moving around the thorax, either anteriorly to posteriorly or vice versa.
- **Muscles That Attach Here:** Latissimus dorsi, intercostals, pectoralis minor, serratus anterior, serratus posterior superior, serratus posterior inferior,

iliocostalis, and scalenes

Musculature with Palpation Instructions

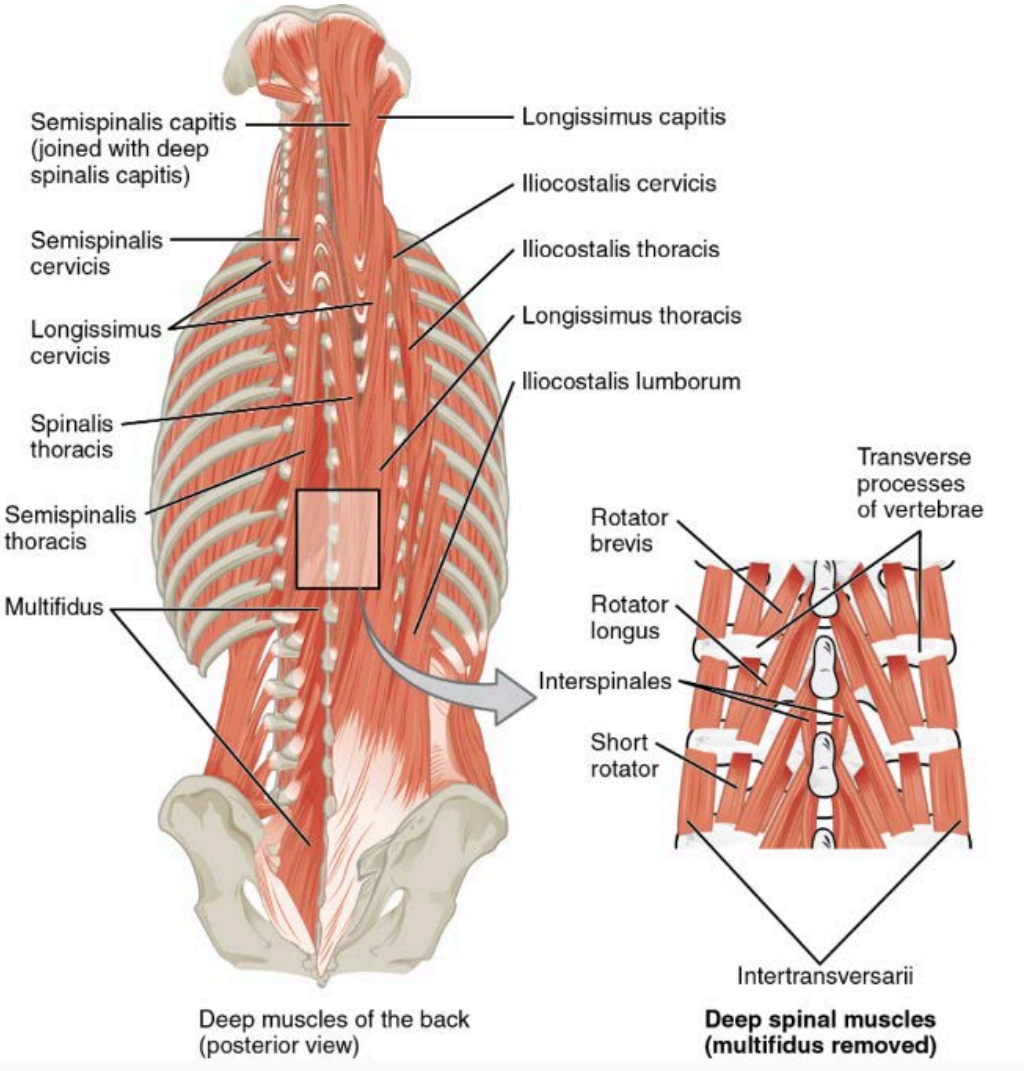


Figure 5.6. *Deep Musculature of the Back; Posterior View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

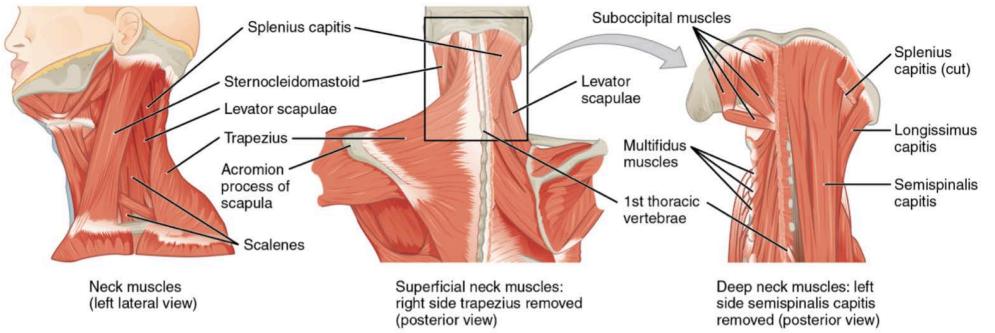


***Figure* 5.7.** *Musculature of the Neck; Sagittal and Posterior Views by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix is used under a CC BY 4.0 license.*

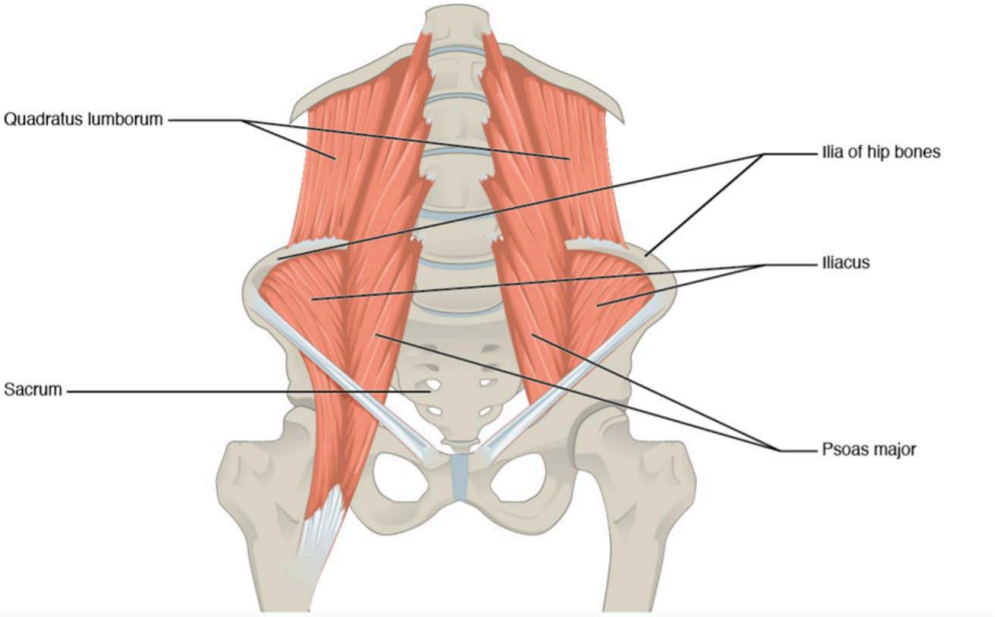


***Figure* 5.8.** *Deep Musculature of the Anterior Abdomen; Anterior View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

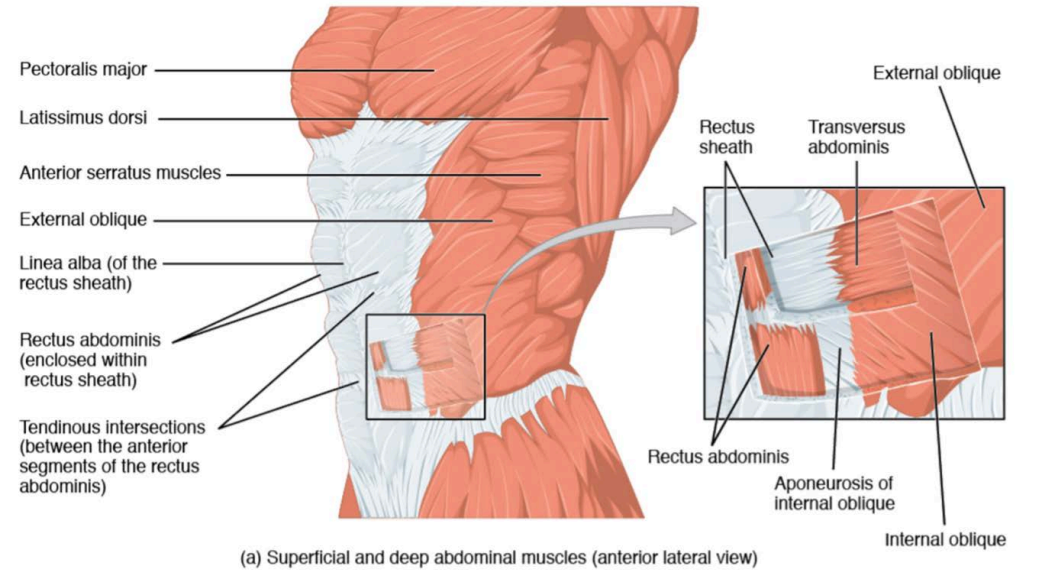


Figure 5.9. *Deep Musculature of the Abdomen; Anterior View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

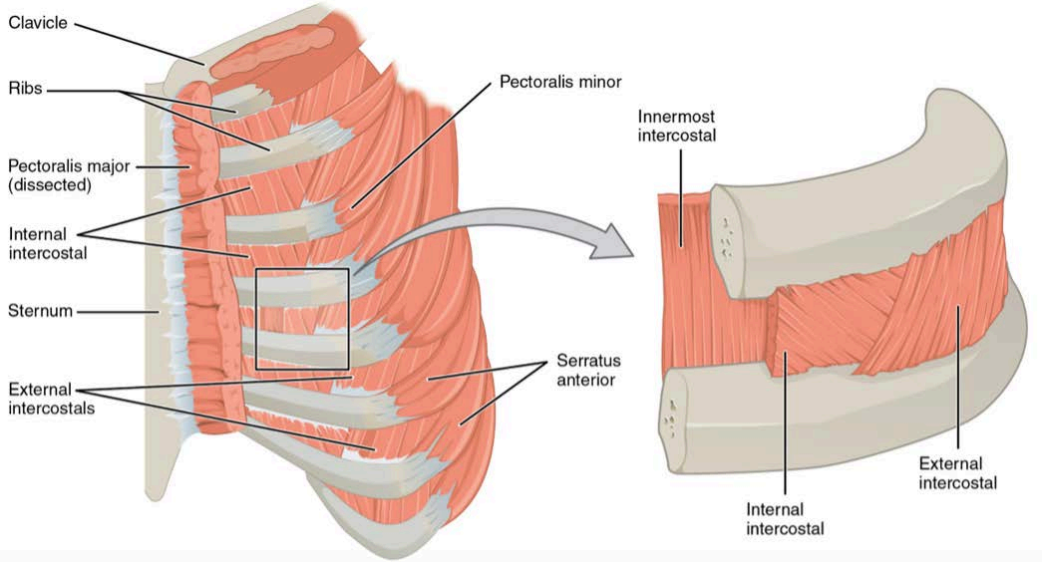


Figure 5.10. *Musculature of the Ribs; Anterior View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix is used under a CC BY 4.0 license.*

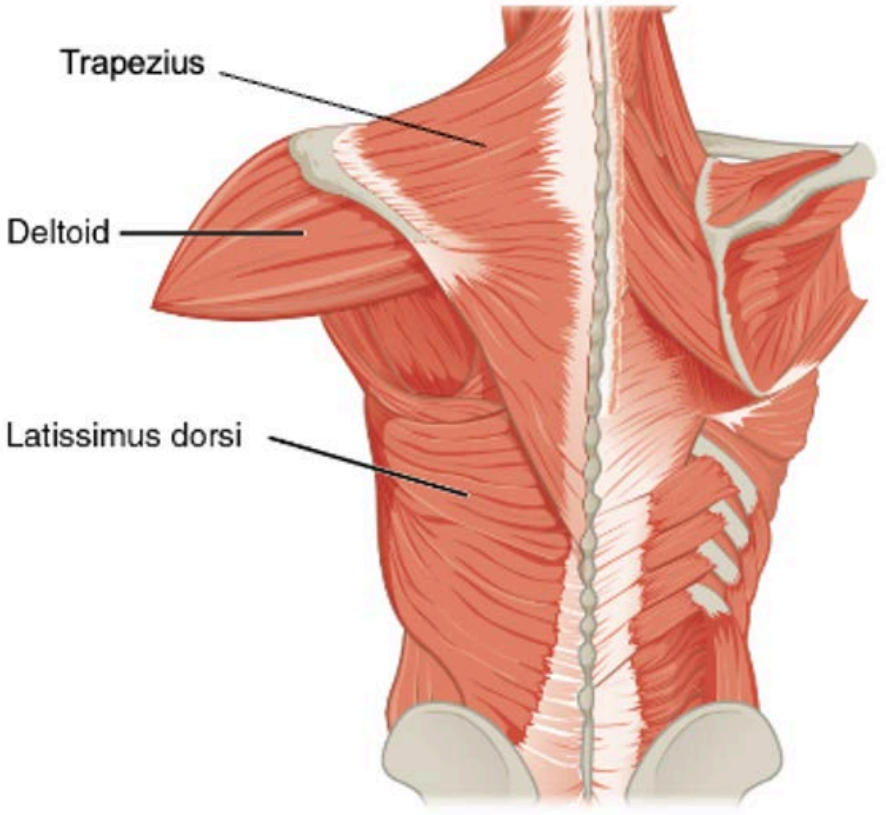


***Figure* 5.11.** *Muscles of the Back; Posterior View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (altered) and is used under a CC BY 4.0 license.*

Erector Spinae Muscles (Spinalis, Longissimus, Iliocostalis)

- **Origin(s):** Spinous processes of the thoracic vertebrae, sacrum, sacroiliac ligaments, and the iliac crest of the ilium.
- **Insertion(s):**
  - **Iliocostalis:** Angles of lower ribs and transverse processes of cervical spine
  - **Longissimus:** Transverse processes of thoracic and cervical spine, mastoid process
  - **Spinalis:** Spinous processes of thoracic and cervical spine
- **Action(s):** Extension of the spine
- **Innervation(s):** Dorsal rami of spinal nerves

- **How to Palpate**
  - **Position of Partner:** Prone, sitting, standing
  - **Directions:** Lateral to either side of the spine are the muscles that compose the erector spinae group. In individuals with more muscle mass, these muscles may appear as a hump on both sides of the spine that are running in a linear direction up and down the length of the spine. To engage these muscles and make them even more palpable, have your partner lie prone on a table. Have them extend their arms and legs straight out, then have them lift their legs and arms off the table a few inches.

Transversospinalis Muscles (Semispinalis, Multifidus, Rotatores)

- **Origin(s):** Transverse processes of vertebrae
- **Insertion(s):** Spinous processes of vertebrae
- **Action(s):** Extend and rotate the spine
- **Innervation(s):** Dorsal rami of spinal nerves
- **How to Palpate**
  - **Position of Partner:** Prone, sitting, standing
  - **Directions:** These muscles are found in a similar location to the erector spinae; however, they lie deeper and more medial to the erector spinae. To palpate the area of the muscles, feel immediately lateral to a spinous process on either side.

Splenius Capitis and Cervicis

- **Origin(s):**
  - **Capitis:** Nuchal ligament and spinous processes of the cervical vertebrae
  - **Cervicis:** Spinous processes of thoracic vertebrae
- **Insertion(s):**
  - **Capitis:** Occipital bone and mastoid process of the temporal bone
  - **Cervicis:** Transverse processes of cervical vertebrae
- **Action(s):** Extension, rotation, and lateral flexion of the head
- **Innervation(s):** Dorsal rami of spinal nerves

- **How to Palpate**
    - **Position of Partner:** Prone, sitting
    - **Directions:** First identify the fiber direction of these muscles. They run on the opposite diagonal of the upper trapezius. When starting at the more lateral and superior attachments, like the mastoid process and transverse processes of the cervical vertebrae, continue to palpate by moving inferiorly and medially toward the spinous processes of the cervical and thoracic vertebrae.

Suboccipitals (Rectus Capitis Posterior Major, Rectus Capitis Minor, Obliquus Capitis Superior, and Obliquus Capitis Inferior)

- **Location:** Inferior occipital bone to the first two cervical vertebrae
- **Action(s):** Ipsilateral rotation, ipsilateral flexion, and extension of the head
- **Innervation(s):** Suboccipital nerve
- **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** To palpate all the suboccipital muscles as a group, use the external occipital protuberance as a superior landmark. This protuberance is the large bump found on the occipital bone. Move inferiorly to this protuberance about 2–3 inches, while also moving laterally to capture all the muscles of this group.

Quadratus Lumborum

- **Origin(s):** Iliac crest
- **Insertion(s):** 12th rib and lumbar vertebrae
- **Action(s):** Lateral flexion of the spine
- **Innervation(s):** Ventral rami of spinal nerves
- **How to Palpate**
    - **Position of Partner:** Prone, sitting, side-lying
    - **Directions:** To palpate the quadratus lumborum, begin by appreciating the origin and insertion of the muscle from the iliac crest to the 12th rib and

lumbar vertebrae. Palpate along these landmarks, taking note that superficial back muscles overlay this muscle.

Rectus Abdominis

- **Origin(s):** Pubic bone
- **Insertion(s):** Ribs and xiphoid process of sternum
- **Action(s):** Flexion of the spine
- **Innervation(s):** Intercostal nerves (T6–T11) and subcostal nerve (T12)
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Palpate from one end of the muscle, either its origin or insertion, to the other end. Gauge your pressure along the way to ensure you're not palpating too deeply into the abdomen.

External Oblique

- **Origin(s):** Ribs
- **Insertion(s):** Xiphoid process, iliac crest, pubic bone, linea alba, inguinal ligament, and anterior superior iliac spine
- **Action(s):** Flexion of the spine and contralateral rotation of the spine
- **Innervation(s):** Intercostal nerves (T7–T11) and subcostal nerve (T12)
- **How to Palpate**
        - **Position of Partner:** Supine
        - **Directions:** Begin by identifying the fiber direction of the muscle that you will palpate along. With your partner in a supine position, palpate laterally to the rectus abdominis. The muscle fibers of the external oblique run from a superolateral to inferomedial direction along a diagonal.

Internal Oblique

- **Origin(s):** Inguinal ligament and iliac crest
- **Insertion(s):** Linea alba and pubic bone
- **Action(s):** Ipsilateral rotation of the spine
- **Innervation(s):** Intercostal nerves (T7–T11) and subcostal nerve (T12)
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Palpate this muscle in a similar manner to the external oblique. Begin by identifying the fiber direction of this muscle, which runs in the opposite direction of the external oblique. With your partner in a supine position, palpate laterally to the rectus abdominis. The muscle fibers of the internal oblique run from a superomedial to inferolateral direction along a diagonal.

Transverse Abdominis

- **Origin(s):** Iliac crest, inguinal ligament, thoracolumbar fascia
- **Insertion(s):** Xiphoid process of the sternum, linea alba, and pubic bone
- **Action(s):** Compression of the abdomen
- **Innervation(s):** Intercostal nerves (T6–T11) and subcostal nerve (T12)
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Because this is the deepest abdominal layer, it is very difficult to palpate this muscle. When attempting to do so, it's important to visualize the breadth of this muscle and work in the transverse direction along the direction of the fibers working between all of its attachment sites.

Diaphragm

- **Attachments:** Lumbar vertebrae, costal cartilages and ribs, and xiphoid process of the sternum

- **Action(s):** Increase intra-abdominal pressure
- **Innervation(s):** Phrenic nerve
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** This muscle runs circumferentially around the inside of the thorax; however, it is possible to palpate the edges of the muscle anteriorly where it meets the ribs. Begin your palpation by finding the edges of the costal margins, and then wrap your fingers under these margins while your partner relaxes their musculature as much as possible. Having your partner take a deep breath in will help you access this muscle while you're palpating the appropriate area.

Intercostals (External Intercostals, Internal Intercostals)

- **Attachments:** These muscles attach from one to the next rib
- **Action(s):** Elevation or depression of the ribs
- **Innervation(s):** Intercostal nerves
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Because these muscles run between the ribs, simply locate an intercostal space, and palpate the soft tissue area between the ribs. When palpating this area, you are palpating all three layers of the intercostals.

Serratus Posterior Superior

- **Origin(s):** Nuchal ligament and cervical vertebrae
- **Insertion(s):** Ribs (2–5)
- **Action(s):** Elevation of the ribs
- **Innervation(s):** Intercostal nerves
- **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** This muscle is located deep to the rhomboids and runs diagonally in this area. To palpate, begin at its origin and work toward the area of the scapula. At this point the muscle dives deep to the scapula to

insert on the ribs, so you will not be able to palpate it any further.

Serratus Posterior Inferior

- **Origin(s):** Thoracic and lumbar vertebrae
- **Insertion(s):** Ribs (9–12)
- **Action(s):** Depressions of the ribs
- **Innervation(s):** Anterior rami of thoracic spinal nerves
- **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** This muscle is located in the lumbar region. Begin by palpating immediately lateral to the lumbar and inferior thoracic vertebrae, and then move even more laterally while moving superiorly to the inferior ribs.

Other Anatomical Landmarks

Ligamentum Nuchae

- **How to Palpate**
    - **Position of Partner:** Prone or sitting
    - **Directions:** This ligament spans the external occipital protuberance to the spinous process of C7. It runs in a linear orientation from the tip of one spinous process to the next. To palpate the structure, begin by finding the external occipital protuberance. Then proceed to palpate inferiorly directly down the spinous processes, and gaps between them, of the cervical spine until you reach the large hump of the base of the neck that is created by the C7 spinous process.

Supraspinous Ligament

- **How to Palpate**
  - **Position of Partner:** Prone or sitting
  - **Directions:** This ligament is continuous with the ligamentum nuchae. It starts at the spinous process of C7 and extends inferiorly down the spine to the sacrum. Begin at the spinous process of C7 and continue to palpate inferiorly along the spinous processes of the spine until the sacrum is reached.

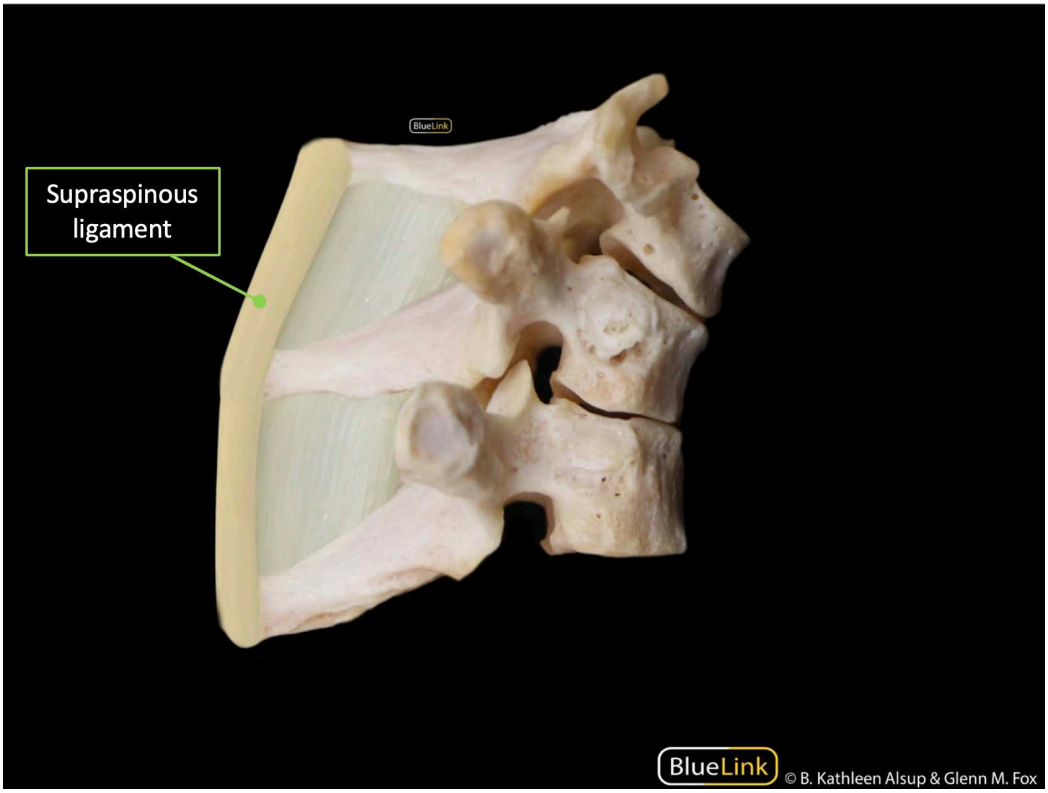


Figure 5.12. *Supraspinous ligament; Sagittal View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Thoracolumbar Fascia

- **How to Palpate**

- **Position of Partner:** Prone, sitting
- **Directions:** This fascia is expansive throughout the thoracic and lumbar regions of the spine and serves as an attachment point for many structures. Before beginning to palpate, view Figure 5.13 to observe this structure's diamond shape. Then, with your partner in a prone position, visualize this large diamond on their lower back. To palpate the structure, slowly work your way throughout the entirety of this diamond region.

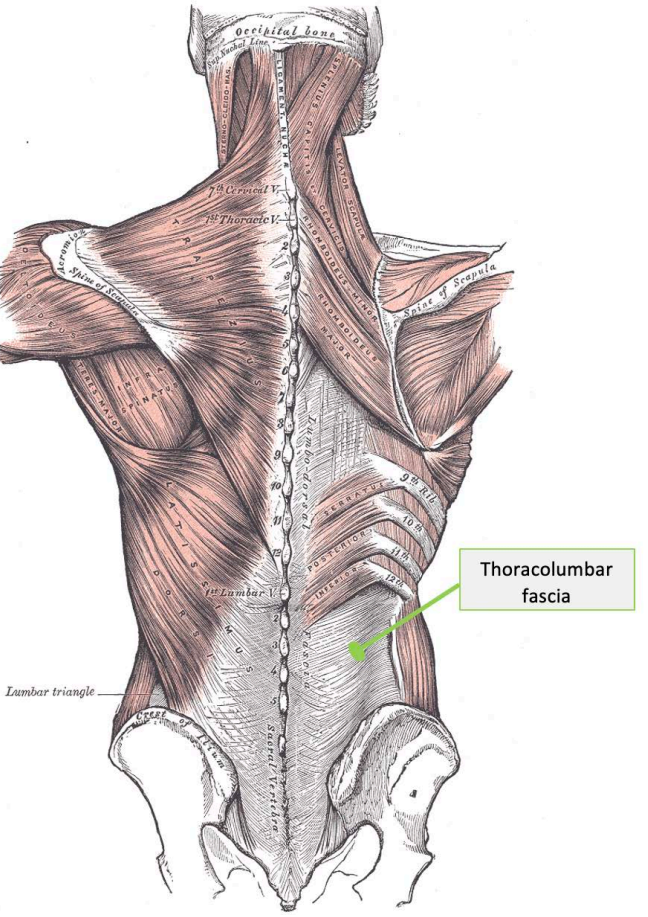
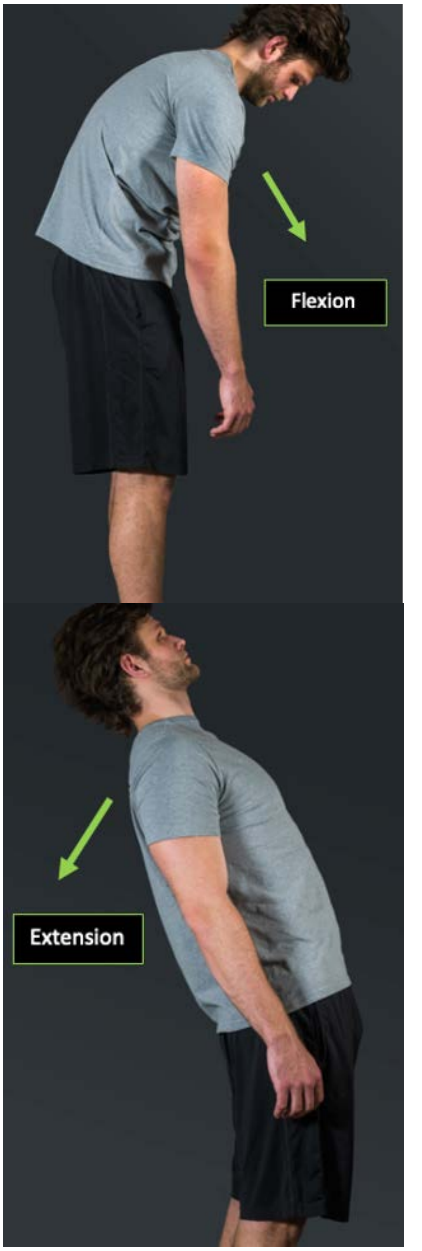
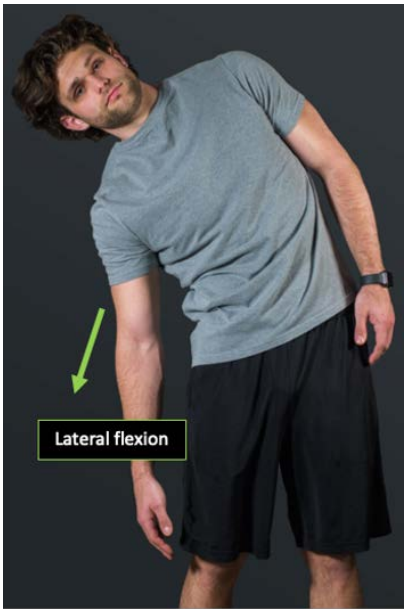


***Figure* 5.13.** *Thoracolumbar Fascia by Henry Vandyke Carter and Henry Gray has been modified (altered) and is in the public domain.*

Range of Motion

Table 5.1 Range of Motion for the Spine, Thorax & Abdomen

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Flexion and Extension of the Spine	For active ranges of flexion and extension of the spine, always make sure you have set up a safe environment for your partner to perform these motions in. If they are standing, make sure they have a table, object, or yourself to assist with their balance.	

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Lateral Flexion of the Spine	When assessing these ranges, it's important to ensure the person is moving within the frontal plane to prevent other movements from occurring.	
Rotation of the Spine	Each region of the spine (i.e., cervical, thoracic, and lumbar) has different ranges when it comes to rotation. It may be appropriate to address the rotation of each region separately, or to assess the ability of the spine to rotate as a whole.	

Figures 5.14-5.17 by Dan Silver are used under a CC BY 4.0 license.

Clinical Correlations

Herniated Disc

- **Background:** The term *hernia* describes a structure displaced from its original position. A herniated disc refers to an intervertebral disc that has shifted out of its place between two vertebral bodies. When this structure moves out of place, it can potentially push into a nerve nearby, causing irritation of the nerve and related symptoms elsewhere in the body.

Figure 5.18. *Disc Herniation by Mjorter is in the public domain.*

Diastasis Recti

- **Background:** The separation or tearing of the rectus abdominis muscle is called diastasis recti. This commonly occurs with pregnancy as the growing abdomen stretches abdominal muscles to their limit and beyond. With targeted exercises and physical therapy, this issue can be reduced conservatively; however, surgery may sometimes be warranted.

Review Questions: Skeletal Landmarks of the Spine, Thorax, and Abdomen

1. How many vertebrae can be found in the cervical, thoracic, and lumbar regions respectively?
2. The transverse process points out laterally in the (frontal / sagittal / transverse) plane.
3. The spinous process can be found on the (anterior / posterior) side of a vertebrae.
4. The most inferior portion of the sternum is the _____.
5. There are _____ pairs of ribs within the body.
6. The last rib is lateral to which vertebrae?
7. How many ribs directly attach to the sternum, and are therefore named true ribs?
8. The foramen, formed by the stacking of one vertebra on top of another, which can be seen in a sagittal view is the _____ foramen.
9. The superior articulating processes of one vertebra communicate with the _____ _____ of the next superior vertebra.
10. The inferior angle is lateral to which vertebrae?

Review Questions: Musculature of the Spine, Thorax, and Abdomen

1. The most lateral muscle of the erector spinae group is the _____.
2. The serratus posterior superior acts to _____ the ribs, while the serratus posterior inferior acts to _____ them.
3. The internal oblique is (superficial / deep) to the transverse abdominis.
4. The supraspinous ligament begins at which vertebrae?
5. Which muscle attaches to the mastoid process of the temporal bone and acts to move the head?
6. The quadratus lumborum originates on the (pubic bone / iliac crest / sacrum).
7. What are the three muscles that compose the transversospinalis group?
8. The external oblique helps with _____rotation, while the internal oblique helps with _____.
9. The phrenic nerve innervates which muscle of the abdomen?
10. Name the muscles that run from one rib to the next and help with respiration.

6. The Hip and Thigh

Skeletal Landmarks with Palpation Instructions

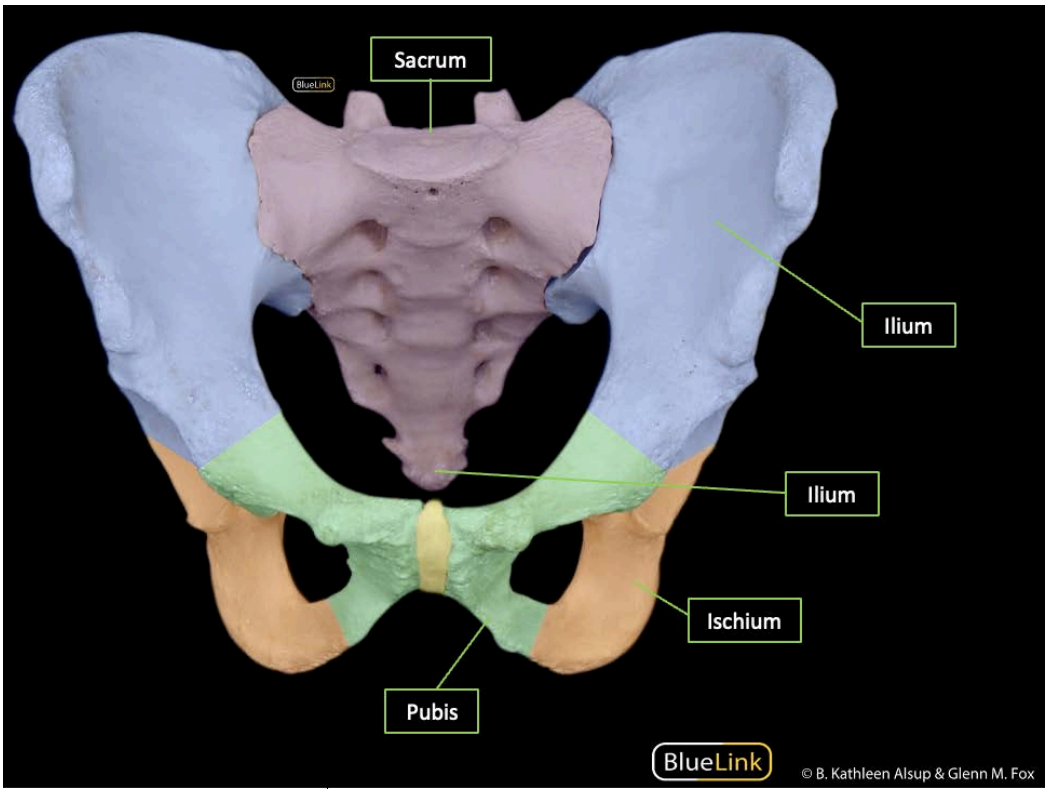


Figure 6.1. *Bones of the Hip Girdle by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

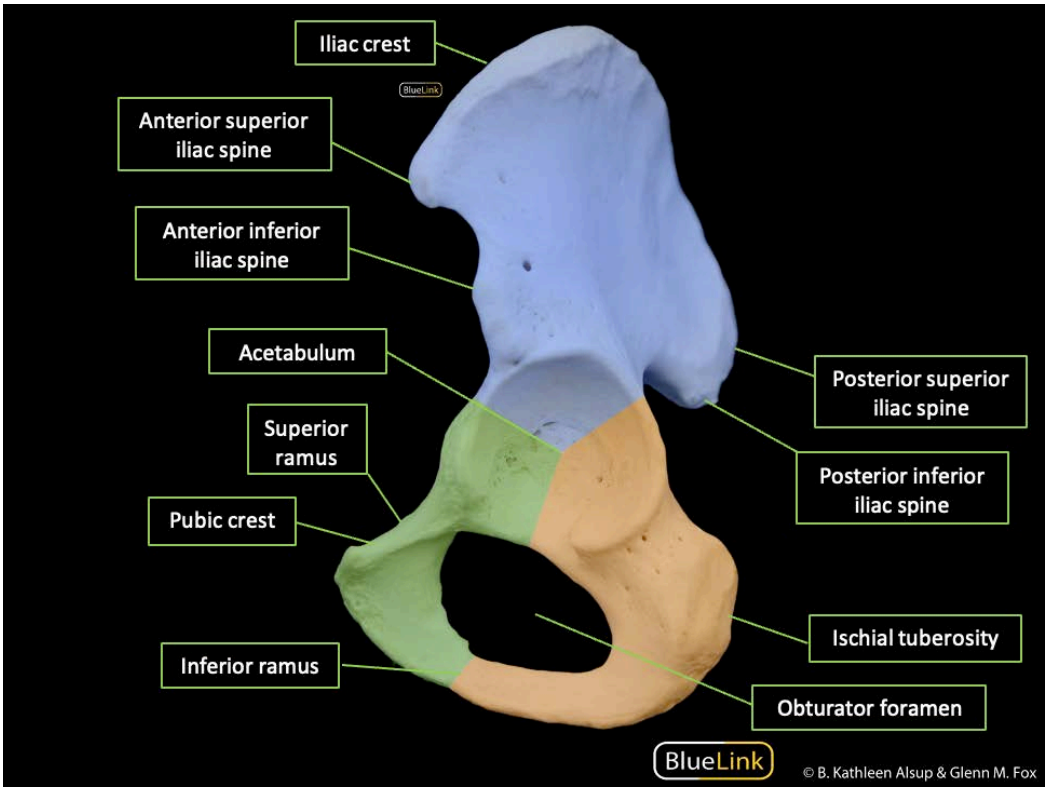


Figure 6.2. *Skeletal Landmarks of the Os Coxae; Lateral View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

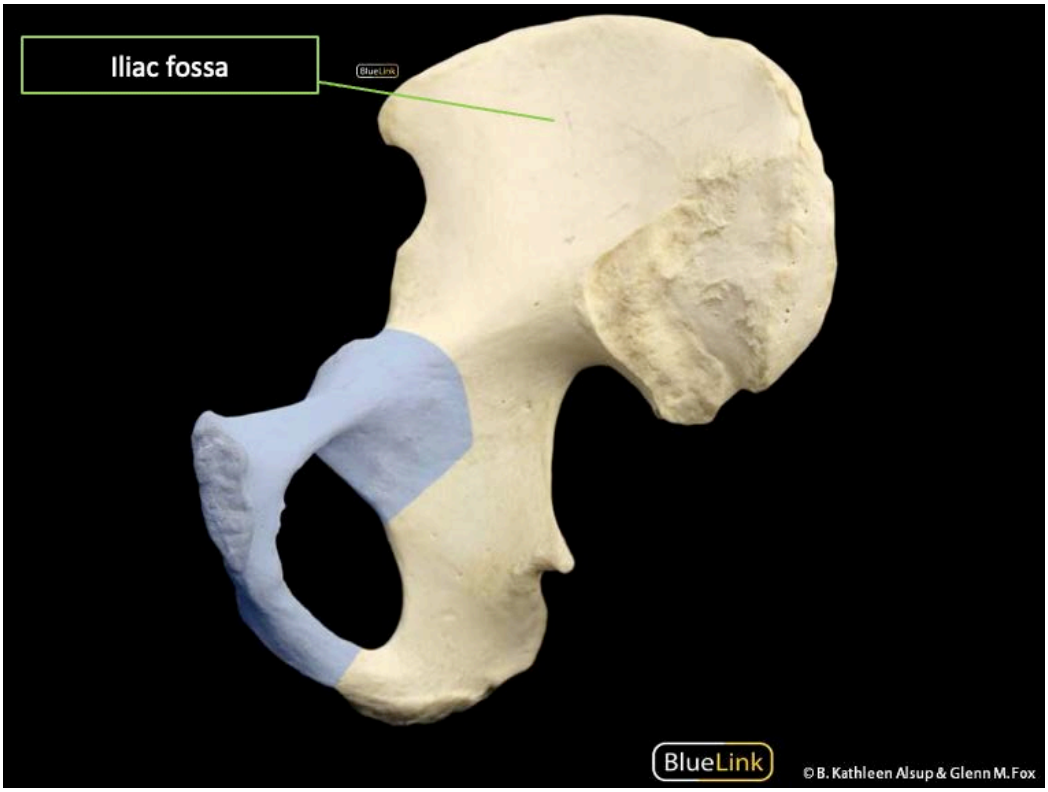


Figure 6.3. *Medial View of the Os Coxae by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

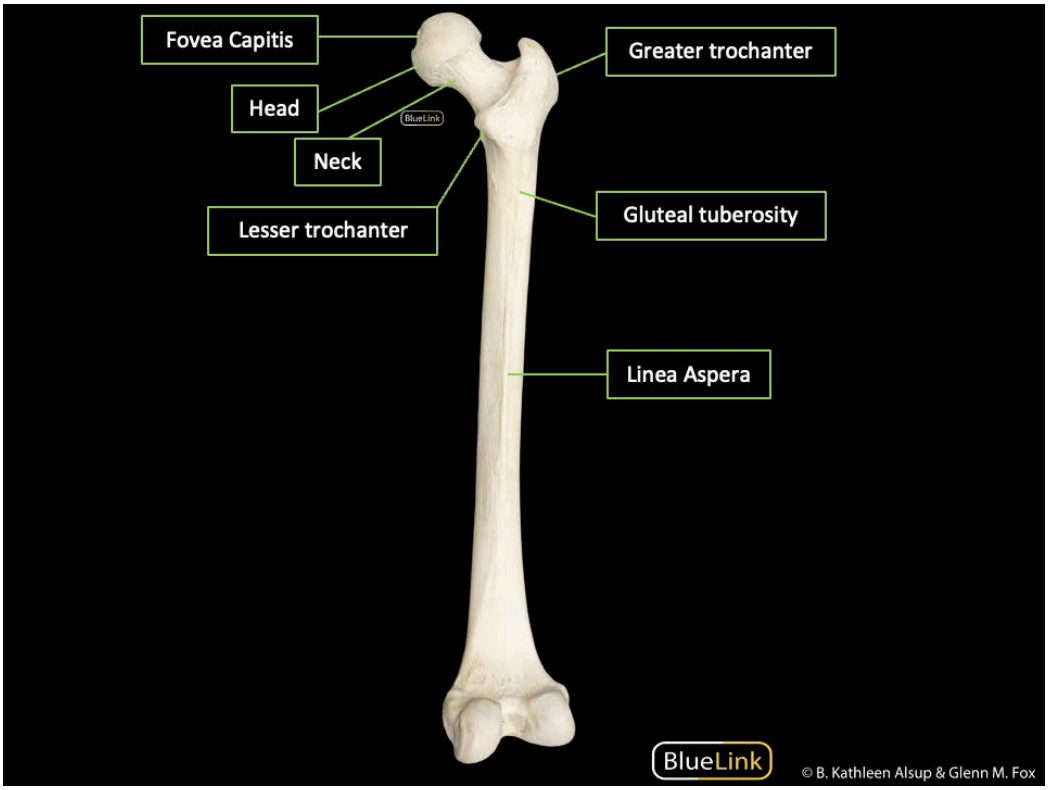


Figure 6.4. *Skeletal Landmarks of the Proximal Femur; Posterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Sacrum

- **How to Palpate**
  - **Position of Partner:** Prone
  - **Directions:** With your partner in a prone position, orient yourself to the triangular boundaries of the sacrum. Palpate the midline of the sacrum, which will bisect this triangle, as well as the articulations of the sacroiliac joints. The examiner may also follow the spinous processes of the lumbar spine inferiorly, whereby palpating inferior to the spinous process of L5 will give rise to the posterosuperior aspect of the sacrum.
- **Muscles That Attach Here:** The sacrum serves as the proximal or distal attachment for numerous muscles and ligaments in the lumbopelvic region. Refer to the corresponding content on the hip and spine for further details about structures that attach to this location.

- **Structures That Attach Here:** Sacroiliac ligaments, sacrotuberous ligament, sacrospinous ligaments

Coccyx

- **How to Palpate**
  - **Position of Partner:** Prone
  - **Directions:** With your partner in a prone position, palpate inferiorly along the medial sacral crest toward the superior gluteal cleft. Palpate the superior aspect of the coccyx and the lateral and inferior aspects of the coccyx as much as you are able.
- **Muscles That Attach Here:** Ischiococcygeus, levator ani muscles, gluteus maximus
- **Structures That Attach Here:** Sacrospinous ligament, sacrotuberous ligament, sacrococcygeal ligament

Ilium

- **Iliac Crest**
  - **How to Palpate**
    - **Position of Partner:** Standing, side-lying, supine
    - **Directions:** The iliac crest may be appreciated along three different pathways: 1) palpate the anterior superior iliac spine and slide posteriorly along the crest, 2) palpate the posterior superior iliac spine and slide anteriorly along the crest, and 3) locate the mid-axillary line of the body, and, at this line, move inferiorly from the ribs, or move superiorly from the greater trochanter, to meet the apex of the iliac crest.
  - **Muscles That Attach Here:** Iliacus, quadratus lumborum, external oblique, and tensor fascia latae

- **Iliac Fossa**
  - **How to Palpate**
    - **Position of Partner:** Supine, hook-lying
    - **Directions:** Locate the anterior superior iliac spine and palpate superiorly and posteriorly along the inner rim of the iliac crest. The depth of your palpation will depend on the pliability of tissue in the area and your partner's tolerance of the palpation.
  - **Muscles That Attach Here:** Iliacus

- **Anterior Superior Iliac Spine**
  - **How to Palpate**
    - **Position of Partner:** Supine, standing
    - **Directions:** Place your hand at the lateral aspect of the abdomen at the mid-axillary line, below the umbilicus. From here, find and follow the iliac crest anteriorly until the anterior superior iliac spine is appreciated. This will be the most prominent skeletal landmark on the anterior hip.
  - **Muscles That Attach Here:** Sartorius, tensor fascia latae
  - **Structures That Attach Here:** Inguinal ligament

- **Anterior Inferior Iliac Spine**
  - **How to Palpate**
    - **Position of Partner:** Supine, standing
    - **Directions:** Begin by locating the anterior superior iliac spine. Next, palpate inferiorly and slightly medially to the anterior inferior iliac spine.
  - **Muscles That Attach Here:** Rectus femoris, iliacus

- **Posterior Superior Iliac Spine**
  - **How to Palpate**
    - **Position of Partner:** Prone, standing
    - **Directions:** Place your hands at the mid-axillary line on the superior aspect of the iliac crest. Follow the iliac crest posteriorly toward the sacrum. Palpate the bony spine of the posterior superior iliac spine at the end of the iliac crest.
  - **Muscles That Attach Here:** Lumbar multifidus

Ischium

- **Ischial Tuberosity**
  - **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Identify the gluteal fold, or sulcus, between the buttocks. Palpate medially and superiorly from the midpoint of the gluteal fold until the ischial tuberosity is appreciated. You could also approach this structure by moving inferomedially from lateral hip structures, such as the greater trochanter, to palpate this landmark. Although a great deal of musculature and soft tissue may cover this skeletal landmark, it will still be prominent.
  - **Muscles That Attach Here:** Semitendinosus, semimembranosus, long head of biceps femoris, inferior gemellus, and quadratus femoris
  - **Structures That Attach Here:** Sacrotuberous ligament

Pubis

- **Pubic Crest**
  - **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Palpate at the navel and move inferiorly along the midline of the abdomen until you palpate the bony ridge of the pubic crest. This will be the first skeletal landmark you feel when moving in this direction.
  - **Muscles That Attach Here:** Rectus abdominis, external oblique
  - **Structures Located Near this Landmark:** The inguinal ligament inserts next to the pubic crest at the pubic tubercle.

- **Superior Ramus**
  - **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** First, locate the pubic crest. Palpate laterally from the pubic crest along the anterior aspect of the ilium toward the anterior

inferior iliac crest. Appreciate the superior ramus, which is located along the bony ridge lateral to the pubic crest.

- **Muscles That Attach Here:** Pectineus

Femur

- **Greater Trochanter**
  - **How to Palpate**
    - **Position of Partner:** Standing, supine, side-lying, prone
    - **Directions:** Locate the midpoint of the iliac crest along the lateral side of the body. Palpate inferiorly from this point toward the lateral aspect of the hip complex until the bony ridge of the greater trochanter can be felt. To confirm you are at the correct location, have your partner internally and externally rotate their hip while you continue to feel this area. With this motion you should be able to feel the bony ridge rolling underneath your fingers.
  - **Muscles That Attach Here:** Gluteus medius, gluteus minimus, piriformis, obturator internus, superior gemellus, inferior gemellus, and vastus lateralis

- **Gluteal Tuberosity**
  - **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Orient yourself to the posterior aspect of the greater trochanter and palpate inferiorly along the lateral aspect of the femur until the tapering of the gluteus maximus muscle is felt. At the insertion of this muscle is the gluteal tuberosity on the femur.
  - **Muscles That Attach Here:** Gluteus maximus and adductor portion of adductor magnus

Musculature with Palpation Instructions

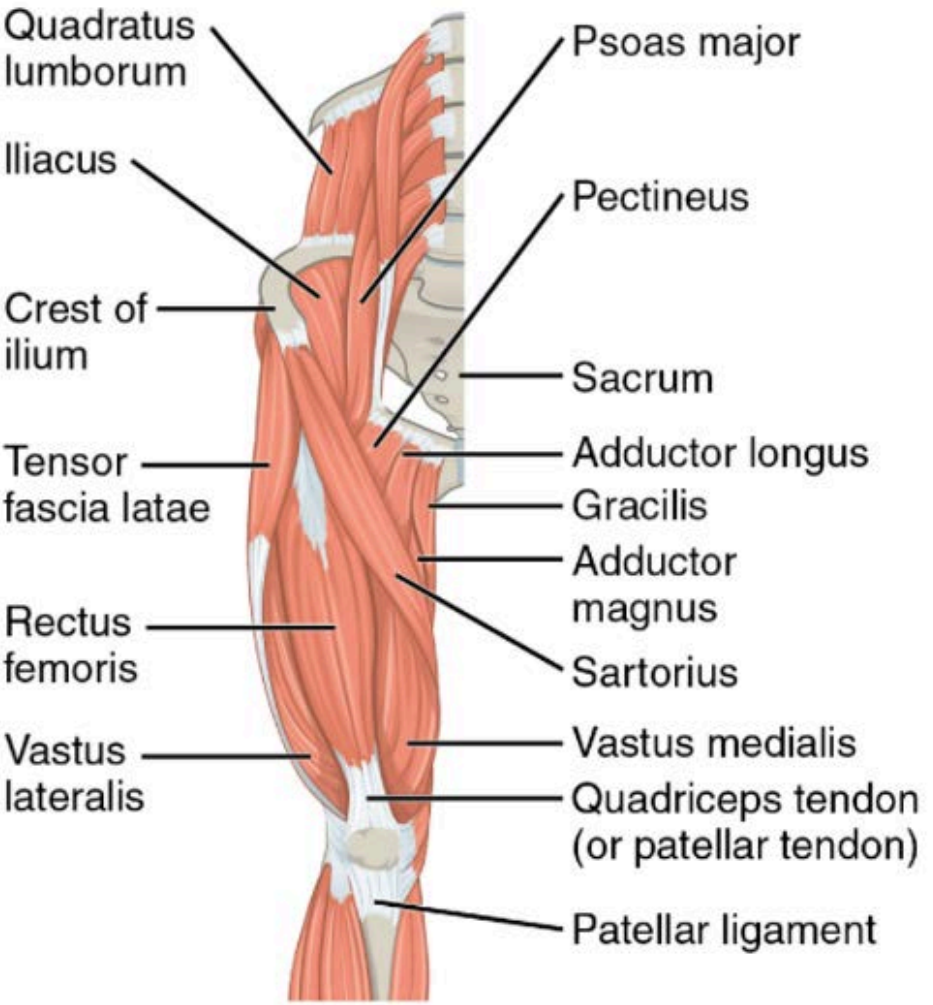


Figure 6.5. *Muscles of the Anterior Hip and Thigh; Anterior View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 License.*

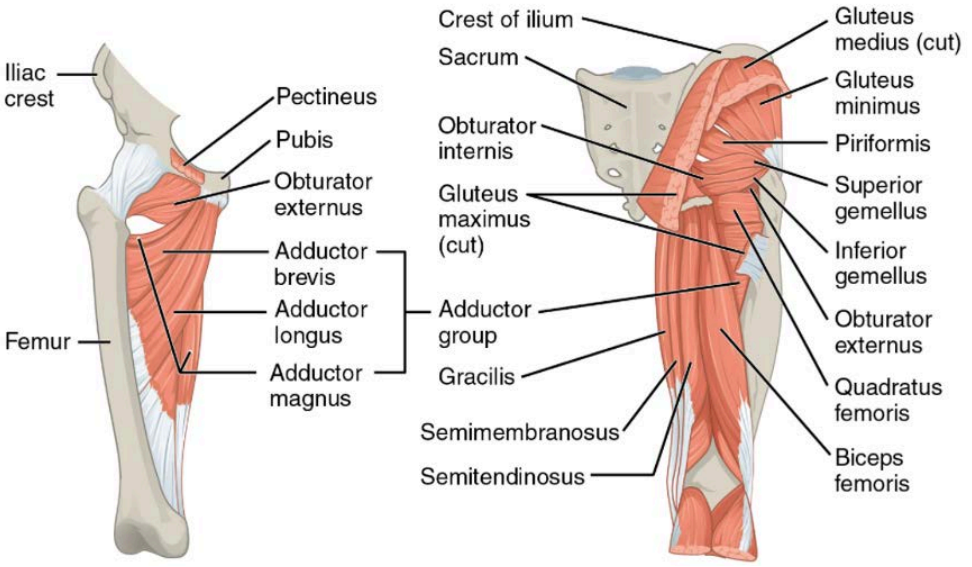


Figure 6.6. *Deep Muscles of the Hip and Thigh; Anterior View and Musculature of the Posterior Hip and Thigh by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 License.*

Quadriceps

- **Rectus Femoris**
  - **Origin(s):** Anterior inferior iliac spine, ilium superior to acetabulum
  - **Insertion(s):** Base of patella via quadriceps tendon, indirectly via patellar ligament to the tibial tuberosity
  - **Action(s):** Knee extension, hip flexion
  - **Innervation(s):** Femoral nerve
  - **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** Palpate along an imaginary line between the origin and insertion of the muscle. Appreciate the fibers of the muscle belly along this line. You may ask your partner to extend their knee or flex their hip to accentuate the muscle and its borders through this muscle contraction.
- **Vastus Lateralis**

- **Origin(s):** Greater trochanter, linea aspera
- **Insertion(s):** Base of patella via quadriceps tendon, indirectly via patellar ligament to tibial tuberosity
- **Action(s):** Knee extension
- **Innervation(s):** Femoral nerve
- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Palpate superolaterally from the base of the patella into the muscle belly of the vastus lateralis. Instruct your partner to extend their knee to appreciate the muscle contraction and border of the vastus lateralis. You can also orient to this muscle on the lateral aspect of the thigh using the iliotibial tract/band. The vastus lateralis muscle will pass deep to this structure as it travels laterally.

- **Vastus Medialis**
  - **Origin(s):** Intertrochanteric line, linea aspera
  - **Insertion(s):** Base of patella via quadriceps tendon; indirectly via patellar ligament to tibial tuberosity
  - **Action(s):** Knee extension
  - **Innervation(s):** Femoral nerve
  - **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** Palpate superomedially from the base of the patella into the muscle belly of the vastus medialis. Instruct your partner to extend their knee to appreciate the muscle contraction and the border of the vastus medialis.

Gluteals

- **Gluteus Maximus**
  - **Origin(s):** Ilium posterior to posterior gluteal line, sacrum, coccyx, sacrotuberous ligament
  - **Insertion(s):** Iliotibial tract, gluteal tuberosity
  - **Action(s):** Hip extension and lateral rotation
  - **Innervation(s):** Inferior gluteal nerve
  - **How to Palpate**

        - **Position of Partner:** Prone
        - **Directions:** Locate the borders of the gluteus maximus via its proximal attachments, along the gluteal fold inferiorly, and to its distal attachments along the posterior iliotibial tract and gluteal tuberosity. Palpate superiorly from these borders to appreciate this muscle. Your partner may perform active hip extension, or a gluteal squeeze, to help you identify this muscle.
- **Gluteus Medius**
    - **Origin(s):** External surface of the ilium between anterior and posterior gluteal lines
    - **Insertion(s):** Lateral surface of the greater trochanter
    - **Action(s):** Hip abduction, medial rotation
    - **Innervation(s):** Superior gluteal nerve
    - **How to Palpate**
        - **Position of Partner:** Side-lying
        - **Directions:** Palpate the greater trochanter along the lateral aspect of the hip and move superiorly toward the iliac crest to appreciate the anterior and posterior fibers of the gluteus medius along the outer aspect of the ilium. Your partner can perform active hip abduction to help you better appreciate this muscle.
- **Gluteus Minimus**
    - **Origin(s):** External surface of the ilium between the anterior and inferior gluteal lines
    - **Insertion(s):** Anterior surface of the greater trochanter
    - **Action(s):** Hip abduction, medial rotation
    - **Innervation(s):** Superior gluteal nerve
    - **How to Palpate**
        - **Position of Partner:** Side-lying
        - **Directions:** Like the gluteus medius, palpate the greater trochanter, and gradually move superiorly along the anterior portion of the ilium on the lateral hip. Note that the gluteus minimus is located deep to the gluteus medius and has a similar location and orientation.

Sartorius

- **Origin(s):** Anterior superior iliac spine
- **Insertion(s):** Pes anserine
- **Action(s):** Hip flexion, abduction, and lateral rotation and flexion of the knee
- **Innervation(s):** Femoral nerve
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Begin at the proximal attachment at the ASIS and palpate inferomedially along a diagonal to the medial aspect of the thigh toward the pes anserine. The pes anserine is located on the proximal tibia along the medial side. Instruct your partner to complete hip flexion, abduction, and lateral rotation, as if crossing their leg into a figure four position, to better palpate this muscle. In this position you may be able to distinctly feel the proximal end of the muscle as it contracts.

Adductor Longus

- **Origin(s):** Body of pubis inferior to pubic crest
- **Insertion(s):** Middle third of the linea aspera
- **Action(s):** Hip adduction
- **Innervation(s):** Obturator nerve
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Broadly palpate the medial thigh and ask your partner to adduct their hip. As they actively perform this motion, preferably against resistance applied by the examiner's opposite hand, palpate toward the pubic bone. Among the muscles of the medial compartment, palpate along the proximal attachment toward the distal attachment, appreciating the muscle belly of the adductor longus as it angles toward the linea aspera.

Adductor Magnus

- **Origin(s):**
  - **Adductor Portion:** Inferior ramus of pubis and ramus of the ischium
  - **Hamstring Portion:** Ischial tuberosity
- **Insertion(s):**
  - **Adductor Portion:** Gluteal tuberosity, linea aspera, medial supracondylar line
  - **Hamstring Portion:** Adductor tubercle of the femur
- **Action(s):**
  - **Adductor Portion:** Hip adduction, hip flexion
  - **Hamstring Portion:** Hip extension
- **Innervation(s):**
  - **Adductor Portion:** Obturator nerve
  - **Hamstring Portion:** Tibial nerve
- **How to Palpate**
  - **Position of Partner:** Supine, side-lying
  - **Directions:** Begin by palpating at the adductor tubercle of the femur, and instruct your partner to adduct the hip against either manual resistance or gravity. Palpate the muscle fibers of the magnus by moving proximally, being mindful of bordering muscles of the medial thigh.

Gracilis

- **Origin(s):** Body and inferior ramus of pubis
- **Insertion(s):** Pes anserine
- **Action(s):** Hip adduction, medial rotation, knee flexion
- **Innervation(s):** Obturator nerve
- **How to Palpate**
  - **Position of Partner:** Supine
  - **Directions:** Broadly palpate the medial thigh and ask your partner to adduct their hip. As they actively perform this motion, preferably against resistance applied by the examiner's opposite hand, palpate along the proximal attachment, moving in a straight line distally toward its insertion

at the pes anserine.

Pectineus

- **Origin(s):** Superior ramus of pubis
- **Insertion(s):** Pectineal line of femur
- **Action(s):** Hip adduction, flexion, medial rotation
- **Innervation(s):** Femoral nerve (potential for obturator nerve)
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Place your partner's leg of focus in a position of hip flexion and lateral rotation. You may orient to the region by identifying the adductor longus as described above. Slide superolaterally toward the anterior superior iliac spine and palpate deep to the pectineus. You may appreciate the muscle contraction of this muscle by instructing your partner to adduct their hip.

Tensor Fascia Latae

- **Origin(s):** Anterior superior iliac spine, iliac crest
- **Insertion(s):** Iliotibial band to the lateral condyle of the proximal tibia (Gerdy's tubercle)
- **Action(s):** Hip abduction, medial rotation
- **Innervation(s):** Superior gluteal nerve
- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Palpate the anterior superior iliac spine and transition your hand toward the muscle belly by moving posteriorly and slightly distal to the anterior superior iliac spine. Instruct your partner to medially rotate or abduct the hip to appreciate the muscle belly.

Piriformis

- **Origin(s):** Anterior sacrum, superior margin of greater sciatic notch, sacrotuberous ligament
- **Insertion(s):** Superior aspect of greater trochanter
- **Action(s):** Hip lateral rotation in positions of hip extension, hip abduction in positions of hip flexion
- **Innervation(s):** Anterior rami of sacral nerves
- **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Begin by locating the muscle's distal attachment and palpating toward the proximal attachment by pressing deep into the gluteus maximus. Your partner may be cued to perform lateral rotation of their hip, with their knee flexed to 90 degrees, in order for you to better appreciate the muscle belly.

Deep Lateral/External Rotators

- **Obturator Internus**
    - **Origin(s):** Obturator membrane
    - **Insertion(s):** Greater trochanter
    - **Action(s):** External rotation of extended hip, abduction of flexed hip
    - **Innervation(s):** Nerve to obturator internus
- **Superior and Inferior Gemelli**
    - **Origin(s):** Superior: Ischial spine; Inferior: Ischial tuberosity
    - **Insertion(s):** Superior and Inferior: Greater trochanter
    - **Action(s):** External rotation of extended hip, abduction of flexed hip
    - **Innervation(s):** Superior: Nerve to obturator internus; Inferior: Nerve to quadratus femoris
- **Quadratus Femoris**
    - **Origin(s):** Ischial tuberosity
    - **Insertion(s):** Intertrochanteric crest
    - **Action(s):** External rotation of extended hip, abduction of flexed hip
    - **Innervation(s):** Nerve to quadratus femoris
- **How to Palpate**

- **Position of Partner:** Prone, side-lying
- **Directions:** The deep lateral rotators of the hip, including the piriformis, obturator internus, superior and inferior gemelli, and quadratus femoris, lie deep to the gluteal muscle groups in the posterolateral hip. Truly palpating these muscles is difficult due to the overlay of more dense, superficial gluteal musculature. Palpation of these structures is best performed with your partner in prone or side-lying position and following grossly from the insertion on the greater trochanter back toward each muscle's origin.

Iliacus

- **Origin(s):** Iliac crest, iliac fossa, ala of sacrum, anterior sacroiliac ligaments
- **Insertion(s):** Tendon of psoas major and less trochanter of femur
- **Action(s):** Hip flexion
- **Innervation(s):** Femoral nerve
- **How to Palpate**
  - **Position of Partner:** Hook-lying
  - **Directions:** Locate the anterior superior iliac spine and palpate superiorly and posteriorly along the inner rim of the iliac crest. The muscle belly will line the space previously palpated when locating the skeletal landmark of the iliac fossa.

Psoas Major

- **Origin(s):** Lateral aspects of vertebral bodies of T12–L5, transverse process of T12–L5 vertebrae, lateral aspect of intervertebral discs
- **Insertion(s):** Lesser trochanter
- **Action(s):** Hip flexion
- **Innervation(s):** Anterior rami of lumbar nerves
- **How to Palpate**
  - **Position of Partner:** Hook-lying
  - **Directions:** Identify your partner's navel and move approximately 2–3 fingerbreadths inferolaterally. Palpate deeply from anterior to posterior on the abdominal wall toward the muscle. Instruct your partner to perform

ipsilateral active hip flexion, or perform hip flexion against resistance, to appreciate the contraction of the psoas major. The examiner must acknowledge that the specificity of this technique can be challenged given the distance between the anterior abdominal wall and the muscle and that you may be palpating over abdominal contents. Intra-abdominal pressure may also affect the success of this palpation.

Hamstrings

- **Biceps Femoris**
  - **Origin(s):**
    - **Long Head:** Ischial tuberosity
    - **Short Head:** Linea aspera
  - **Insertion(s):** Head of fibula
  - **Action(s):** Knee flexion, hip extension
  - **Innervation(s):**
    - **Long Head:** Tibial nerve
    - **Short Head:** Common fibular nerve
  - **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** First, palpate the superficial tendon of the biceps femoris from the head of the fibula. Have your partner flex their knee to make this tendon more pronounced. Of all the tendons of the posterior knee, this will be the most lateral tendon. Next, move superiorly toward the muscle belly on the lateral aspect of the posterior thigh to complete your palpation.
- **Semitendinosus**
  - **Origin(s):** Ischial tuberosity
  - **Insertion(s):** Pes anserine
  - **Action(s):** Knee flexion, hip extension
  - **Innervation(s):** Tibial nerve
  - **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Palpate the superficial tendon of the muscle along the medial aspect of the knee. To note, the tendon of this muscle can also

be distinctly palpated along the posterior knee. Although the gracilis muscle has the most medial tendon along the posterior knee, the semitendinosus tendon can be palpated next door, laterally, to the gracilis. Once you have located the tendon of the semitendinosus, follow the muscle proximally toward its origin by palpating the medial side of the posterior thigh.

- **Semimembranosus**
  - **Origin(s):** Ischial tuberosity
  - **Insertion(s):** Posterior portion of medial condyle of tibia
  - **Action(s):** Knee flexion, hip extension
  - **Innervation(s):** Tibial nerve
  - **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Orient to the medial aspect of the knee via the semitendinosus. Attempt to palpate deep to the anterior and posterior aspects of the tendon of the semitendinosus to the semimembranosus. To note, the distal tendon of the semimembranosus is not distinctly palpable like the distal tendon of the semitendinosus. The muscle belly and tendon of the semimembranosus lie deep to the semitendinosus, which limits the specificity for palpation of this tissue alone.

Other Anatomical Landmarks

Insertion of Rectus Abdominis/Pubic Crest

- **How to Palpate**
  - **Position of Partner:** Supine
  - **Directions:** Locate the distal attachment of this muscle by palpating the pubic crest. Slide just superiorly to this bony landmark to appreciate the tendon of the rectus abdominis inserting here.

Inguinal Ligament

- **How to Palpate**
  - **Position of Partner:** Supine
  - **Directions:** Locate the proximal and distal attachments for the inguinal ligaments, which are the anterior superior iliac spine and the pubic tubercle, respectively. Begin by palpating this thin ligament at the anterior superior iliac spine and move inferomedially toward its distal attachment.

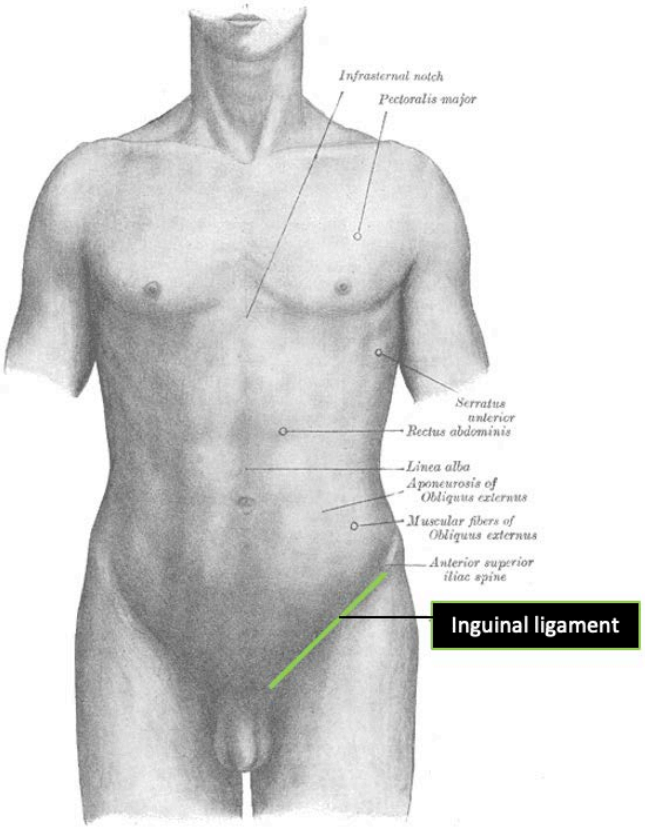


Figure 6.7. *Inguinal Ligament by Henry Vandyke Carter and Henry Gray has been modified (altered) and is in the public domain.*

Iliotibial Band

- **How to Palpate**
  - **Position of Partner:** Side-lying
  - **Directions:** Locate the distal attachment at the lateral condyle of the proximal tibia (Gerdy's tubercle), which is located on the proximal lateral aspect of the tibia. Then, palpate superiorly along the iliotibial band tissue at the level of the lateral femoral condyle. Along the distal aspect of the lateral thigh, the iliotibial band can be appreciated. Make sure to differentiate between the vastus lateralis tissue and biceps femoris tendon when palpating this structure.

Femoral Artery

- **How to Palpate:** Palpate medially to the sartorius at its proximal end to feel the pulsing of the femoral artery. Located in this same area are the femoral vein and nerve.

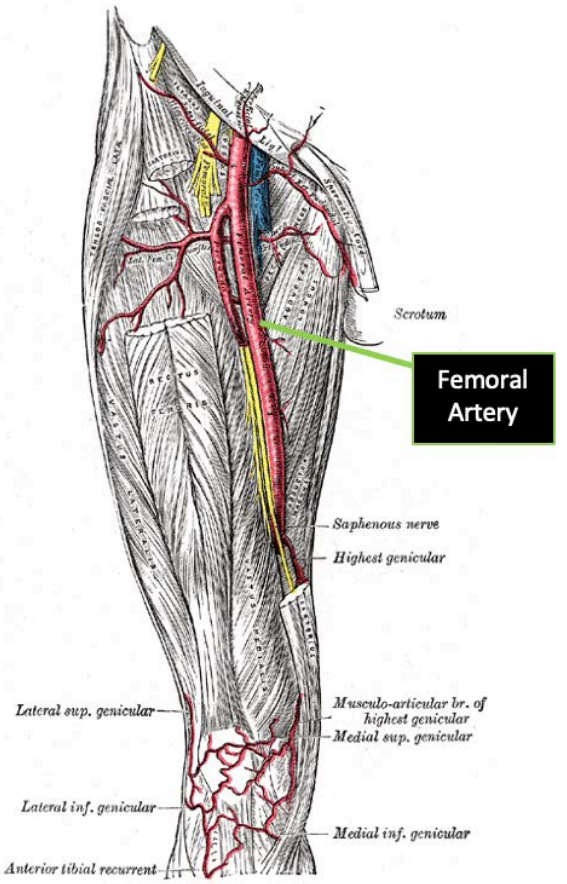
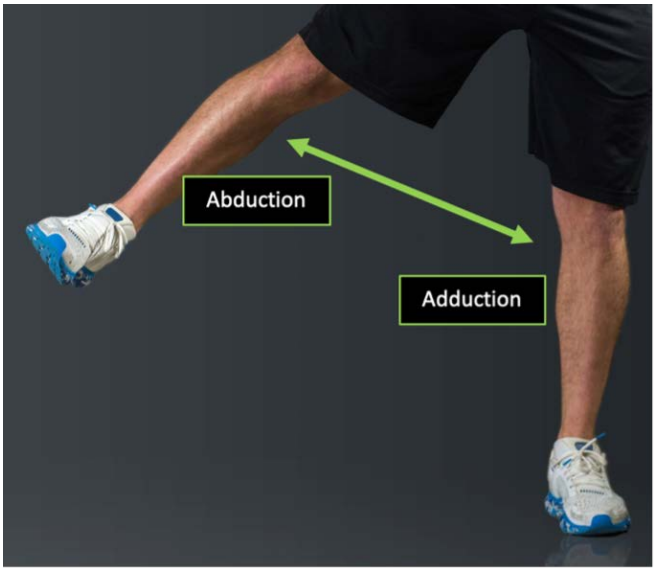
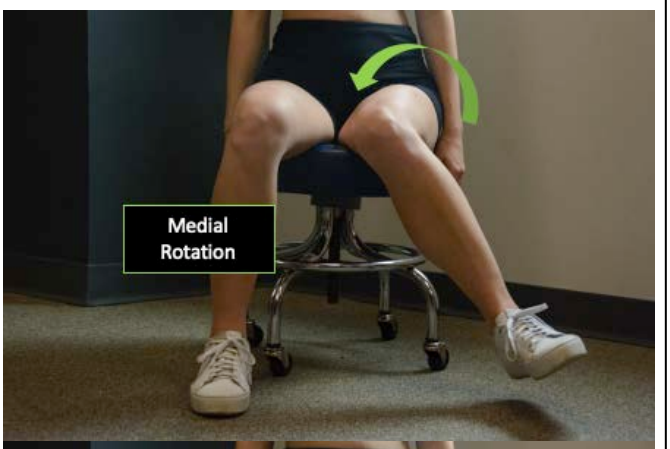
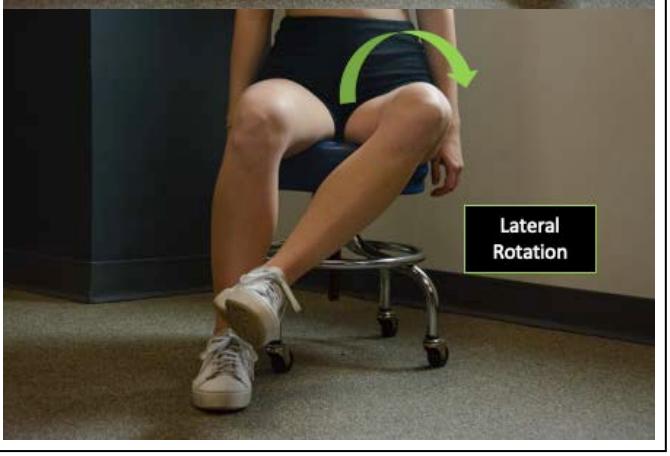


Figure 6.8. *Femoral Artery by Henry Vandyke Carter and Henry Gray has been modified (altered) and is in the public domain.*

Range of Motion

Table 6.1 Range of Motion of the Hip & Thigh

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Hip Flexion and Extension	When assessing flexion of the hip, the knee should be flexed in order to avoid any restrictions caused by tight hamstrings.	

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Hip Abduction and Adduction	When setting up your partner to assess all ranges of the hip, it's important to think about what position may be best to yield the greatest range. For abduction and adduction, the side-lying position will be most helpful.	
Hip Internal (Medial) and External (Lateral) Rotation	These ranges can be assessed by placing the lower limb in several different positions. You can have your partner lie in a supine position and then flex their hip to about 90 degrees, or they can be seated off the end of the table, where you can examine the range the lower leg arcs through during these motions.	 

Clinical Correlations Relating to the Hip and Thigh

Patellar Pubic Percussion Test: Hip Fracture

- **Background:** The patellar pubic percussion test is a useful clinical examination procedure for healthcare professionals to detect hip-related fractures that present with limited signs and symptoms. A patient is in supine position with their legs extended, and the examiner places the bell of a stethoscope on the patient's pubic symphysis. Next, the examiner taps each patella, comparing the pitch and volume of the affected and unaffected sides. A decrease in sound on the affected side compared to the unaffected side warrants a referral for radiographic imaging. This osteophonic examination procedure has strong diagnostic utility.

Athletic Groin Pain

- **Background:** Athletic groin pain is a broad term describing a collection of tissue structures responsible for pain felt in the inguinal region, where the inferior abdomen meets the proximal region of the thigh. This pain is typically experienced by individuals participating in multidirectional sports, such as football, soccer, and hockey. Healthcare providers will complete a patient history and physical examination to determine hip regions responsible for pain. Among other potential diagnoses, athletic groin pain may be categorized in the following groups: adductors, inguinal, pubic, and iliopsoas. Palpation, active and passive range of motion, and resistive testing are useful to differentiate among etiologies for groin pain.

Trendelenburg Gait (Compensated/Uncompensated)

- **Background:** Trendelenburg gait is an abnormal gait pattern characterized by abnormal functioning of the hip abductor mechanism. This may occur for a variety of reasons, including pain and muscle weakness. The hip abductor muscle group, primarily the gluteus medius, is responsible for this gait feature. Abnormal function of the hip abductors can result in the inability to support the ipsilateral pelvis, which causes the pelvis to drop toward the contralateral side of the stance leg. To decrease the degree of pelvic drop, an individual may shift their weight onto the involved stance leg during stance. This is described as a compensated Trendelenburg gait.

Review Questions: Skeletal Landmarks of the Hip and Thigh

1. The _____ is the origin of the iliacus muscle.
2. The anterior superior iliac spine is the bony attachment of which muscle(s)?
3. (True/False) The piriformis inserts on the lesser trochanter to facilitate internal rotation of the hip.
4. Describe how you might palpate the pubic crest on your partner.
5. The greater trochanter is located (medial / lateral) to the lesser trochanter.
6. The coccyx is located (medial / lateral/ inferior/ superior) to the sacrum.
7. The biceps femoris inserts on which of the following structures? (head of fibula / pes anserine/ tibial tuberosity)
8. Which three bones comprise the pelvis?
9. The inguinal ligament attaches to which two bony landmarks?
10. The pectineal line of the femur is the distal attachment site for _____ (psoas major / pectineus / adductor longus /gracilis).

Review Questions: Musculature of the Hip and Thigh

1. Which three muscles comprise the pes anserine?
2. What is the action of the sartorius muscle?
3. (True/False) The obturator nerve innervates the adductor portion of the adductor magnus, and the tibial nerve innervates the hamstring portion of the adductor magnus.
4. A nerve injury to the femoral nerve would affect which of the following muscles? (rectus femoris / adductor magnus / piriformis / superior gemelli)
5. What is the action of the gluteus minimus muscle?
6. (True/False) The gluteus medius muscle is deep to the gluteus maximus muscle.
7. The hamstring muscle group facilitates (flexion / extension) at the hip joint, and (flexion / extension) at the knee joint.
8. Rectus femoris facilitates (flexion / extension) at the hip joint and (flexion / extension) at the knee joint.
9. Your partner reports pain with active knee flexion. If a muscle strain is responsible for this pain, which of the following muscles is most likely implicated in this scenario? (piriformis / sartorius / semitendinosus / iliopsoas)
10. The muscle insertion of the iliopsoas is (proximal / distal) to the muscle insertion of the adductor magnus.

7. The Knee and Lower Leg

Skeletal Landmarks with Palpation Instructions

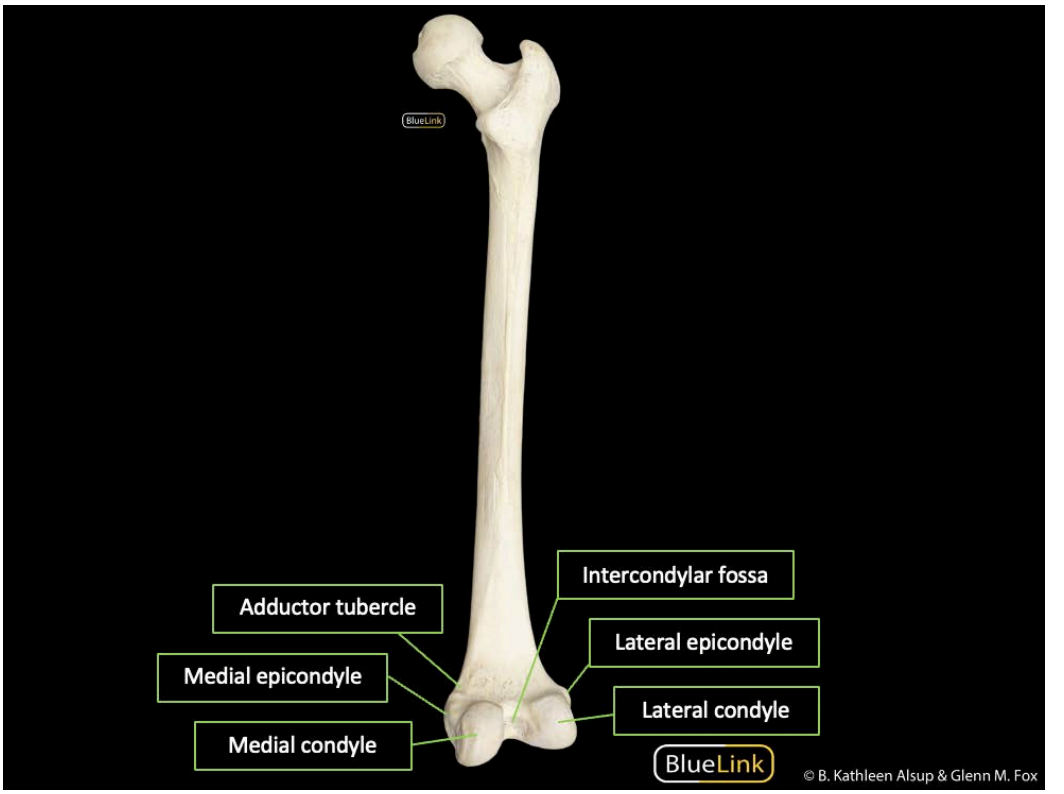


***Figure* 7.1.** *Skeletal Landmarks of the Distal Femur; Posterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

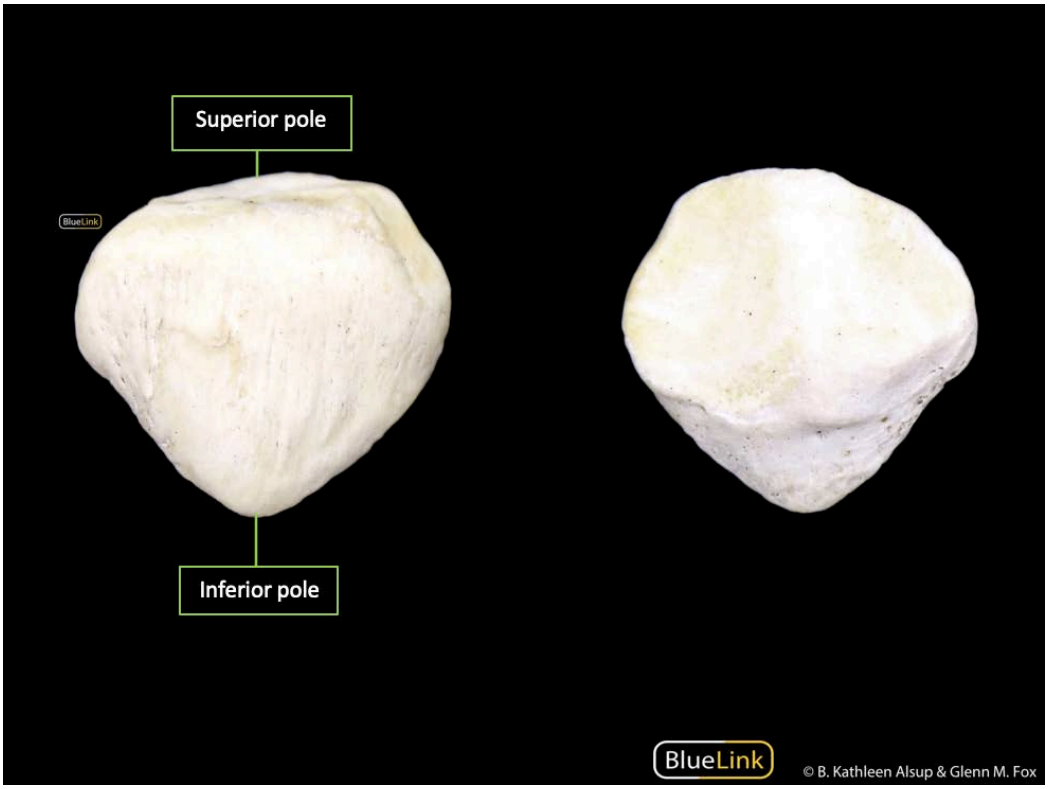


***Figure* 7.2.** *Anterior and Posterior Views of the Patella by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

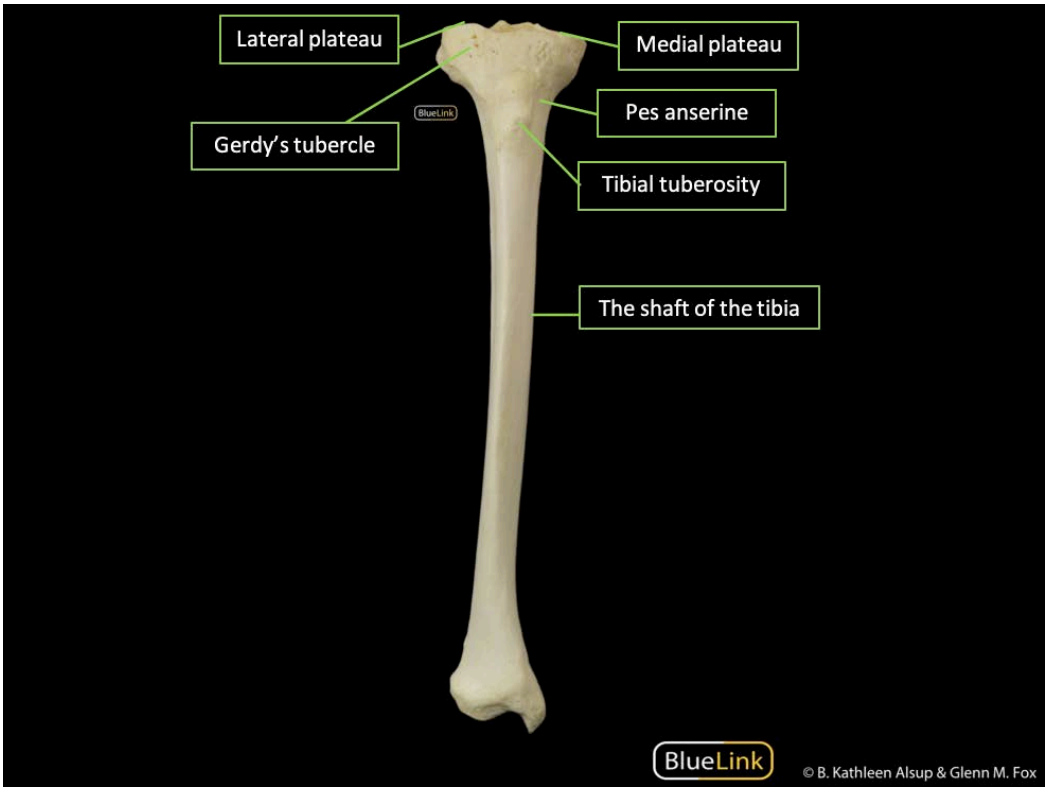


***Figure* 7.3.** *Skeletal Landmarks of the Proximal Tibia; Anterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Figure 7.4. *Skeletal Landmark of the Proximal Fibula by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Patella

- **Poles of the Patella**
  - **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** Locate the patella and orient the superior, inferior, medial, and lateral poles while palpating each aspect of this bone.
  - **Structures That Attach Here:** Quadriceps tendon/patellar tendon, medial and lateral patellofemoral ligaments

Femur

- **Medial and Lateral Femoral Condyles**
  - **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** Palpate the patella and locate the medial and lateral borders. Palpate immediately to each side of the patella to locate the femoral condyles. You can also gently push the patella laterally to access the anterior aspect of the medial femoral condyle, and vice versa for the lateral femoral condyle. When your partner is positioned with their knee flexed, in either a seated or supine position, you will be able to access more of the distal articulating surfaces given the position of the femur and posterior positioning of the tibia on the condyles.
  - **Muscles That Attach Here:** Gastrocnemius (lateral and medial femoral condyles), plantaris (lateral femoral condyle), popliteus (lateral femoral condyle)
  - **Structures That Attach Here:** The anterior cruciate ligament attaches to the lateral femoral condyle, and the posterior cruciate ligament attaches to the medial femoral condyle.
- **Medial and Lateral Femoral Epicondyles**
  - **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** Begin by palpating the femoral condyles. Then move transversely to the sides of the knee, either medially, for the medial epicondyle, or laterally, for the lateral epicondyle. The epicondyles will feel like small bumps or protrusions on either side of the distal femur.
  - **Structures That Attach Here:** Medial collateral ligament (medial epicondyle), lateral collateral ligament (lateral epicondyle)

- **Adductor Tubercle**
  - **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:** First locate the medial epicondyle as described above. Palpate proximally to this structure, sinking into the soft tissue of the medial compartment of the thigh. Within this tissue the tubercle may

be located, which will feel like a depression of the femur as it graduates to the slender shaft of the bone.
    - **Muscles That Attach Here:** Adductor magnus (adductor portion)

Tibia

- **Medial and Lateral Tibial Plateaus**
    - **How to Palpate**
        - **Position of Partner:** Sitting
        - **Directions:** Locate the medial aspect of the knee by palpating the patella and/or superior third of the patellar tendon. Palpate medially or laterally to the midline along the anterior aspect of the knee joint line. Palpate into the joint line, which feels like a depression of tissue between the femur and tibia. Attempt to appreciate the very small, accessible flat shelf of the tibial plateau, which is located toward the inferior aspect of the joint line.
    - **Structures That Attach Here:** Medial and lateral menisci, coronary ligaments, anterior cruciate ligament, posterior cruciate ligament
- **Pes Anserine**
    - **How to Palpate**
        - **Position of Partner:** Supine, sitting
        - **Directions:** Place your partner in a supine or seated position. Locate the tibial tuberosity and, from there, palpate medially approximately two finger breadths to locate the pes anserine tendon. Alternatively, follow the muscle belly and tendon of the semitendinosus, gracilis, or sartorius muscle to its insertion at the pes anserine. Selective muscle contraction through active range of motion or resistive testing may be performed to appreciate each muscle.
    - **Muscles That Attach Here:** Semitendinosus, gracilis, sartorius
- **Lateral Condyle of the Proximal Tibia (Gerdy's Tubercle)**
    - **How to Palpate**
        - **Position of Partner:** Supine, sitting
        - **Directions:** First, locate the tibial tuberosity. Palpate superolaterally to the tibial tuberosity, approximately halfway between the tibial tuberosity and the anterior aspect of the head of the fibula. Make sure

to stay on the tibia and not palpate too far onto the femur. Alternatively, find and follow the iliotibial band to its insertion on this broad, bony aspect of the tubercle.
    - **Structures That Attach Here:** Iliotibial band
- **Tibial Tuberosity**
    - **How to Palpate**
        - **Position of Partner:** Supine, sitting, standing
        - **Directions:** Locate the apex of the patella and palpate inferiorly along the patellar tendon to the bony ridge of the tibial tuberosity. Visually, this protrusion may be identified before even palpating the structure.
    - **Muscles That Attach Here:** Quadriceps complex via the patellar tendon/ligament
- **Shaft**
    - **How to Palpate**
        - **Position of Partner:** Supine, sitting, standing
        - **Directions:** Locate the tibial tuberosity and palpate inferiorly along the shaft of the tibia along the anterior aspect of the lower shank.
    - **Muscles That Attach Here:** The shaft of the tibia serves as a proximal and distal attachment for numerous muscles of the knee, and of the ankle and foot complex. Refer to muscle structures within this chapter and the next for more details.

Fibula

- **Head of Fibula**
    - **How to Palpate**
        - **Position of Partner:** Supine, sitting
        - **Directions:** Locate the tibial tuberosity and then palpate transversely, moving laterally around the tibia until you meet the prominent head of the fibula. Alternatively, you may palpate the distal fibula at the lateral malleolus and follow the fibula proximally until the head of the fibula is appreciated.
    - **Muscles That Attach Here:** Biceps femoris, fibularis longus, soleus, tibialis posterior, extensor digitorum longus, flexor hallucis longus, extensor hallucis longus, fibularis brevis, fibularis tertius

- **Structures That Attach Here:** Lateral collateral ligament

Musculature with Palpation Instructions

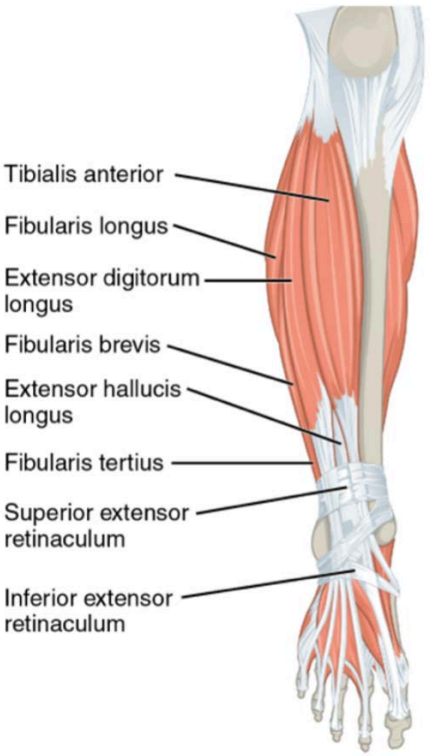


Figure 7.5. *Muscles of the Lower Leg: Anterior View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

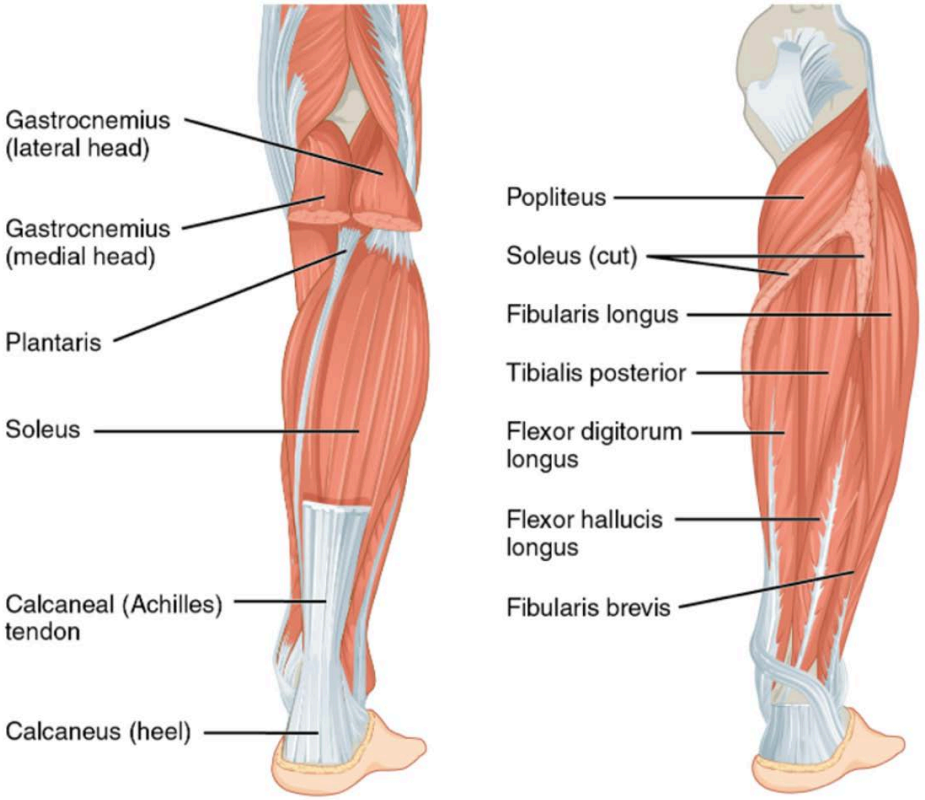


***Figure* 7.6.** *Muscles of the Lower Leg; Posterior View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

Gastrocnemius

- **Origin(s):** Lateral condyle (lateral head), medial condyle (medial head)
- **Insertion(s):** Calcaneus
- **Action(s):** Ankle plantarflexion, knee flexion
- **Innervation(s):** Tibial nerve
- **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Appreciate the superficial soft tissue contours of the medial and lateral heads of the gastrocnemius and palpate from the posterior aspect of the knee joint inferiorly along each muscle belly. Continue to

palpate inferiorly along the Achilles tendon to the muscle insertion at the heel.

Soleus

- **Origin(s):** Posterior head and superior aspect of the fibula, soleal line, and middle third of tibia
- **Insertion(s):** Calcaneus
- **Action(s):** Ankle plantarflexion
- **Innervation(s):** Tibial nerve
- **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Begin by appreciating the muscle contour and bellies of the gastrocnemius and its medial and lateral heads as described above. Palpate the medial aspect of the soleus by sliding medially from the bottom third of the tibia toward the posterior shank. Palpate the lateral aspect of the soleus by sliding laterally from the bottom third of the tibia posteriorly, appreciating the change in muscle bulk and contour between the gastrocnemius and soleus. You may position the knee in flexion and ask your partner to plantarflex. In this position, the soleus becomes a more effective plantar flexor than the gastrocnemius.

Plantaris

- **Origin(s):** Lateral condyle of femur
- **Insertion(s):** Calcaneus
- **Action(s):** Ankle plantarflexion
- **Innervation(s):** Tibial nerve
- **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Locate the intersection of the lateral head of the gastrocnemius and the medial aspect of the biceps femoris tendon. Palpate superomedially within the popliteal space, aiming for the posterior aspect of the lateral condyle of the femur. Palpate deep within the tissue until you

appreciate the small muscle belly of the plantaris. This muscle can be difficult to palpate given the required depth of palpation through superficial tissues, as well as variation in the actual size of the muscle belly itself.

Popliteus

- **Origin(s):** Lateral aspect of the lateral femoral condyle
- **Insertion(s):** Posterior aspect of tibia superior to soleal line
- **Action(s):** Knee medial rotation, unlocking mechanism, knee flexion
- **Innervation(s):** Tibial nerve
- **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Locate the medial knee joint line on the medial aspect of the leg and move posteriorly and inferiorly until you palpate the proximal posterior tibia. Palpate deep to the superficial tissue (i.e., medial head of the gastrocnemius) to press into the tissue of the popliteus. Given the anatomical position of this muscle, and degree of overlying muscle tissue, the specificity of palpating this structure is poor. You may consider sliding the soft tissue of the gastroc-soleus complex to improve your access on the posterior shank.

Fibularis Longus

- **Origin(s):** Head and superior two-thirds of the fibula
- **Insertion(s):** Base of 1st metatarsal, medial cuneiform
- **Action(s):** Ankle eversion, plantarflexion
- **Innervation(s):** Superficial fibular nerve
- **How to Palpate**
    - **Position of Partner:** Sitting, supine, side-lying
    - **Directions:** Acknowledge the origin of the muscle by palpating the lateral aspect of the fibular head. Follow the muscle belly to its tendon along the lateral aspect of the distal shank and posterior to the lateral malleolus. Instruct your partner to evert the foot against resistance to appreciate the

muscle belly and its tendon as it wraps around the plantar surface of the foot. As the tendon wraps around the plantar surface of the foot on the way to its insertion, it is likely you will lose the ability to accurately palpate it due to approximation with other tissue structures.

Fibularis Brevis

- **Origin(s):** Inferior two-thirds of fibula
- **Insertion(s):** Lateral base of 5th metatarsal
- **Action(s):** Ankle eversion, plantarflexion
- **Innervation(s):** Superficial fibular nerve
- **How to Palpate**
    - **Position of Partner:** Sitting, supine, side-lying
    - **Directions:** Appreciate the origin of the muscle by palpating the lateral aspect of the fibular head. Follow the muscle belly to its tendon along the lateral aspect of the distal shank and posterior to the lateral malleolus. Instruct your partner to evert the foot against resistance to appreciate the muscle belly and its tendon as it descends around the fibular tubercle/trochlea on its way to the lateral base of the 5th metatarsal.

Fibularis Tertius

- **Origin(s):** Inferior fibula, interosseous membrane
- **Insertion(s):** Dorsal base of the 5th metatarsal
- **Action(s):** Ankle dorsiflexion, eversion
- **Innervation(s):** Deep fibular nerve
- **How to Palpate**
    - **Position of Partner:** Sitting, supine, side-lying
    - **Directions:** Locate the insertion point of the fibularis tertius at the dorsal base of the 5th metatarsal. Instruct your partner to evert and dorsiflex their foot. Identify the tendon on the lateral side of the foot, lateral to the tendons of the extensor digitorum muscle. Follow the tendon proximally along the dorsum of the foot toward the anterolateral aspect of the distal shank, at the inferior aspect of the fibula, to palpate the muscle belly.

Tibialis Anterior

- **Origin(s):** Lateral condyle of tibia, superior half of tibia, interosseous membrane
- **Insertion(s):** Medial cuneiform, base of 1st metatarsal
- **Action(s):** Ankle dorsiflexion, inversion
- **Innervation(s):** Deep fibular nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Instruct your partner to dorsiflex their foot and appreciate the thick, cord-like tendon that is visible at the anterior talocrural joint line and runs medially to the plantar aspect of the foot toward its insertion points. Palpate the length of the tendon, and move proximally to the muscle belly, located just lateral to the anterior aspect of the tibia.

Extensor Digitorum Longus

- **Origin(s):** Lateral condyle of tibia, superior three-fourths of fibula, interosseous membrane
- **Insertion(s):** Middle and distal phalanx of 2–5
- **Action(s):** Digit extension, ankle dorsiflexion
- **Innervation(s):** Deep fibular nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Palpate along the dorsal aspects of the 2nd–5th digits with one hand and instruct your partner to extend their toes against resistance. Appreciate the tendons of the extensor digitorum longus along the dorsal aspect of the foot, up to the muscle belly in the anterior compartment of the lower leg.

Extensor Hallucis Longus

- **Origin(s):** Interosseous membrane, fibula
- **Insertion(s):** Distal phalanx of 1st digit

- **Action(s):** Great toe extension, ankle dorsiflexion
- **Innervation(s):** Deep fibular nerve
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Palpate along the dorsal aspects of the 1st digit with one hand and instruct your partner to extend their toe against resistance. Appreciate the tendon of the extensor hallucis longus, running from the distal great toe along the dorsal aspect of the foot, up to its muscle belly in the anterior compartment of the lower leg.

Tibialis Posterior

- **Origin(s):** Interosseous membrane, tibia
- **Insertion(s):** Navicular tuberosity, cuneiform, cuboid, sustentaculum tali, base of 2nd–4th metatarsals
- **Action(s):** Ankle plantarflexion, composite foot inversion
- **Innervation(s):** Tibial nerve
- **How to Palpate**
    - **Position of Partner:** Prone, side-lying
    - **Directions:** Palpate along the flexor retinaculum, posterior to the medial malleolus. Instruct your partner to plantarflex and invert the foot. With these motions you may see the tendon of this muscle moving slightly over the posterior aspect of the medial malleolus. Continue to palpate the tibialis posterior tendon just posterior to the medial malleolus and follow the tendon up to the muscle belly located on the posterior aspect of the distal shank. Due to the girth of the gastrocnemius-soleus complex, and comparatively thin muscle belly of the tibialis posterior, the specificity of the palpation is likely challenging. It may be more prudent to leverage knowledge of the origin of the muscle tissue rather than relying on specific palpation strategies for this muscle.

Flexor Digitorum Longus

- **Origin(s):** Tibia

- **Insertion(s):** Base of distal phalanges of digits 2–5
- **Action(s):** Digit 2–5 flexion (MTP, PIP, DIP), ankle plantarflexion
- **Innervation(s):** Tibial nerve
- **How to Palpate**
    - **Position of Partner:** Prone, side-lying
    - **Directions:** Instruct your partner to plantarflex the 2nd–5th digits against resistance to help make the distal tendons of this muscle more prominent. Palpate and follow the tendons along the plantar aspect of the foot to the medial malleolus, where the muscle then ascends the posterior aspect of the distal shank. Like the tibialis posterior muscle, this muscle will be difficult to palpate toward its origin because of its location deep to the superficial posterior muscles of the lower leg.

Flexor Hallucis Longus

- **Origin(s):** Inferior two-thirds of fibula, interosseous membrane
- **Insertion(s):** Base of distal phalanx of 1st digit
- **Action(s):** 1st digit flexion (MTP, IP), ankle plantarflexion
- **Innervation(s):** Tibial nerve
- **How to Palpate**
    - **Position of Partner:** Prone, side-lying
    - **Directions:** Have your partner plantarflex their 1st digit against your resistance to help make this muscle's distal tendon more prominent. Then follow the tendon toward the medial malleolus and up to the muscle belly, which is located on the posterior aspect of the distal shank. Along with the other muscles of the deep compartment of the posterior lower leg, this muscle will be difficult to palpate toward its proximal end.

Other Anatomical Landmarks

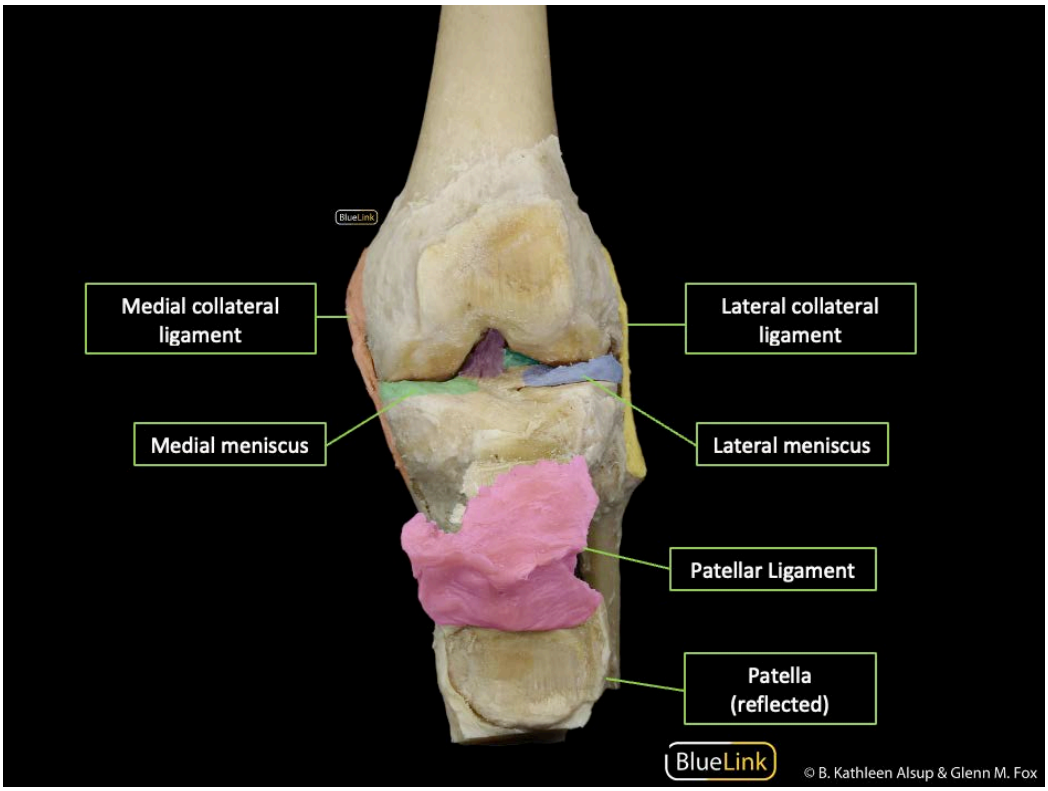


Figure 7.7. *Ligaments and Meniscus of the Knee; Anterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Patellar Tendon

- **How to Palpate**
  - **Position of Partner:** Supine, standing, sitting
  - **Directions:** You may begin by palpating the apex of the patella or by palpating the tibial tuberosity. If beginning at the apex of the patella, palpate inferiorly along the patellar tendon, appreciating its proximal and distal attachments and borders. If beginning at the tibial tuberosity, palpate superiorly along the tendon, appreciating its attachments and borders.

Medial Collateral Ligament

- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Begin by locating the medial epicondyle of the femur, one of its attachment points. Palpate from this area, moving distally to the medial aspect of the proximal tibia, its other attachment site. Palpate over the medial aspect of the joint line, strumming over the broad, thin tissue crossing the joint surface medially and appreciating the anatomical boundaries of this medial stabilizer of the knee joint.

Lateral Collateral Ligament

- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** First, have your partner flex their knee of interest and cross that leg over their other leg into a figure four position. Palpate along the lateral aspect of the knee from its proximal attachment at the lateral femoral epicondyle to its distal attachment at the head of the fibula, strumming over the thick, cylindrical tissue. With your partner in the figure four position, this ligament should be pronounced, making it easy to differentiate from surrounding structures.

Medial and Lateral Meniscus

- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** Locate the plateaus of the tibia and palpate along these areas to appreciate the anterior aspects of the menisci. Given the anatomical location of these structures, the specificity of palpation is poor; however, palpation of the medial and lateral joint lines is often performed as part of the physical examination of a suspected meniscus injury.

Medial Patellofemoral Ligament

- **How to Palpate**
    - **Position of Partner:** Supine
    - **Directions:** Locate the two bony attachments of the ligament at the superomedial aspect of the patella and medial condyle of the femur. Begin by palpating along the superomedial aspect of the patella while moving toward the femur to appreciate this structure.

Iliotibial Band (IT Band/Tract)

- **How to Palpate**
    - **Position of Partner:** Side-lying
    - **Directions:** Locate the distal attachment of the iliotibial band at the lateral condyle of the proximal tibia (Gerdy's tubercle), and palpate superiorly along the iliotibial band tissue at the level of the lateral femoral condyle. Along the distal aspect of the lateral thigh, the iliotibial band can be appreciated. Often this structure feels very hard in comparison to the soft tissue that surrounds it. Make sure to differentiate between the vastus lateralis tissue and biceps femoris tendon.

Range of Motion

Table 7.1 Range of Motion of the Knee & Lower Leg

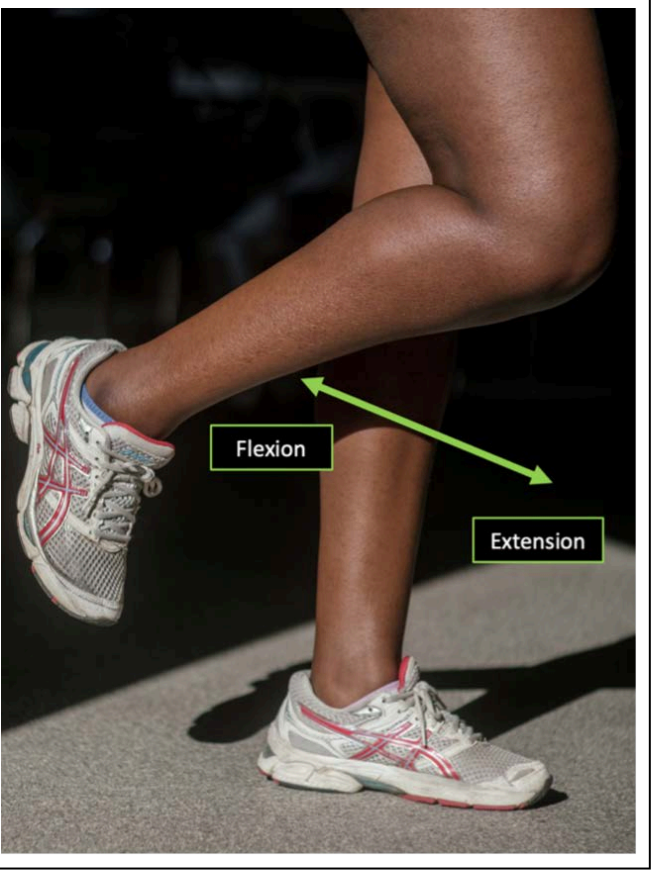
Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Knee Flexion and Extension	For passive and resistive range of motion assessments, have your partner lie prone to access the largest possible range. To truly appreciate the end range of extension, it may be necessary to have them lie supine with a bolster behind their knee. When the person extends their knee, you'll then be able to appreciate the end range of their ability to extend their knee.	

Figure 7.8 by Dan Silver is used under a CC BY 4.0 License.

Clinical Correlations

Unhappy Triad Injury

- **Background:** An unhappy triad injury describes a traumatic injury of the knee

involving the anterior cruciate ligament, medial collateral ligament, and medial meniscus. This injury is often the result of an abduction-external rotation force at the knee joint. For example, a lateral blow to the knee while the foot is planting to pivot can cause this injury to occur.

Anterior Knee Pain (Patellofemoral Pain Syndrome, Iliotibial Band Syndrome, and Patellar Tendinopathy)

- **Background:** Three common overuse injuries of the knee are patellofemoral pain syndrome, iliotibial band syndrome, and patellar tendinopathy. Healthcare professionals will often combine a subjective history and physical examination to differentially diagnose the source of knee pain. Pain with palpation of the patella, iliotibial band, or patellar tendon may implicate patellofemoral pain syndrome, iliotibial band syndrome, and/or patellar tendinopathy, respectively.

Ottawa Knee Rules

- **Background:** The Ottawa Knee Rules are a highly sensitive clinical screening tool to determine the need for radiographic imaging for a suspected knee fracture. A healthcare provider will refer a patient to an emergency department for radiographic imaging if any of the following are present during a physical examination with a history of trauma: 1) age fifty-five or older, 2) tenderness to palpation of the fibular head, 3) isolated tenderness of the patella, 4) inability to flex the knee to 90 degrees, 5) inability to bear weight for four steps at time of injury and in the emergency department.

Review Questions: Skeletal Landmarks of the Knee and Lower Leg

1. The apex of the patella is (superior / inferior) to the base.
2. The distal attachment of the iliotibial band is (tibial tuberosity / lateral condyle) of the proximal tibia (Gerdy's tubercle / fibular head).

3. The (long head / short head) of the biceps femoris originates from the ischial tuberosity, and the (long head / short head) of the biceps femoris originates from the linea aspera.
4. The _____ is the distal attachment of the adductor magnus muscle.
5. The medial and lateral menisci are anchored upon the (tibial plateau / tibial tuberosity / femoral condyles).
6. The quadriceps tendon inserts on the (base of patella / tibial tuberosity / medial epicondyle).
7. What are the proximal and distal attachments of the medial collateral ligament?
8. The head of the fibula is located (distally / proximally) along the length of the fibula.
9. The medial meniscus is located on top of what skeletal landmark of the tibia?
10. The anterior inferior iliac spine is the proximal attachment of (rectus femoris / vastus intermedius / vastus medialis/ vastus lateralis).

Review Questions: Musculature of the Knee and Lower Leg

1. Name the muscles that comprise the quadriceps muscle group.
2. The rectus femoris acts as a (flexor / extensor) at the hip, and a (flexor / extensor) at the knee.
3. What are the two actions of the biceps femoris?
4. The vastus intermedius is (superficial / deep) to the rectus femoris.
5. Identify the three muscles that insert at the pes anserine.
6. The semitendinosus acts as a (flexor / extensor) at the hip, and a (flexor / extensor) at the knee.
7. A traumatic injury affecting the function of the femoral nerve would result in muscle weakness or the inability to perform what motion?
8. Which two nerves innervate the biceps femoris?

9. What are the actions of the gastrocnemius muscle?
10. The gastrocnemius and soleus muscle share what muscle action?

8. The Ankle and Foot

Skeletal Landmarks with Palpation Instructions

Figure 8.1. *Skeletal Landmark of the Distal Tibia; Anterior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

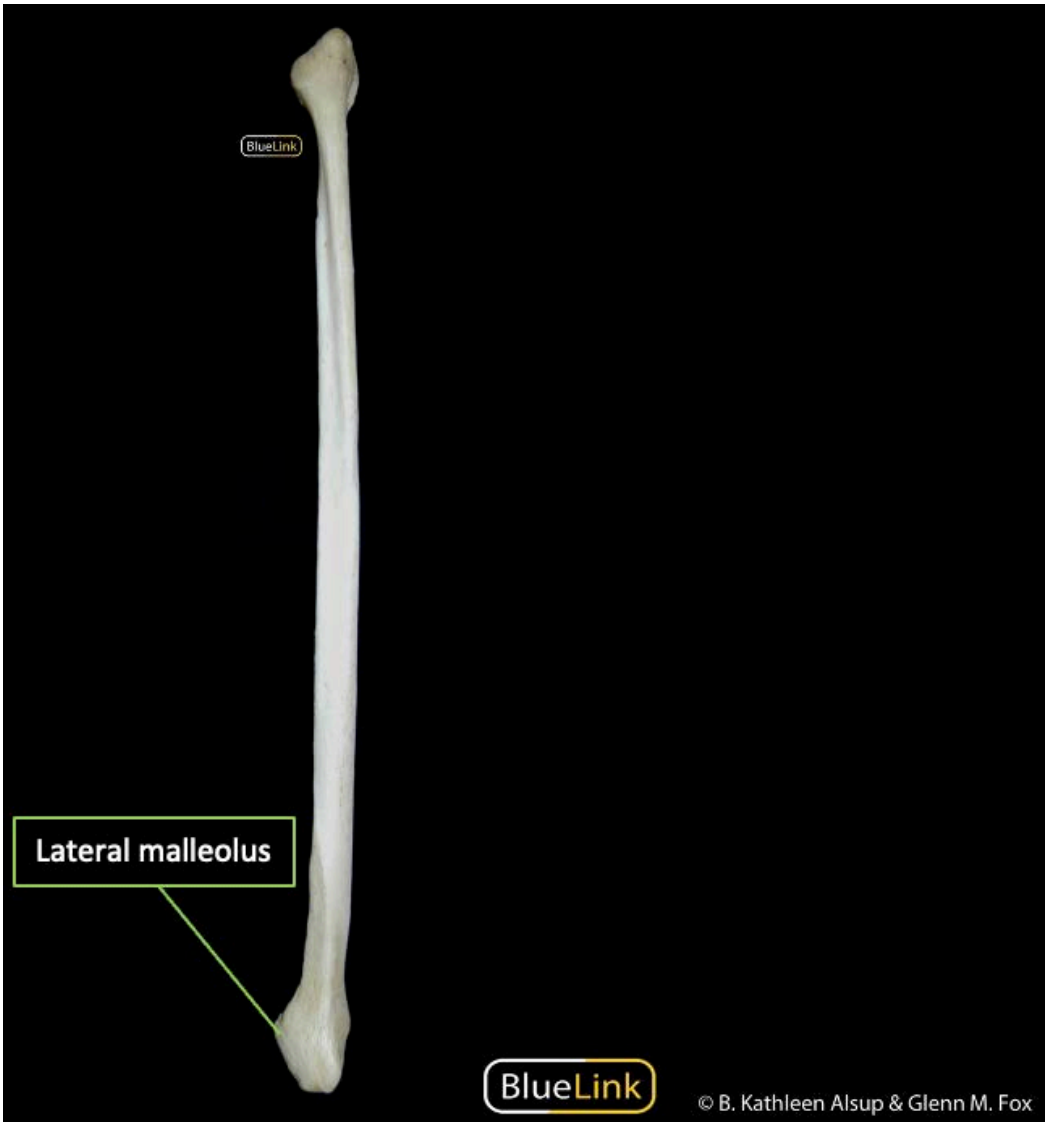


Figure 8.2. *Skeletal Landmark of the Distal Fibula by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

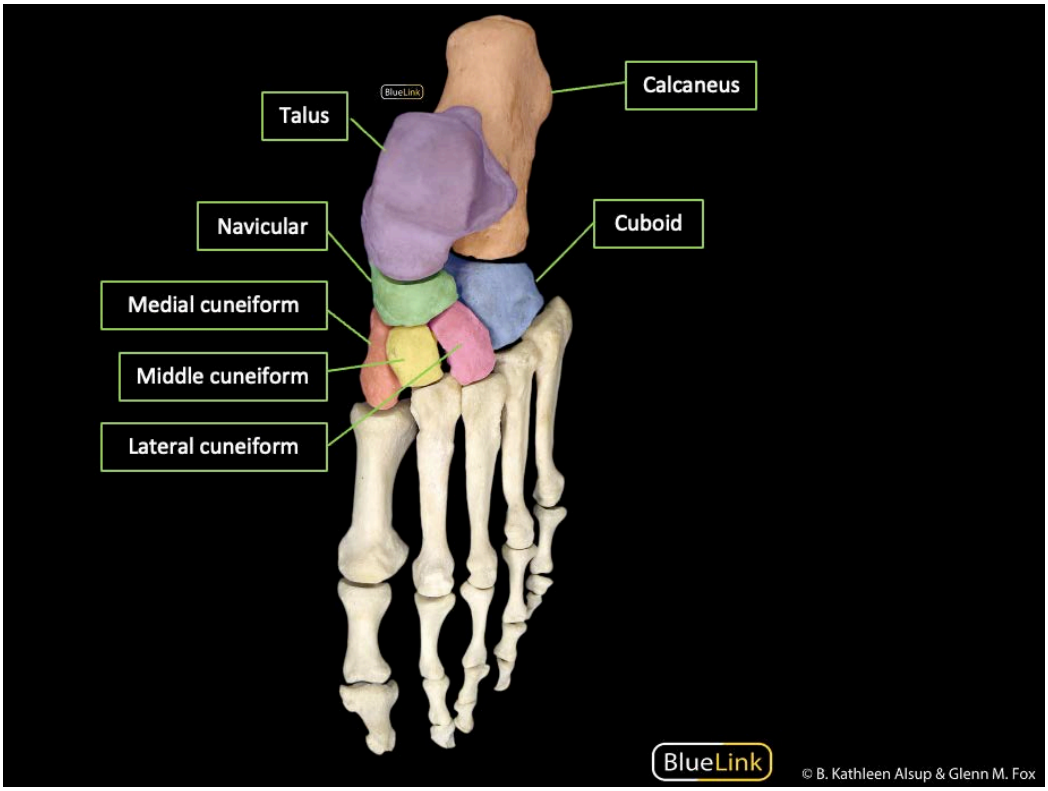


Figure 8.3. *Tarsal Bones of the Foot; Superior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

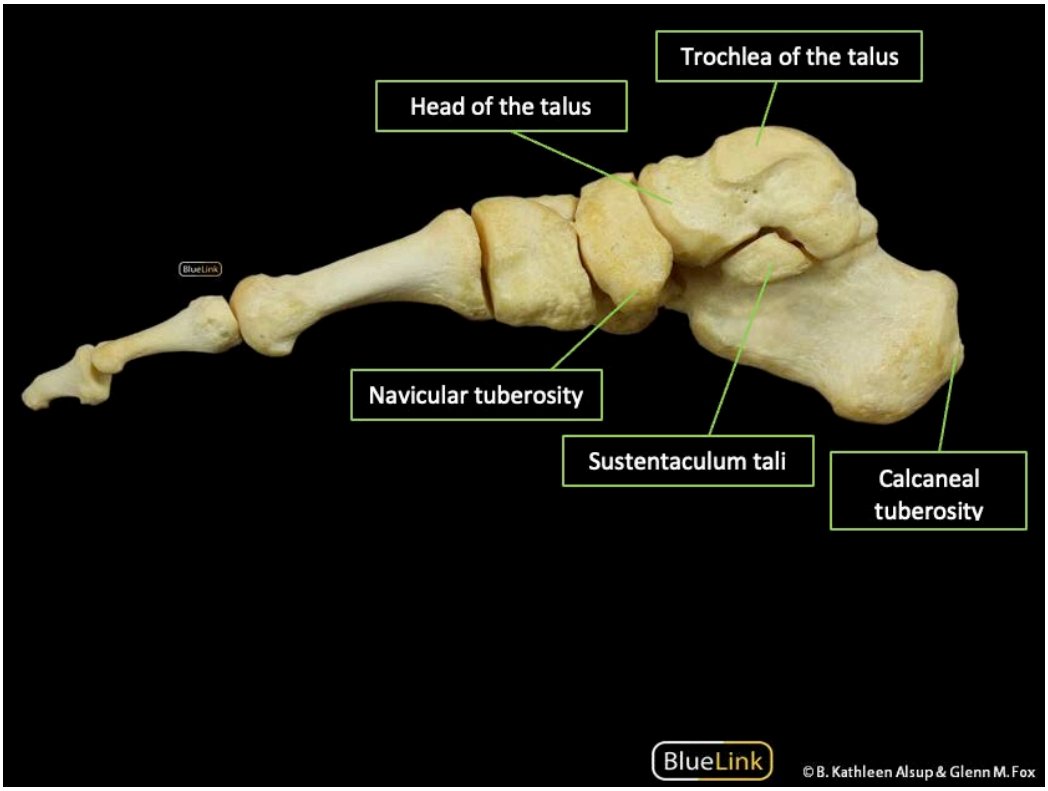


Figure 8.4. *Skeletal Landmarks of the Medial Foot by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

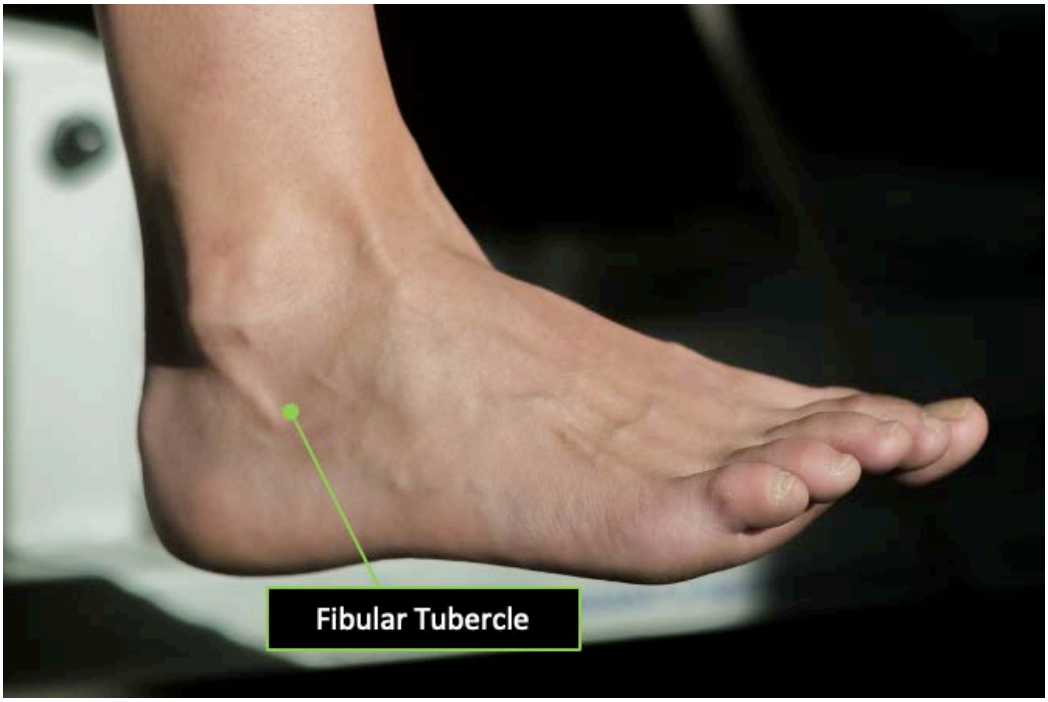


Figure 8.5. *The Fibular Tubercle; Lateral View of the Foot by Dan Silver is used under a CC BY 4.0 License.*

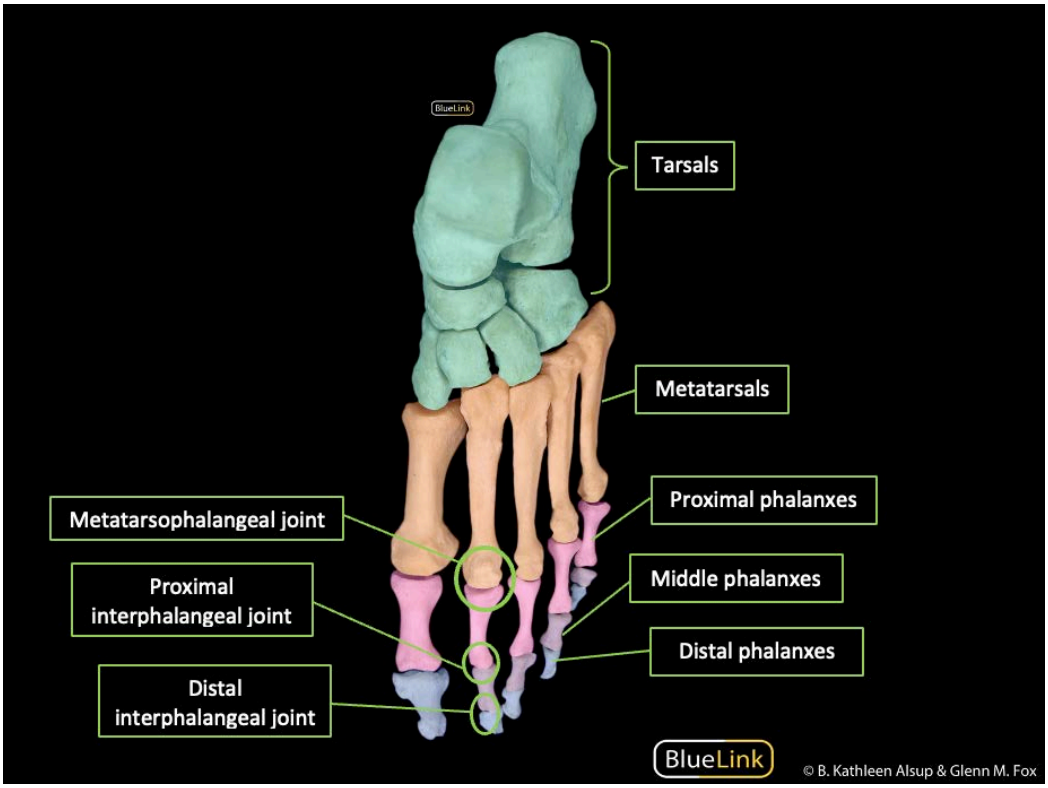


Figure 8.6. *Bones and Joints of the Foot; Superior View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Tibia and Fibula

- **Medial and Lateral Malleoli**
  - **How to Palpate**
    - **Position of Partner:** Supine, sitting
    - **Directions:**
      - **Medial Malleoli:** Begin by locating the medial aspect of the tibia and follow this bone inferiorly until you access this bulbous structure on the medial aspect of the ankle/foot complex. Appreciate the inferior tip, the anterior, and the posterior boundaries.
      - **Lateral Malleoli:** Begin by locating the lateral aspect of the fibula and follow this bone inferiorly until you access this bulbous

structure on the lateral aspect of the ankle/foot complex. Appreciate the inferior tip, the anterior, and the posterior boundaries.

- **Structures That Attach Here:** The medial and lateral malleoli serve as the attachment site for numerous ligaments that support the talocrural, hindfoot, and midfoot joints. Please see sections that follow regarding pertinent ligaments.

Calcaneus

- **Calcaneus**
  - **How to Palpate**
    - **Position of Partner:** Prone, sitting
    - **Directions:** Locate the heel of the foot. Palpate the posterior aspect of the foot complex, appreciating the medial, lateral, posterior, and inferior aspects of this large hindfoot bone.
  - **Muscles That Attach Here:** Gastrocnemius, soleus, plantaris, abductor hallucis, flexor digitorum brevis, abductor digiti minimi, quadratus plantae, extensor digitorum brevis, extensor hallucis brevis
  - **Structures That Attach Here:** Plantar fascia, deltoid ligament, short and long plantar ligaments

- **Calcaneal Tuberosity**
  - **How to Palpate**
    - **Position of Partner:** Prone
    - **Directions:** Begin by locating the Achilles tendon and palpate inferiorly along the tendon until it inserts on the calcaneus at the calcaneal tuberosity. Feel for the dissipation of the tendon as it attaches to the calcaneus on the inferior aspect of the posterior calcaneus.
  - **Muscles That Attach Here:** Gastrocnemius, soleus, plantaris

- **Sustentaculum Tali**
  - **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Palpate the medial malleolus as described above and move

your fingers inferiorly until a shelf-like bony ridge is felt. This structure is located approximately 1–1½ inches inferior to the tip of the medial malleolus. This skeletal landmark creates a groove for the flexor hallucis longus tendon to run underneath.
    - **Structures That Attach Here:** Plantar calcaneal ligament, deltoid ligament.

- **Fibular Tubercle/Trochlea**
    - **How to Palpate**
        - **Position of Partner:** Sitting
        - **Directions:** Orient yourself to your partner's lateral ankle. Locate the lateral malleolus and travel on a downward and slightly anterior diagonal about 1 inch from this landmark. A small protuberance can be felt here. Have your partner evert their foot so these tendons become more prominent, and then they may be able to guide you to this landmark.
    - **Structures Located Near This Landmark:** The distal tendons of the fibularis longus and fibularis brevis muscles hinge around this landmark as they travel to their insertions.

Navicular

- **Navicular Tuberosity**
    - **How to Palpate**
        - **Position of Partner:** Sitting, supine
        - **Directions:** Start by locating the midpoint of the medial malleolus and palpate 2 inches inferiorly at approximately 45–60 degrees toward the medial midfoot until the tuberosity of the navicular bone is appreciated. Alternatively, you may begin by palpating the 1st metatarsal and gradually moving proximally along the medial aspect of the foot. Pass along the medial cuneiform and palpate the navicular bone. This tuberosity should feel like a prominent elevation to the bone and, in some cases, may even be visible as it protrudes from the medial foot.
    - **Muscles That Attach Here:** Tibialis posterior
    - **Structures That Attach Here:** Spring ligament, deltoid ligament

Talus

- **Head of Talus**
  - **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin by locating the navicular bone and the medial malleolus. Draw a line between these two structures and appreciate the bony indentation between the navicular tubercle and the prominent medial malleolus. By everting and inverting the foot, you will appreciate the head of the talus extending into your fingers, during eversion specifically.

- **Trochlea of Talus**
  - **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Appreciate the talus deep on the medial and lateral aspects of the anterior compartment tendons (i.e., tibialis anterior, extensor hallucis longus, extensor digitorum) by palpating with your thumb and fingers, respectively. Locate the midpoint of the medial and lateral aspects of the talus, and plantarflex and invert the foot to better expose the articular surface of the talus.

- **Medial Tubercle of Talus**
  - **How to Palpate**
    - **Position of Partner:** Sitting, supine
    - **Directions:** Begin by locating the medial malleolus and palpate in an inferior and posterior direction on the foot at roughly a 45-degree angle. Appreciate the bony tubercle of the talus to locate this landmark.
  - **Structures that Attach Here:** Deltoid ligament (posterior talotibial ligament)

Metatarsals

- **1st–5th Metatarsals**
  - **Palpation Directions**
    - **Position of Partner:** Sitting, supine
    - **Directions:** Orient to the proximal phalanx of digits 1–5. Palpate proximally over the metatarsophalangeal joint and onward to the metatarsal bones. Appreciate the distal and proximal aspects of the bone, concluding at the tarsometatarsal junction.
  - **Muscles That Attach Here:**
    - **1st Metatarsal:** Tibialis anterior, fibularis longus
    - **2nd–4th Metatarsals:** Tibialis posterior, adductor hallucis
    - **5th Metatarsal:** Fibularis brevis, flexor digiti minimi brevis
    - **Plantar and dorsal interossei** also attach to different areas of the digits.
- **Styloid Process of 5th Metatarsal**
  - **How to Palpate**
    - **Position of Partner:** Sitting, supine
    - **Directions:** Locate the shaft of the 5th metatarsal using the strategy described above. Palpate proximally along the 5th metatarsal until the large bulbous bony process on the lateral aspect of the midfoot is appreciated.
  - **Muscles That Attach Here:** Fibularis brevis, fibularis tertius

Phalanxes

- **Proximal, Middle, and Distal Phalanxes**
  - **How to Palpate**
    - **Position of Partner:** Sitting, supine
    - **Directions:** Locate the distal phalanx at the most distal aspect of each of the phalanges. Appreciate the proximal, middle, and distal phalanxes by palpating distally.
  - **Muscles That Attach Here:**

- **Distal Phalanx of Digit 1:** Flexor hallucis longus, extensor hallucis longus
- **Proximal Phalanx of Digit 1:** Abductor hallucis, flexor hallucis brevis, adductor hallucis, extensor hallucis brevis
- **Distal Phalanges of Digits 2–5:** Flexor digitorum longus, extensor digitorum longus
- **Middle Phalanges of Digits 2–5:** Flexor digitorum brevis, extensor digitorum longus
- **Proximal Phalanx of Digit 5:** Abductor digit minimi, flexor digiti minimi brevis
- **Plantar and dorsal interossei** also attach to different areas of the phalanges and metatarsals.

Medial, Middle, and Lateral Cuneiforms

- **How to Palpate**
  - **Position of Partner:** Sitting, supine
  - **Directions:** Locate the medial cuneiform by palpating toward the proximal end of the 1st metatarsal. Then roll over the base of the 1st metatarsal onto the medial cuneiform. Move laterally along the midfoot to appreciate the middle and lateral cuneiforms, aligning with the 2nd and 3rd metatarsals, respectively.
- **Muscles That Attach Here:**
  - **Medial Cuneiform:** Tibialis anterior, tibialis posterior, fibularis longus, flexor hallucis brevis
  - **Lateral Cuneiform:** Flexor hallucis brevis

Cuboid

- **How to Palpate**
  - **Position of Partner:** Sitting, supine
  - **Directions:** Locate the styloid process of the 5th metatarsal and palpate superiorly and posteriorly on an imaginary line toward the center point of the lateral malleolus. After rolling off the ridge of the 5th metatarsal,

appreciate the cuboid bone along the lateral aspect of the foot.

- **Muscles That Attach Here:** Tibialis posterior, flexor hallucis brevis
- **Structures That Attach Here:** Long and short plantar ligaments

Joints

- **How to Palpate** The individual metatarsophalangeal and interphalangeal joints can be palpated. First, using Figure 8.6, identify which joint to palpate, and feel around the joint surfaces from all accessible points.

Musculature with Palpation Instructions

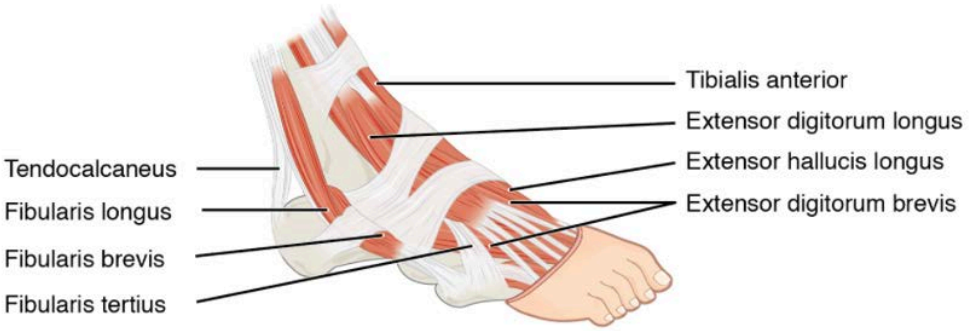


Figure 8.7. *Muscles of the Anterolateral Foot by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

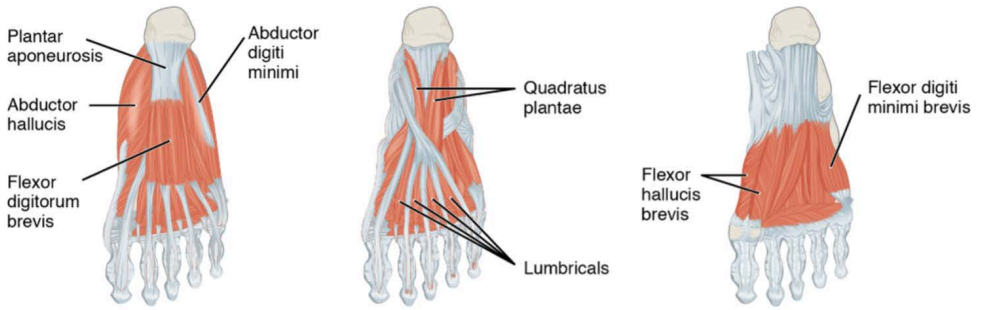


Figure 8.8. *Muscles of the Foot; Plantar View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

Extensor Digitorum Brevis

- **Origin(s):** Calcaneus
- **Insertion(s):** Tendons of extensor digitorum longus 2–5
- **Action(s):** Digit extension 2–5
- **Innervation(s):** Deep fibular nerve
- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Palpate anterior to the lateral malleolus, over the cuboid and lateral cuneiform, on the dorsum of the foot. Instruct the patient to extend digits 2–5 their 2nd–5th digit against resistance and palpate the muscle bulk that emerges on the dorsal side of the foot.

Flexor Digitorum Brevis

- **Origin(s):** Medial tubercle of calcaneal tuberosity, plantar aponeurosis
- **Insertion(s):** Middle phalanx of digits 2–5
- **Action(s):** Digit 2–5 flexion
- **Innervation(s):** Medial plantar nerve
- **How to Palpate**
  - **Position of Partner:** Supine

- **Directions:** Starting at the medial calcaneus, palpate along the longitudinal arch of the plantar surface of the foot toward the 2nd–5th digits. Instruct your partner to perform digit flexion against your resistance, and simultaneously palpate along the longitudinal arch. The muscle is difficult to isolate but may be appreciated by pressing into the tissue of the plantar surface of the foot.

Abductor Hallucis

- **Origin(s):** Medial tubercle of calcaneus, plantar aponeurosis, flexor retinaculum
- **Insertion(s):** Base of proximal phalanx of 1st digit
- **Action(s):** 1st digit abduction, flexion
- **Innervation(s):** Medial plantar nerve
- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Appreciate the muscle tissue by palpating from the origin to insertion along the medial aspect of the foot. Instruct your partner to abduct or flex their 1st digit while you palpate along the medial aspect of the foot to better feel the muscle belly.

Abductor Digiti Minimi

- **Origin(s):** Medial and lateral tubercles of calcaneus, plantar aponeurosis
- **Insertion(s):** Base of proximal phalanx of 5th digit
- **Action(s):** 5th digit abduction, flexion
- **Innervation(s):** Lateral plantar nerve
- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Appreciate the muscle tissue by palpating from the origin to insertion along the lateral aspect of the foot. Instruct your partner to abduct or flex their 5th digit while you palpate along the lateral aspect of the foot to appreciate the muscle belly.

Other Anatomical Landmarks

Achilles Tendon

- **How to Palpate**
  - **Position of Partner:** Prone
  - **Directions:** Locate the calcaneal tuberosity on the posterior aspect of the calcaneus and palpate superiorly along the Achilles tendon. Appreciate the medial and lateral borders and the thickness of the tendon. Alternatively, you can start proximally at the medial and lateral heads of the gastrocnemius and palpate as they come together distally to form the primary bulk of muscle tissue. Then continue to palpate inferiorly until you meet the superior aspect of the Achilles tendon.

Deltoid Ligament

- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Locate the medial malleolus and the attachment sites of the deltoid ligament, which are the navicular bone, talus, and calcaneus. Palpate inferior to the medial malleolus along the broad space between this ligaments' distal attachments to fully appreciate this ligament.

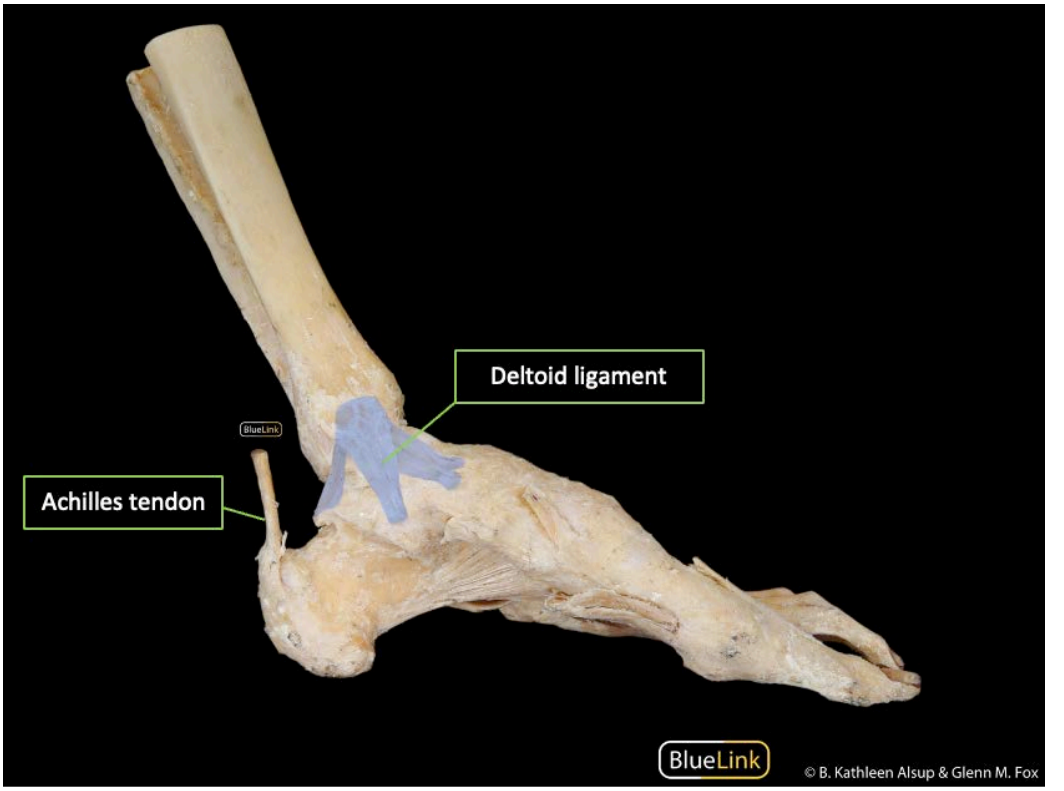


Figure 8.9. *Achilles Tendon and Deltoid Ligament of the Ankle; Medial View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Sinus Tarsi

- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** Locate the tunnel-like space between the talus and calcaneus, anterior and inferior to the lateral malleolus. Have your partner dorsiflex their ankle to make this depression become even more prominent.

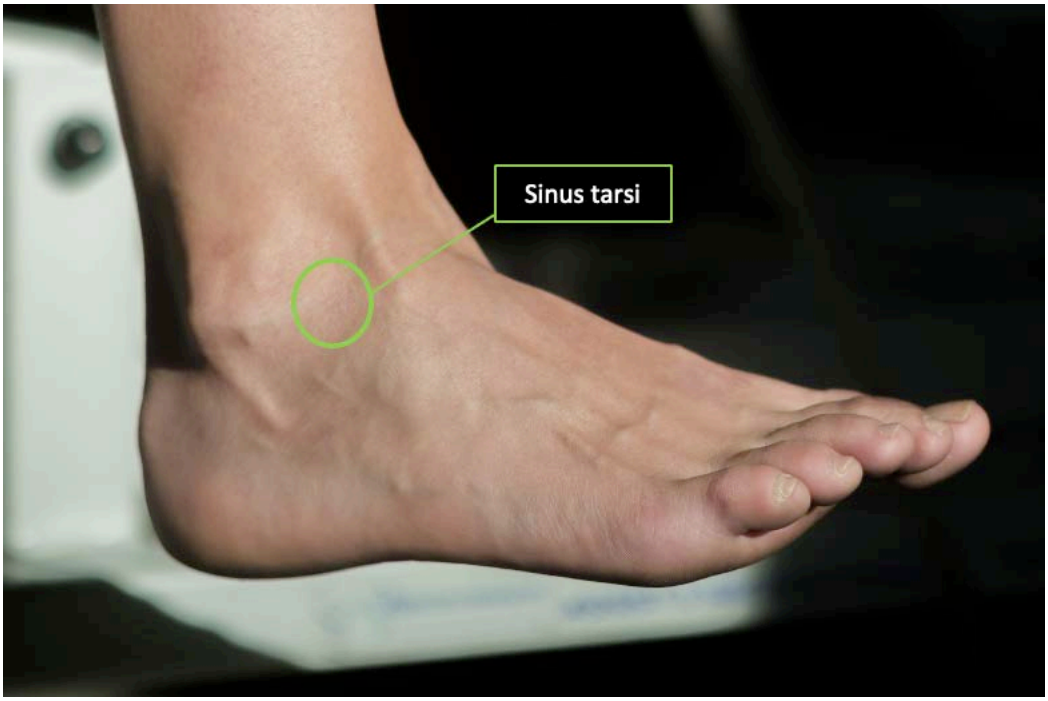


Figure 8.10. *Sinus Tarsi by Dan Silver is used under a CC BY 4.0 License.*

Anterior Talofibular Ligament

- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** Locate the lateral malleolus and palpate along the lateral aspect of the foot toward the neck of the talus. The anterior talofibular ligament traverses these landmarks and lies deep in the sinus tarsi.

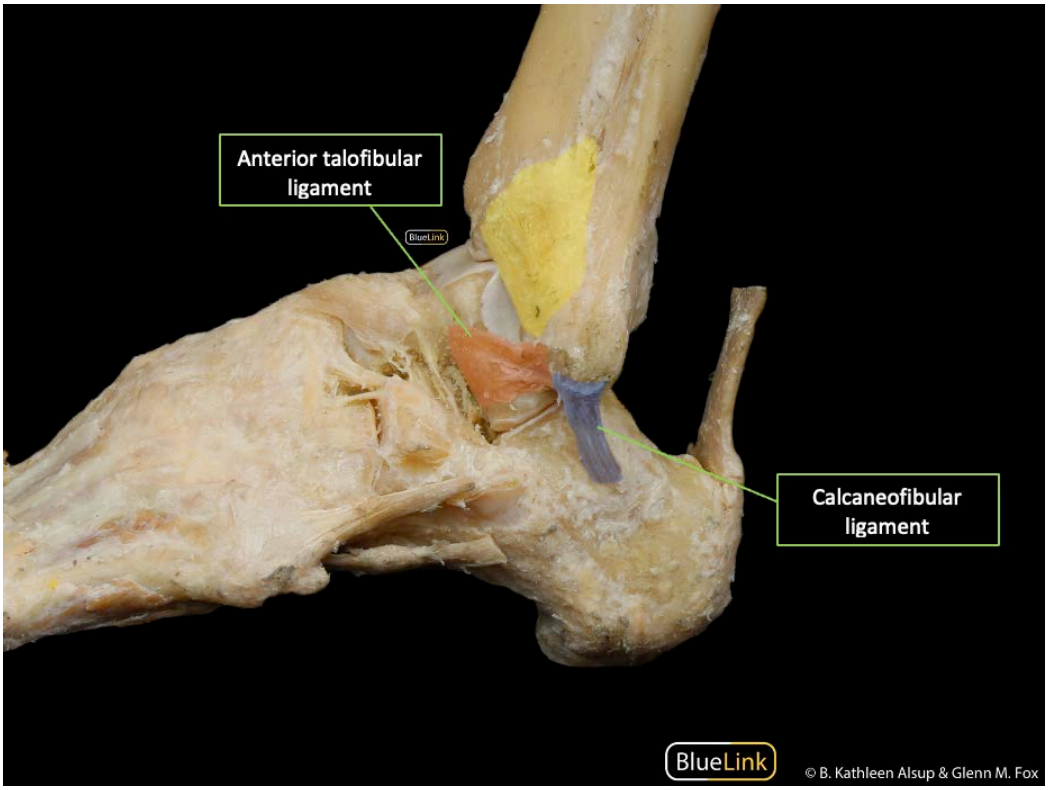


Figure 8.11. *Ligaments of the Lateral Ankle by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Calcaneofibular Ligament

- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** Locate the lateral malleolus and palpate in an inferior, posterior direction at approximately a 30-degree angle toward the calcaneus. The calcaneofibular ligament can be palpated as it traverses these landmarks.

Plantar Aponeurosis/Fascia

- **How to Palpate**

- **Position of Partner:** Prone
- **Directions:** Begin by palpating the medial and lateral aspects of the plantar surface of the calcaneus and follow the superficial tissue along the plantar surface of the foot toward the digits. You may better appreciate this tissue by using one hand to collectively extend the digits of the foot while simultaneously palpating along the plantar surface of the foot with the other hand.

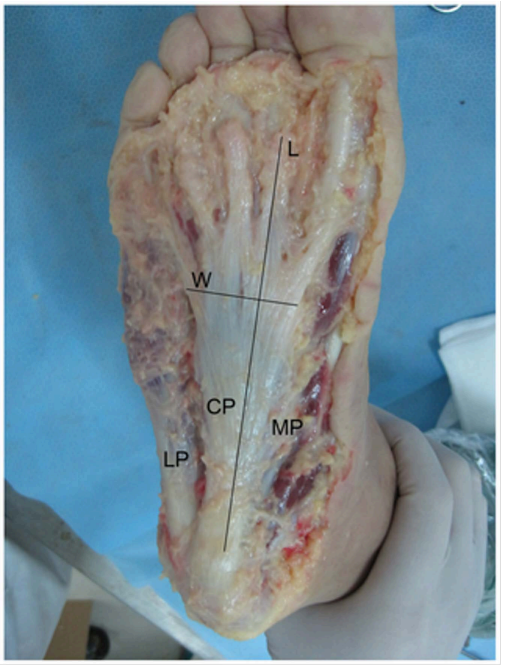


Figure 8.12. *Plantar Aponeurosis by Da-wei Chen, Bing Li, Ashwin Aubeeluck, Yun-feng Yang, Yi-gang Huang, Jia-qian Zhou, Guang-rong Yu is used under a CC BY 4.0 license.*

Dorsalis Pedis Artery

- **How to Palpate**
  - **Position of Partner:** Sitting, supine
  - **Directions:** Begin by locating the extensor hallicus longus tendon, which has been previously described, just distal to the talocrural joint on the dorsal aspect of the foot. Alternatively, you may locate the dorsal aspect of

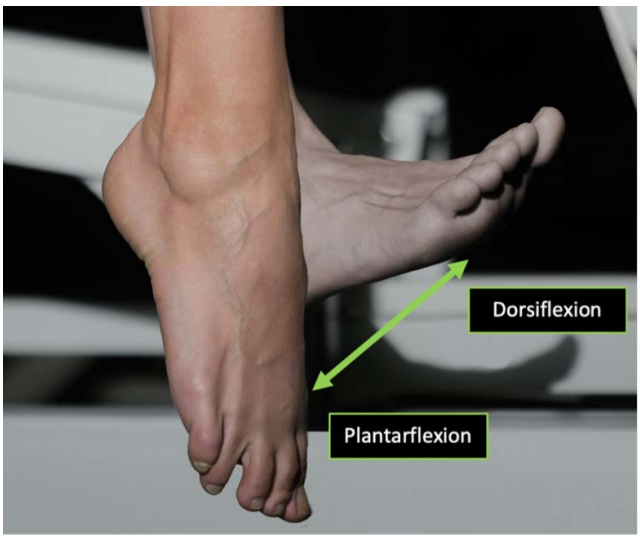
the navicular bone and move posterolaterally in the direction of the laterally malleolus. Appreciate the dorsalis pedis along either pathway.

Posterior Tibial Artery

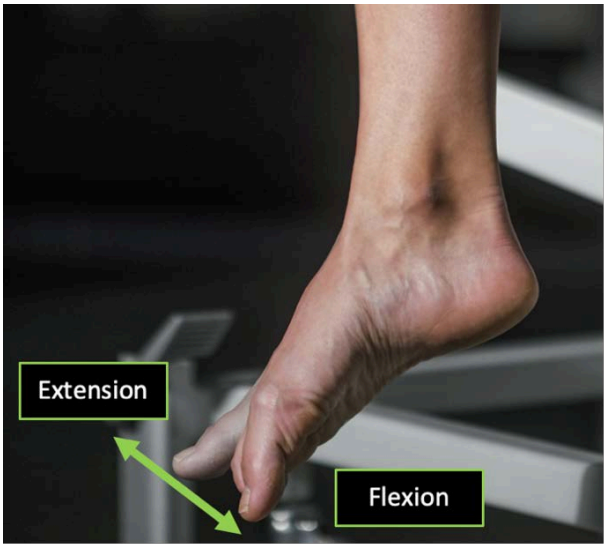
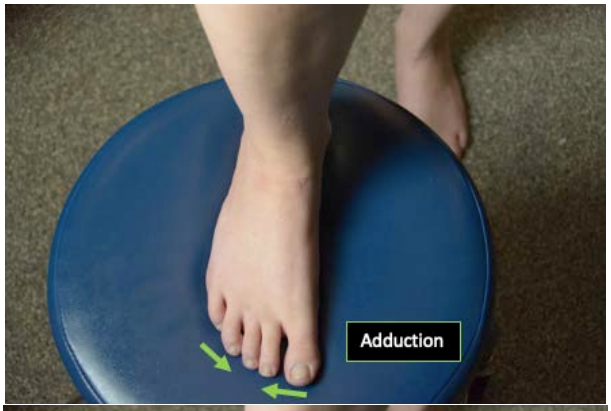
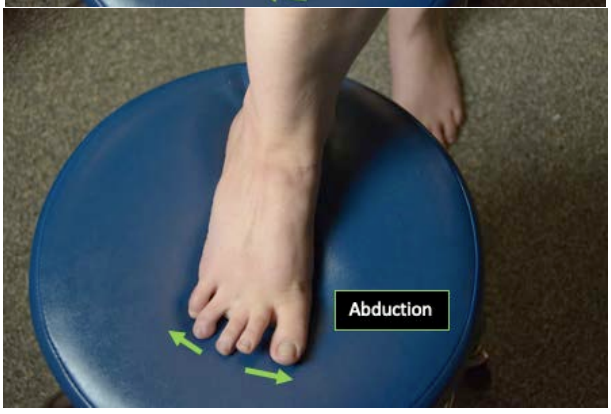
- **How to Palpate**
  - **Position of Partner:** Sitting, supine
  - **Directions:** Locate the posterior aspect of the distal medial malleolus and the insertion of the Achilles tendon on the calcaneus. Palpate directly posteriorly to the medial malleolus, moving toward the midpoint between the medial malleolus and calcaneus to appreciate the posterior tibial artery.

Range of Motion

Table 8.1 Range of Motion of the Ankle & Foot

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Ankle Dorsiflexion and Inversion	These motions come from the talocrural joint, between the distal end of the tibia and the talus. Always remember to encourage your partner to reach their full end range if you are assessing an active or resistive range of these motions.	

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Ankle Inversion and Eversion	This motion occurs at the subtalar joint, so it's important to focus on the hindfoot when assessing these ranges. For instance, when performing a passive range of motion assessment for these ranges it's important to grab the hind heel and move it in the frontal plane in the direction of inversion and eversion.	

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Flexion and Extension of the Toes	Flexion and extension occur at the metatarsophalangeal and interphalangeal joints. Depending on the purpose of these assessments, it may be appropriate to isolate individual joints or to assess all toes at once.	
Abduction and Adduction of the Toes	Abduction and adduction occur at the metatarsophalangeal joints. It's important to recognize that the midline for these motions is defined as being through the third toe, and the other toes either move toward this midline (adduction) or away from this midline (abduction).	 

Figures 8.13-8.18 by Dan Silver are used under a CC BY 4.0 License.

Clinical Correlations

Ankle Sprains

- **Background:** Ankle sprains are a common traumatic injury of the foot and ankle complex. A lateral ankle sprain is the most common ankle sprain, which typically occurs when the ankle and foot are forced into a position of excessive plantarflexion and inversion. Structures on the lateral side of the ankle and foot experience injury as they try to resist these forces. Specifically, the anterior talofibular ligament is the most common ligament affected by lateral ankle sprains.

Figure 8.19. *Lateral Ankle Sprain by Usien is used under a CC BY-SA 3.0 license.*

Ankle and Foot Fractures Using the Ottawa Ankle Rules

- **Background:** The Ottawa Ankle Rules are a highly sensitive screening tool to determine the need for radiographic imaging for a foot and/or ankle fracture following trauma. A healthcare professional will screen a patient to detect if any

of the following are present: 1) bony tenderness from the tip of the medial malleolus to 6 centimeters superiorly along the posterior edge of the tibia, 2) bony tenderness from the tip of the lateral malleolus to 6 centimeters superiorly along the posterior edge of the fibular, 3) bony tenderness at the navicular bone, 4) bony tenderness at the base of the 5th metatarsal, and 5) inability to bear weight for four steps immediately after the injury and in the emergency department. If any of these symptoms are found on a clinical examination, the patient should be referred to an emergency department for radiographic imaging.

Achilles Tendinopathy

- **Background:** Achilles tendinopathy is a common overuse injury, resulting in histological tendon changes and pain during walking, running, and/or jumping. It typically affects individuals in their third through fifth decades, and most commonly affects active patient populations. Palpation of the Achilles tendon may be useful to appreciate changes in the thickness of the Achilles tendon, detect pain along the midportion or insertion of the tendon, and differentiate Achilles pain from pain in other locations of the foot and ankle complex.

Review Questions: Skeletal Landmarks of the Ankle and Foot

1. The sustentaculum tali is located on the (medial / lateral) aspect of the foot, and the sinus tarsi is located on the (medial / lateral) aspect of the foot.
2. The medial malleolus is an extension of the (tibia / fibula), and the lateral malleolus is an extension of the (tibia / fibula).
3. The (head of the talus / trochlea of the talus / medial tubercle of the talus) is the articulating surface of the talus with the tibia to form the proper ankle joint.
4. The navicular bone is (medial / lateral) to the cuboid bone.
5. The anterior talofibular ligament is located (superior and anterior / superior and posterior / inferior and anterior / inferior and posterior) to the calcaneofibular ligament.

6. The tibia extends down the shank (medially / laterally) to the fibula.
7. The 5th metatarsal aligns with what tarsal bone proximally?
8. What bony landmark does the gastroc-soleus complex insert on to?
9. The plantar surface of the distal 1st phalanx is the insertion site for (flexor digitorum longus / flexor hallucis longus / tibialis posterior).
10. Arrange the following landmarks from proximal to distal: proximal phalanx of 1st digit, navicular, medial cuneiform, calcaneus.

Review Questions: Musculature of the Ankle and Foot

1. What is the muscle action of the tibialis anterior?
2. What nerve innervates the fibularis longus muscle?
3. Arrange the following muscles in order from superficial to deep: tibialis posterior, gastrocnemius, soleus.
4. Which of the following muscles does not facilitate ankle dorsiflexion as a primary or secondary movement: tibialis anterior, fibularis tertius, or extensor digitorum brevis?
5. The lateral plantar nerve innervates which of the following muscles: abductor hallucis, flexor digitorum brevis, or abductor digiti minimi?
6. Arrange the following muscles from medial to lateral as they appear in the posterior compartment: flexor hallucis longus, tibialis posterior, flexor digitorum longus.
7. What are the two actions of the fibularis brevis muscle?
8. If an individual were to complain of muscle weakness and pain with ankle dorsiflexion, which of the following nerves would most likely be involved? deep fibular nerve, superficial fibular nerve, medial plantar nerve, or tibial nerve.
9. Flexor hallucis longus performs flexion of the ____ digit(s), and flexor digitorum longus performs flexion of the _____ digit(s).

10. Flexor digitorum brevis is innervated by what nerve?

9. The Head and Neck

Skeletal Landmarks with Palpation Landmarks

Figure 9.1. *Anterior View of the Mandible by Kathleen Alsup & Glenn M. Fox is used with permission of the author.*

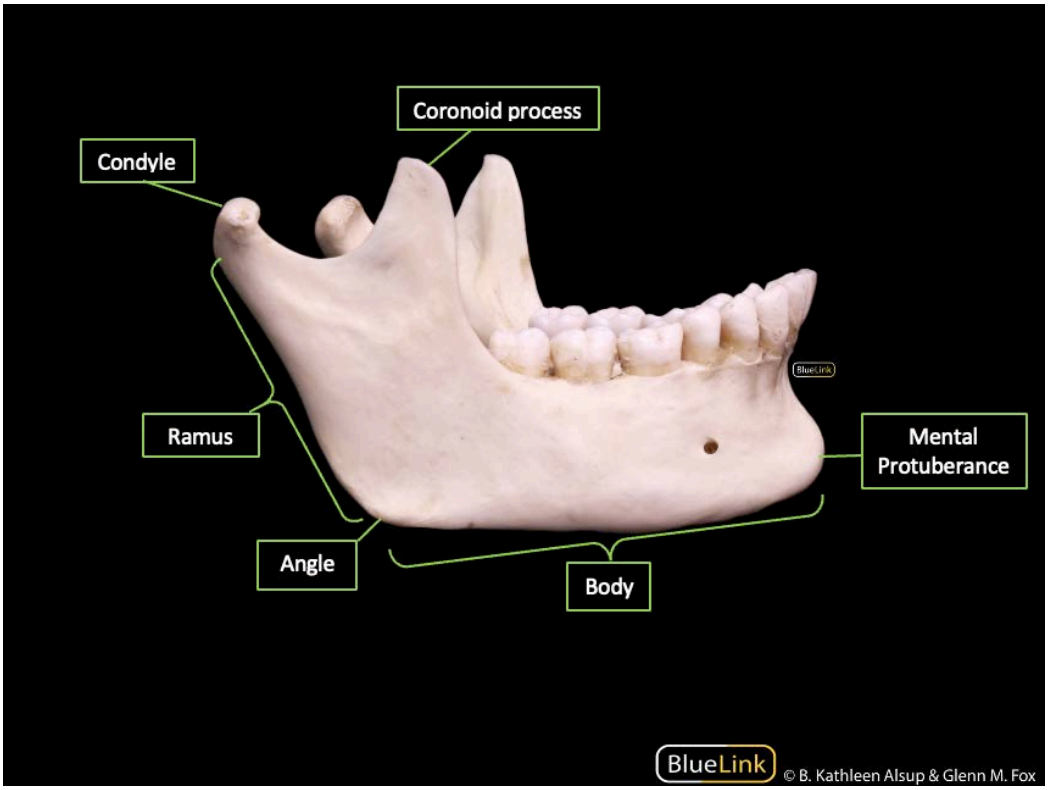


Figure 9.2. *Skeletal Landmarks of the Mandible; Sagittal View by Kathleen Alsup & Glenn M. Fox is used with permission of the author.*

Figure 9.3. *The Hyoid Bone by Kathleen Alsup & Glenn M. Fox is used with permission of the author.*

Mandible

- **Condyle**
  - **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Locate the temporomandibular joint, which is located anterior to the tragus, or middle, of the external ear. Instruct your partner to open and close their mouth while you palpate for the condyle of the mandible, which rotates and anteriorly slides during the opening of the mouth.
  - **Muscles That Attach Here:** Lateral pterygoid
- **Angle**
  - **How to Palpate**

        - **Position of Partner:** Sitting
        - **Directions:** Locate the superior ramus of the condyle and palpate inferiorly toward the angle. This is the point of the mandible where it changes direction. Appreciate the rounded angle of the mandible as it serves as the transition toward the mandibular body.
    - **Muscles That Attach Here:** Masseter
    - **Structure That Attaches Here:** Stylomandibular ligament
- **Ramus**
    - **How to Palpate**
        - **Position of Partner:** Sitting
        - **Directions:** Locate the condyle and angle of the mandible using the strategies above and palpate toward the midpoint of these structures along the broad ramus of the mandible.
    - **Muscles That Attach Here:** Masseter, medial pterygoid, temporalis
- **Mental Protuberance**
    - **How to Palpate**
        - **Position of Partner:** Sitting
        - **Directions:** Locate the midpoint of the right and left halves of the mandible, located anteriorly along the sagittal plane of the face. Palpate the anterior chin, appreciating the slight ridge here, which is the mental protuberance.
- **Body**
    - **How to Palpate**
        - **Position of Partner:** Sitting
        - **Directions:** Appreciate the mental protuberance and the angle of the mandible's boundaries to the body of the mandible. Palpate along the mandible toward the midpoint of both structures, identifying the broad mandibular body along this pathway.
    - **Muscles That Attach Here:** Mylohyoid, geniohyoid

Hyoid

- **How to Palpate**
    - **Position of Partner:** Sitting, supine

- **Directions:** Palpate the thyroid cartilage, where the laryngeal prominence, or Adam's apple, can be identified along the midline of the anterior neck. Slide superiorly along the midline of the neck until you palpate the skeletal body of the hyoid. Alternatively, you may begin at the midpoint of the chin and palpate inferiorly until the hyoid bone is identified. Be aware that this may be an uncomfortable palpation for your partner, so monitor their comfort as you proceed through the process of locating this bone.

- **Muscles That Attach Here:** Suprahyoids: digastric, stylohyoid, mylohyoid, geniohyoid; Infrahyoids: omohyoid, sternohyoid, thyrohyoid

Musculature with Palpation Landmarks

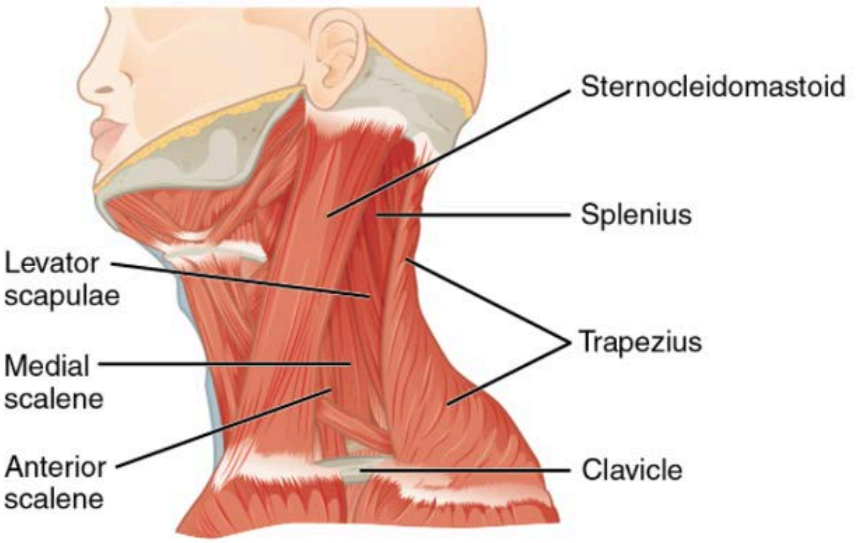


Figure 9.4. *Muscles of the Neck; Sagittal View by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (cropped) and is used under a CC BY 4.0 license.*

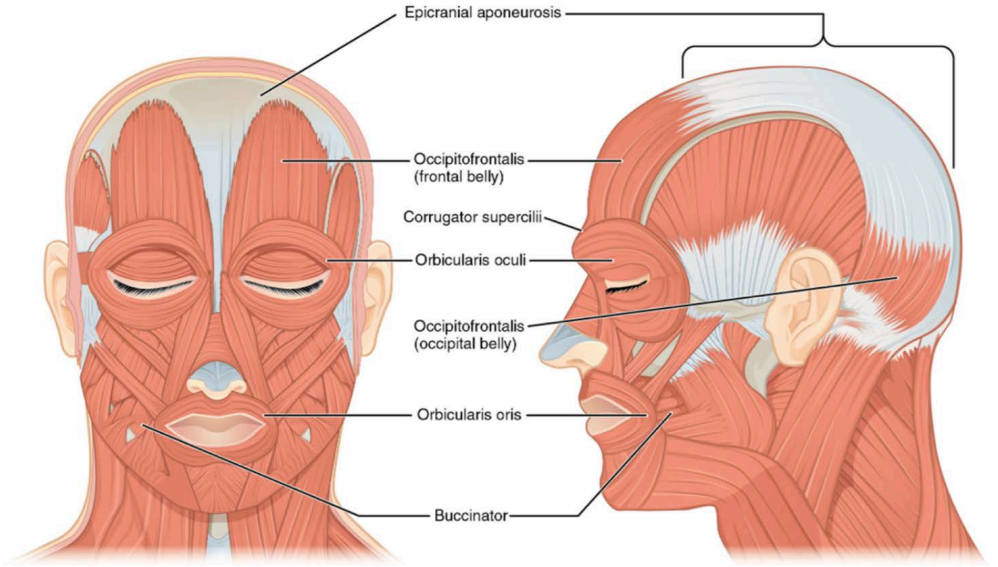


Figure 9.5. *Muscles of the Face; Anterior and Sagittal Views by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix is used under a CC BY 4.0 license.*

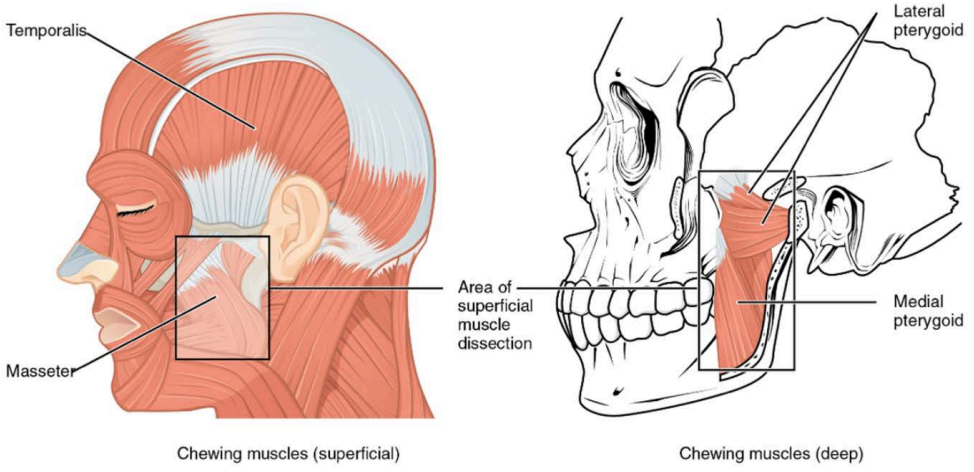


Figure 9.6. *Muscles of the face; Sagittal Views of Superficial and Deep Muscles by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix is used under a CC BY 4.0 license.*

Sternocleidomastoid

- **Origin(s):** Mastoid process, superior nuchal line of the occipital bone
- **Insertion(s):** Manubrium (sternal head), clavicle (clavicular head)
- **Action(s):**
    - **Unilateral:** Ipsilateral cervical flexion, contralateral cervical rotation
    - **Bilateral:** Cervical flexion, atlanto-occipital extension
- **Innervation(s):** Spinal accessory nerve (CN XI)
- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin by locating the sternoclavicular joint, which serves as the midpoint for the distal attachments of the sternocleidomastoid at the medial clavicle and manubrium. Instruct your partner to rotate their head to the contralateral side (e.g., if palpating on your partner's right, instruct them to look left), and visually locate the sternocleidomastoid as it contracts and becomes more prominent while facilitating this motion. Then palpate along this muscle toward its origin at the mastoid process and the superior nuchal line.

Upper Trapezius

- **Origin(s):** Nuchal line, nuchal ligament, external occipital protuberance
- **Insertion(s):** Clavicle, acromion process
- **Action(s):** Scapular elevation, cervical side bending
- **Innervation(s):** Spinal accessory nerve (CN XI)
- **How to Palpate**
    - **Position of Partner:** Sitting, prone
    - **Directions:** Begin by palpating along the acromion process and lateral clavicle and instruct your partner to elevate their ipsilateral shoulder. Palpate along the muscle belly of the upper trapezius as it attaches to the cervical spine and cranium at the nuchal line, nuchal ligament, and external occipital protuberance.

Scalenes

- **Origin(s):**
  - **Anterior:** Transverse process C3-6
  - **Middle and Posterior:** Transverse process of C5-7
- **Insertion(s):**
  - **Anterior and Middle:** 1st rib
  - **Posterior:** 2nd rib
- **Action(s):**
  - **Anterior and Middle:** Cervical flexion, 1st rib elevation
  - **Posterior:** Cervical side bending, 2nd rib elevation during inspiration
- **Innervation(s):** Anterior rami
- **How to Palpate**
  - **Position of Partner:** Supine
  - **Directions:** While your partner is in supine position, support the head with one hand and locate the posterior triangle of the lateral aspect of the neck. This triangle is formed by the sternocleidomastoid, the upper trapezius, and the clavicle. Once this triangle is visualized, palpate deep into the triangle to access the scalenes. The anterior and middle scalenes can be best appreciated due to their anatomical arrangement and can be followed to their insertion on the first rib.

Masseter

- **Origin(s):** Zygomatic bone
- **Insertion(s):** Angle and ramus of the mandible
- **Action(s):** Mandible elevation
- **Innervation(s):** Trigeminal nerve (CN V)
- **How to Palpate**
  - **Position of Partner:** Sitting
  - **Directions:** Palpate the angle of the mandible using the instructions above and instruct your partner to clench their teeth. Palpate superiorly toward the zygomatic bone along the broad, thick masseter muscle.

Temporalis

- **Origin(s):** Temporal fossa of the temporal bone
- **Insertion(s):** Coronoid process and ramus of the mandible
- **Action(s):** Mandible elevation
- **Innervation(s):** Trigeminal nerve (CN V)
- **How to Palpate**
    - **Position of Partner:** Sitting, supine
    - **Directions:** Place your fingers on the lateral aspect of the cranium, located approximately two to three finger breadths superior to the zygomatic arch or posterior-superior to the lateral aspect of the orbit. Instruct your partner to clench their teeth to appreciate a contraction of the temporalis muscle.

Medial Pterygoid

- **Origin(s):** Palatine bones, maxillary bones
- **Insertion(s):** Ramus of mandible
- **Action(s):** Elevates mandible, contralateral lateral deviation
- **Innervation(s):** Trigeminal nerve (CN V)
- **How to Palpate**
    - **Position of Partner:** Sitting, supine
    - **Directions:** This muscle can be palpated extraorally or intraorally. All intraoral palpation should be completed after appropriately donning medical gloves. Extraoral palpation is performed with your partner's head in slight flexion and pressing upward at the angle of the inner surface of the mandible. Intraoral palpation is achieved by sliding a finger along the inner portion of the molars until you palpate the muscle tissue located along the inner portion of the ramus.

Lateral Pterygoid

- **Origin(s):** Sphenoid

- **Insertion(s):** Temporomandibular joint, condyloid process of mandible
- **Action(s):** Mandibular protraction, contralateral lateral deviation
- **Innervation(s):** Trigeminal nerve (CN V)
- **How to Palpate**
    - **Position of Partner:** Sitting, supine
    - **Directions:** Conflicting evidence exists regarding reliable palpation of the lateral pterygoid. Proposed palpation procedures would require supine positioning of the patient. Wearing a medical glove, slide a finger along the lateral aspect of the upper molars. Continue in a posterior-superior direction toward the condyloid process.

Other Anatomical Landmarks

Temporomandibular Joint

- **How to Palpate**
    - **Position of Partner:** Sitting
    - **Directions:** Begin by locating the tragus of the external ear, and palpate anteromedially until you meet the mandibular condyle, located at the inferior aspect of the temporomandibular joint. Instruct your partner to open and close their mouth, appreciating the degree of movement of the condyle on the articular eminence, thus appreciating the degree of movement of this joint.

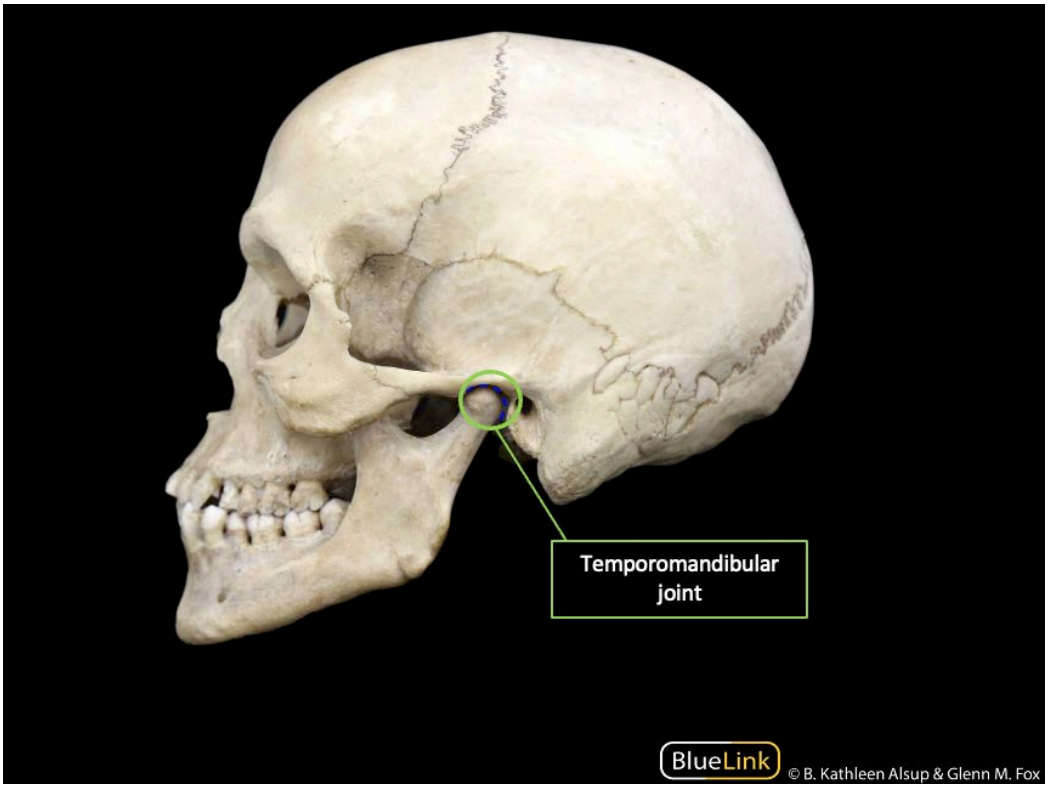


Figure 9.7. *The Temporomandibular Joint; Sagittal View by Kathleen Alsup & Glenn M. Fox has been modified (altered) and is used with permission of the author.*

Laryngeal Prominence of the Thyroid Cartilage

- **How to Palpate**
  - **Position of Partner:** Sitting, supine
  - **Directions:** Orient to the anterior neck, through its superior and inferior borders, the chin and jugular notch, respectively. Follow superior to inferior, or inferior to superior, along the midline of the neck. Locate a prominent ridge along the anterior neck, located approximately two-thirds of the length of the neck, superior to the jugular notch. The laryngeal prominence is colloquially known as the "Adam's apple."

Carotid Artery

- **How to Palpate**
  - **Position of Partner:** Supine, sitting
  - **Directions:** Locate the anteromedial aspect of the sternocleidomastoid and the trachea at the level of the cricoid cartilage. You may move from medial to lateral, or lateral to medial, targeting the middle third of the neck. Gently palpate the carotid artery.

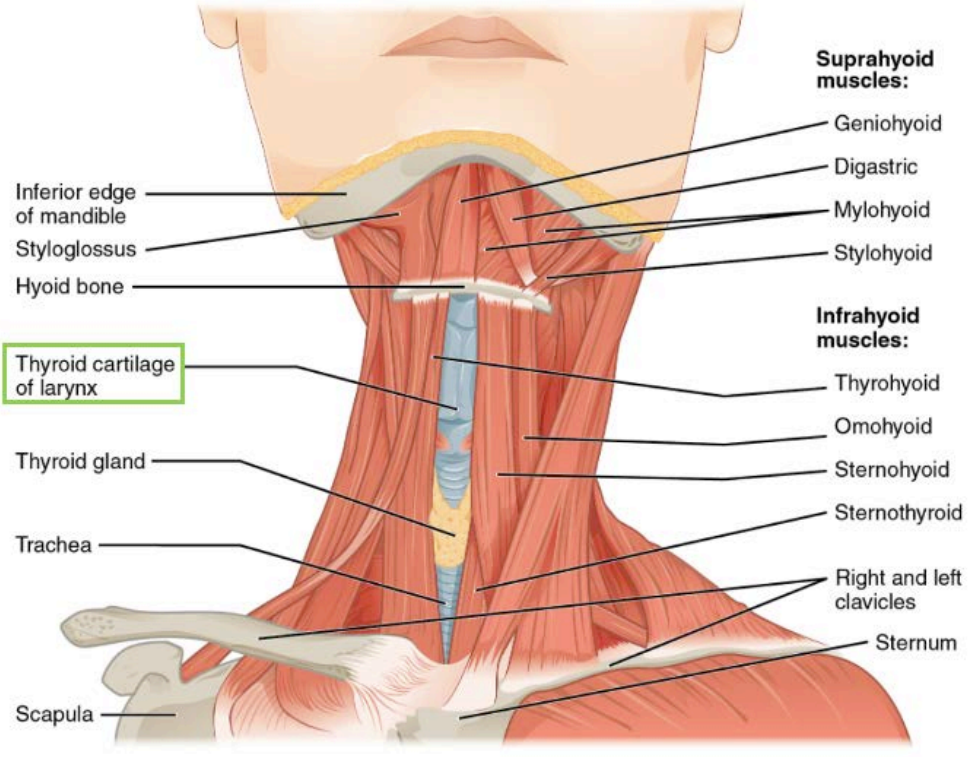


Figure 9.8. *Thyroid Cartilage of the larynx by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (altered) and is used under a CC BY 4.0 license.*

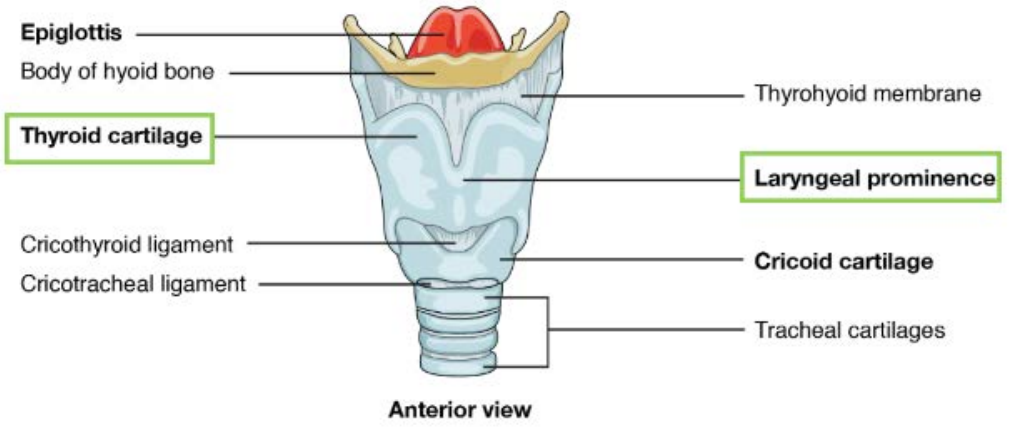
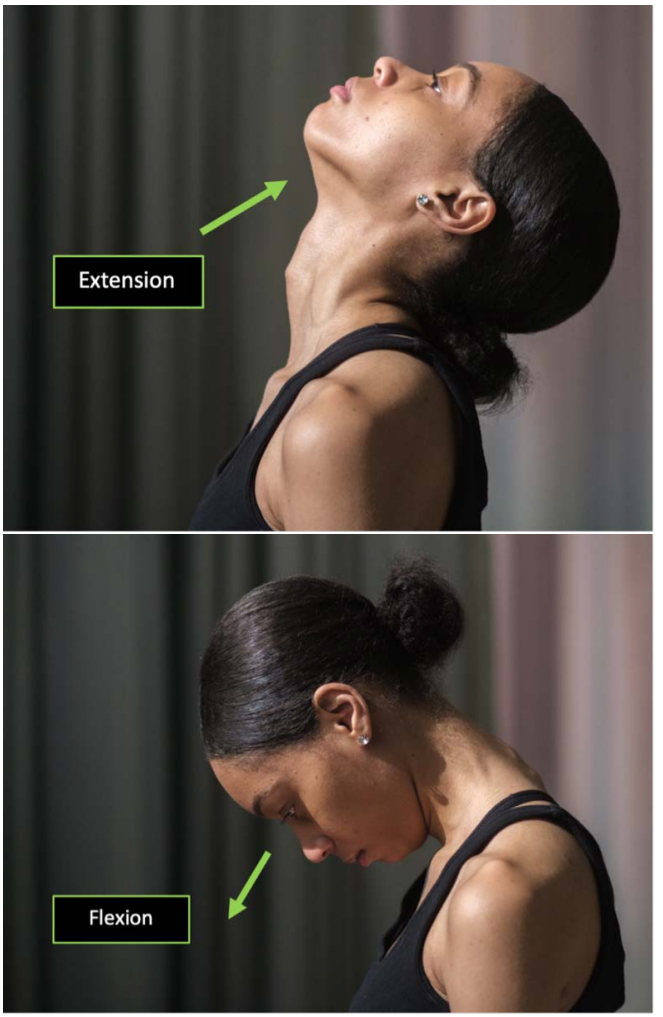


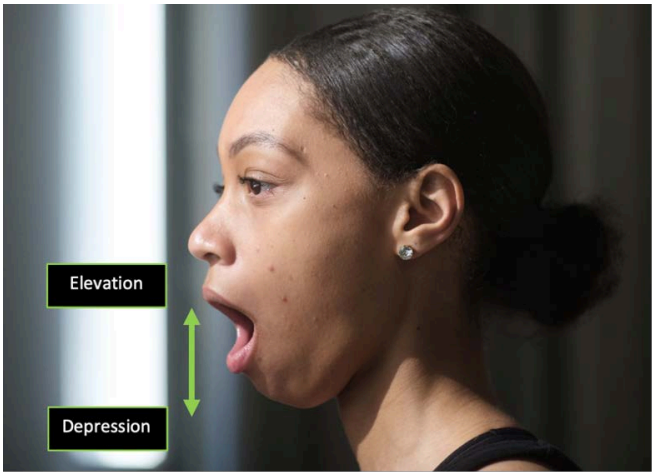
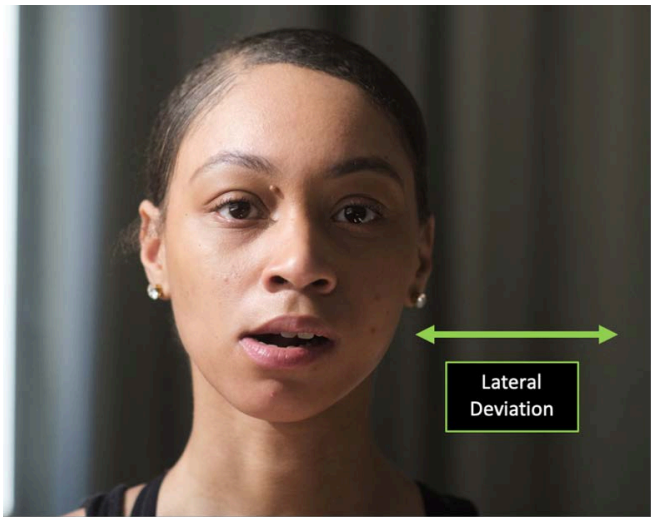
Figure 9.9. *Thyroid Cartilage and Laryngeal Prominence by J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix has been modified (altered) and is used under a CC BY 4.0 license.*

Range of Motion

Table 9.1

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Cervical Flexion and Extension		

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Cervical Lateral Flexion	This motion occurs at the subtalar joint, so it's important to focus on the hindfoot when assessing these ranges. For instance, when performing a passive range of motion assessment for these ranges, it's important to grab the hind heel and move it in the frontal plane in the direction of inversion and eversion.	
Cervical Rotation	Flexion and extension occur at the metatarsophalangeal and interphalangeal joints. Depending on the purpose of these assessments, it may be appropriate to isolate individual joints or to assess all toes at once.	

Joint Actions	Tips for ROM Assessment	Picture of Joint Action
Depression and Elevation of the Mandible		
Lateral Deviation of the Mandible		

Figures 9.10-9.15 by Dan Silver are used under a CC BY 4.0 License.

Clinical Correlations

Whiplash

- **Background:** Whiplash is the most common type of injury following a motor vehicle accident. Whiplash occurs when an individual experiences rapid movement of the neck (e.g., neck flexion to neck extension) and typically results in neck pain, decreased range of motion of the cervical spine, and/or functional activity deficits. Muscles, ligaments, and cervical facet joints of the cervical spine may be implicated in a whiplash injury. Whiplash is typically treated through physical therapy and medical management.

Temporomandibular Joint (TMJ) Pain

- **Background:** Temporomandibular joint pain is a multifactorial musculoskeletal pain condition affecting muscular and/or articular structures of the temporomandibular joint. In addition to pathoanatomical structures, temporomandibular joint pain may be secondary to parafunctional behaviors, psychological distress, or psychosocial dysfunction. An assessment of range of motion and palpation of muscle tissue of the face and TMJ are typically performed to develop a plan of care for these patient populations.

Spinal Accessory Nerve Palsy

- **Background:** A spinal accessory nerve palsy is a transient or permanent loss of nerve function typically due to trauma or a surgical procedure. Muscle weakness in tissues innervated by the spinal accessory nerve, pain in the neck/shoulder complex, and altered shoulder motion are typical physical examination findings. The spinal accessory nerve innervates the trapezius and sternocleidomastoid. In addition to a thorough review of a patient's medical information and subjective history, a physical examination may assist in the differential diagnosis process.

Review Questions: Skeletal Landmarks of the Head and Neck

1. The masseter, medial pterygoid, and temporalis attach to what bony structure?
2. The (angle / condyle) is located between the ramus and body of the mandible.
3. The hyoid is located (superior / inferior) to the laryngeal prominence.
4. Describe how you would palpate the temporomandibular joint.
5. During lateral deviation to the right, the right TMJ glides (laterally / medially), and the left TMJ glides (laterally / medially).

Review Questions: Musculature of the Head and Neck

1. The spinal accessory nerve innervates the (sternocleidomastoid / scales / masseter).
2. What muscles are responsible for mandible elevation?
3. Which of the following motions occurs in the frontal plane? (Cervical flexion / cervical extension / cervical side bending)
4. What is the action(s) of the lateral pterygoid?
5. Unilateral contraction of the sternocleidomastoid results in (ipsilateral / contralateral) cervical rotation.

Answer Key

Chapter 2: Skeletal Landmarks of the Shoulder and Arm

1. Superior angle of the scapula
2. Greater tubercle of the humerus
3. Anterior
4. A tuberosity is created by a muscle pulling on the bone.
5. Acromioclavicular ligament
6. Supraspinous fossa
7. Acromion process
8. Sternum; scapula
9. Intertubercular sulcus/groove
10. A fossa is a slight depression.

Chapter 2: Musculature of the Shoulder and Arm

1. Coracobrachialis, biceps brachii, and pectoralis minor
2. Radial tuberosity
3. Long head of the biceps brachii
4. True
5. Trapezius
6. Medially (internally)
7. Anterior deltoid, pectoralis major, biceps brachii, coracobrachialis
8. Triceps brachii
9. Pectoralis minor
10. Abducts; acromion process

Chapter 3: Skeletal Landmarks of the Elbow and Forearm

1. Olecranon fossa
2. Annular
3. Medial; lateral
4. Olecranon process and medial epicondyle
5. Supracondylar
6. Distal
7. Ulna

8. Posterior
9. Lateral; medial
10. Radial fossa

Chapter 3: Musculature of the Elbow and Forearm

1. Extension of the wrist and radial deviation
2. Triceps brachii
3. Biceps brachii
4. Medial epicondyle; lateral epicondyle
5. Brachioradialis, brachialis
6. Distal; proximal
7. 2–5
8. Anterior
9. Proximal; distal
10. Extend

Chapter 4: Skeletal Landmarks of the Wrist and Hand

1. Posterior
2. Metacarpal
3. Middle phalanx; distal phalanx
4. Capitate and lunate
5. Dorsal
6. Proximal; distal
7. Pinkie
8. Scaphoid and trapezium
9. Distal; proximal
10. So Long to Pinky, Here Comes the Thumb

Chapter 4: Musculature of the Wrist and Hand

1. Flex; extend
2. Posterior
3. One
4. 1st digit; 5th digit
5. 3rd digit
6. 2–5
7. Touching your thumb to your pinkie

8. Adduct; abduct
9. Adductor pollicis
10. Pisiform

Chapter 5: Skeletal Landmarks of the Spine, Thorax, and Abdomen

1. Six cervical, twelve thoracic, and five lumbar vertebrae
2. Frontal
3. Posterior
4. Xiphoid process
5. Twelve
6. 12th thoracic vertebrae
7. Seven
8. Intervertebral foramen
9. Inferior articulating process
10. T7

Chapter 5: Musculature of the Spine, Thorax, and Abdomen

1. Iliocostalis
2. Elevate; depress
3. Superficial
4. C7
5. Splenius capitis
6. Iliac crest
7. Semispinalis, multifidus, rotatores
8. Contralateral; ipsilateral
9. Diaphragm
10. Intercostals (external and internal)

Chapter 6: Skeletal Landmarks of the Hip and Thigh

1. Iliac crest and fossa, ala of sacrum, anterior sacroiliac ligaments
2. Sartorius, tensor fascia latae
3. False
4. Palpate at the navel and move inferiorly along the midline of the abdomen until you palpate the bony ridge of the pubic crest. This will be the first skeletal landmark you feel when moving in this direction.
5. Lateral

6. Inferior
7. Head of fibula
8. Ilium, ischium, pubis
9. ASIS and pubic tubercle
10. Pectineus

Chapter 6: Musculature of the Hip and Thigh

1. Sartorius, semitendinosus, gracilis
2. Flexion, abduction, and lateral rotation of the hip
3. True
4. Rectus femoris
5. Hip abduction, medial rotation
6. True
7. Extension; flexion
8. Flexion; extension
9. Semitendinosus
10. Proximal

Chapter 7: Skeletal Landmarks of the Knee and Lower Leg

1. Inferior
2. Lateral condyle of the proximal tibia (Gerdy's tubercle)
3. Long head; short head
4. Adductor tubercle
5. Tibial plateau
6. Base of patella
7. Proximal: medial epicondyle of femur; Distal: medial aspect of proximal tibia
8. Proximally
9. Medial tibial plateau
10. Rectus femoris

Chapter 7: Musculature of the Knee and Lower Leg

1. Rectus femoris, vastus lateralis, vastus intermedius, vastus medialis
2. Flexor; extensor
3. Knee flexion, hip extension
4. Deep
5. Sartorius, semitendinosus, gracilis

6. Extensor; flexor
7. Knee extension
8. Tibial and common fibular nerves
9. Ankle plantarflexion, knee flexion
10. Ankle plantarflexion

Chapter 8: Skeletal Landmarks of the Ankle and Foot

1. Medial; lateral
2. Tibia; fibula
3. Trochlea of talus
4. Medial
5. Superior and anterior
6. Medially
7. Cuboid
8. Calcaneal tuberosity
9. Flexor hallicus longus
10. Calcaneus, navicular, medial cuneiform, proximal phalanx of 1st digit

Chapter 8: Musculature of the Ankle and Foot

1. Ankle dorsiflexion, inversion
2. Superficial fibular nerve
3. Gastrocnemius, soleus, tibialis posterior
4. Extensor digitorum brevis
5. Abductor digiti minimi
6. Flexor digitorum longus, tibialis posterior, flexor hallucis longus
7. Dorsiflexion, eversion
8. Deep fibular nerve
9. 1st; 2nd–5th
10. Medial plantar nerve

Chapter 9: Skeletal Landmarks of the Head and Neck

1. Ramus of mandible
2. Angle
3. Superior
4. Position your partner seated. Begin by locating the tragus of the external ear, and palpate anteromedially until you meet the mandibular condyle located at

the inferior aspect of the temporomandibular joint. Instruct your partner to open and close their mouth, appreciating the degree of movement of the condyle on the articular eminence, thus appreciating the degree of movement at this joint.

5. Laterally; medially

Chapter 9: Musculature of the Head and Neck

1. Sternocleidomastoid
2. Temporalis, masseter, medial pterygoid
3. Cervical sidebending
4. Mandibular protraction and lateral deviation
5. Contralateral