Shoulder biomechanics

by

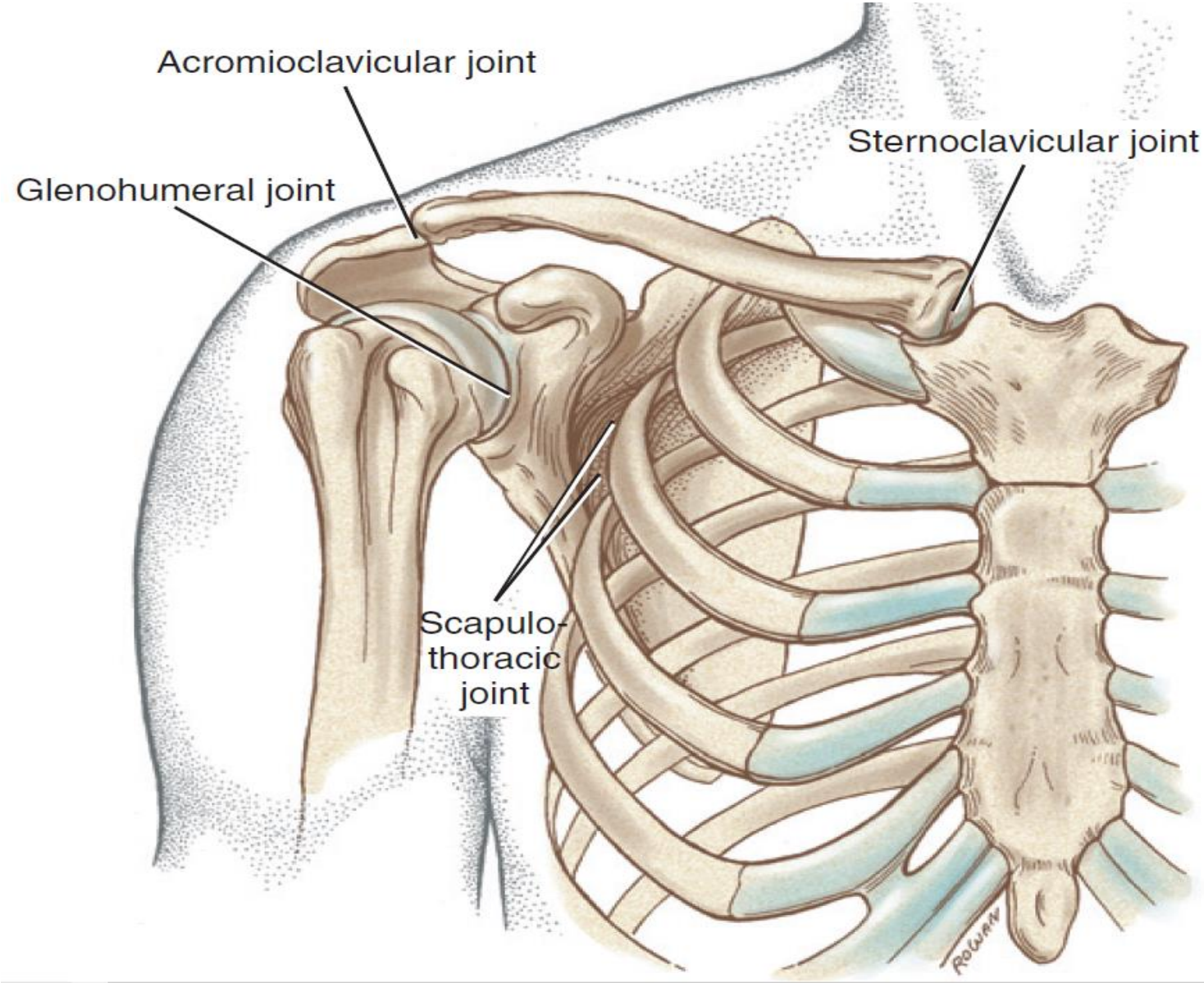
Waleed saber

Orthopedic physical therapy lecturer

s.v.u.

Shoulder Complex

- a set of four mechanically interrelated articulations involving the sternum, clavicle, ribs, scapula, and humerus.
- These joints provide extensive range of motion to the upper extremity

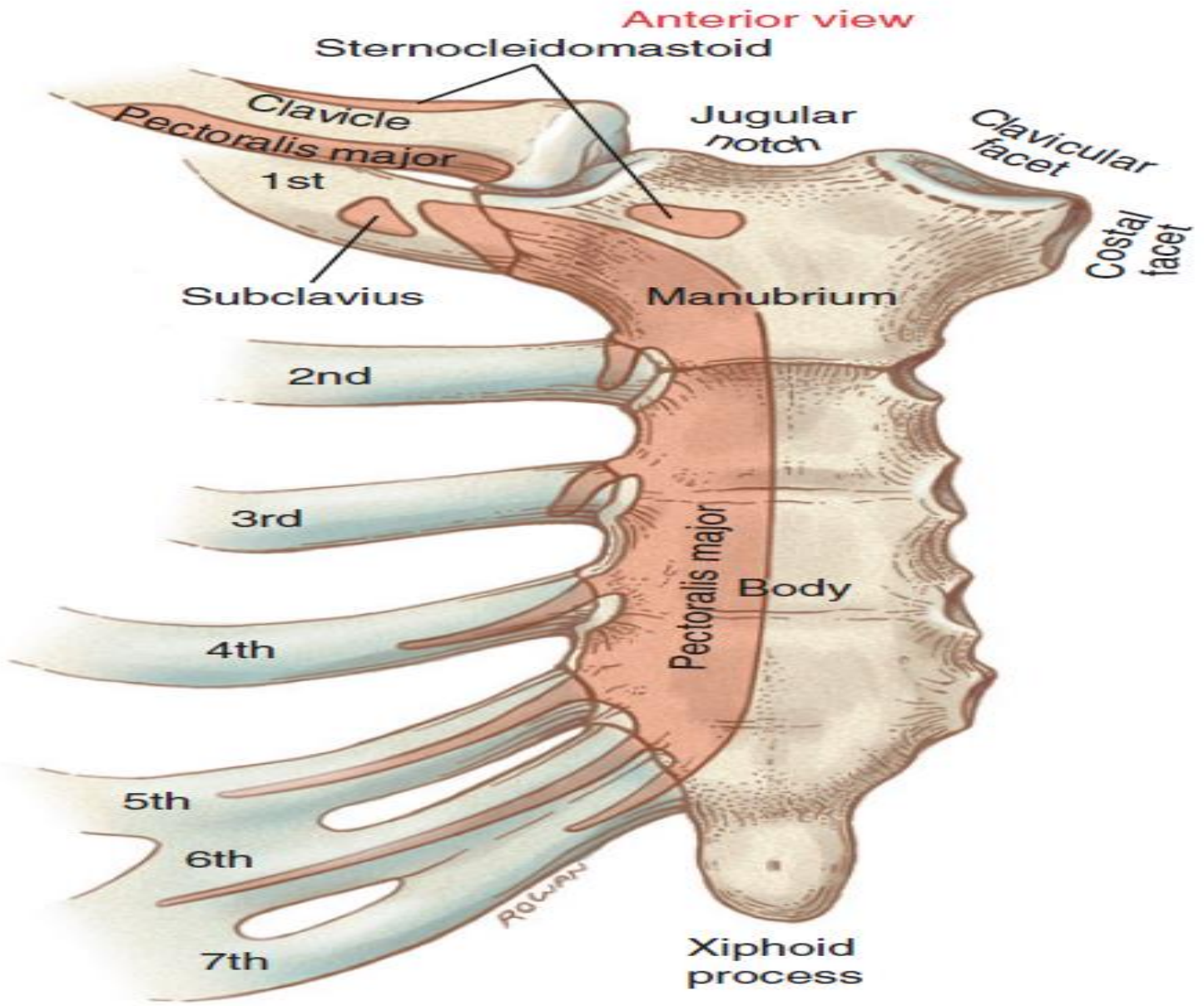


OSTEOLOGY

sternum

Osteologic Features of the Sternum

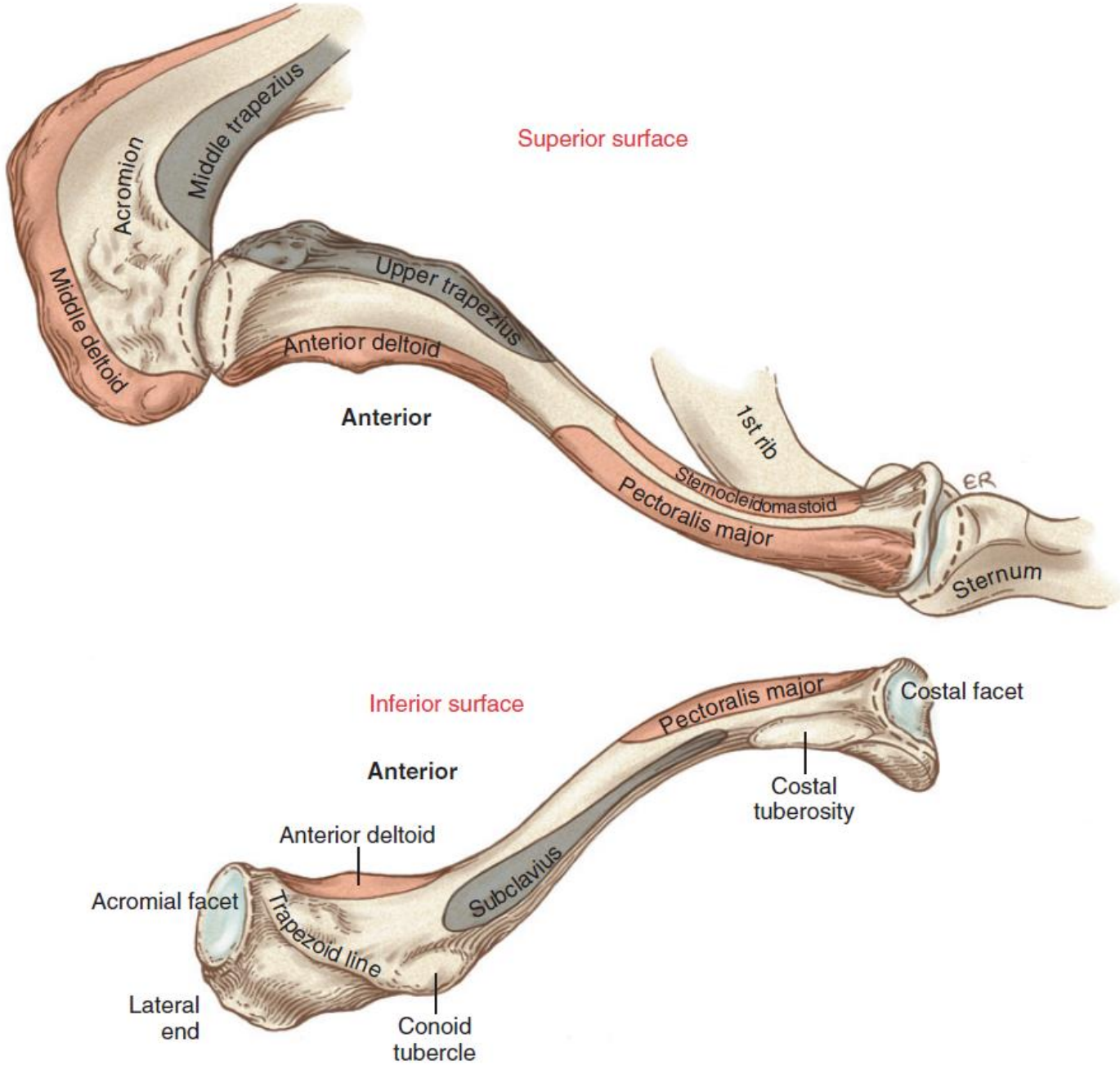
- Manubrium
- Clavicular facets
- Costal facets
- Jugular notch



Clavicle

Osteologic Features of the Clavicle

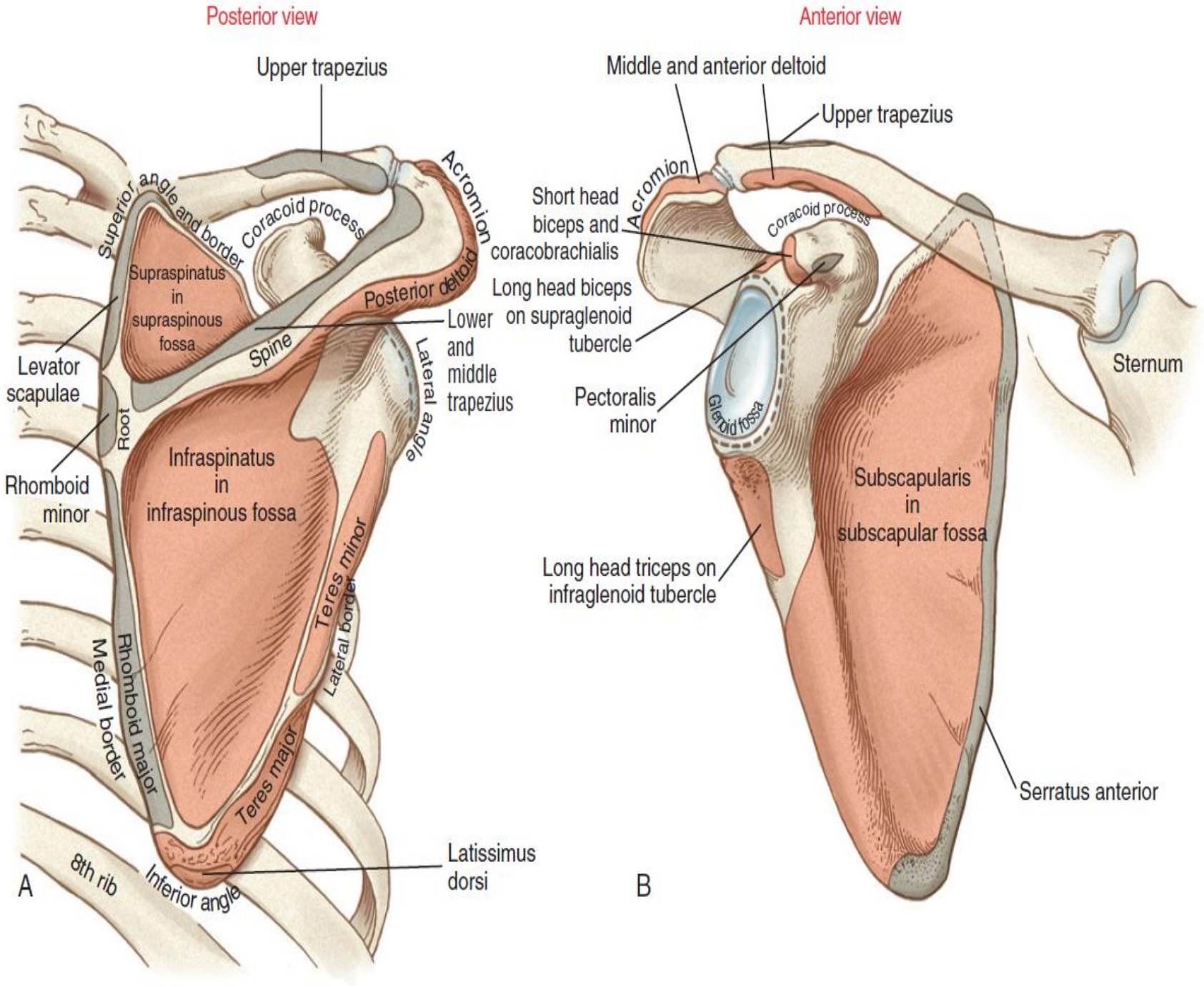
- Shaft
- Sternal end
- Costal facet
- Costal tuberosity
- Acromial end
- Acromial facet
- Conoid tubercle
- Trapezoid line



Scapula

Osteologic Features of the Scapula

- Angles: inferior, superior, and lateral
- Medial or vertebral border
- Lateral or axillary border
- Superior border
- Supraspinous fossa
- Infraspinous fossa
- Spine
- Root of the spine
- Acromion
- Clavicular facet
- Glenoid fossa
- Supraglenoid and infraglenoid tubercles
- Coracoid process
- Subscapular fossa



Proximal-to-Mid Humerus

Osteologic Features of the Proximal-to-Mid Humerus

- Head of the humerus
- Anatomic neck
- Lesser tubercle and crest
- Greater tubercle and crest
- Upper, middle, and lower facets on the greater tubercle
- Intertubercular (bicipital) groove
- Deltoid tuberosity
- Radial (spiral) groove

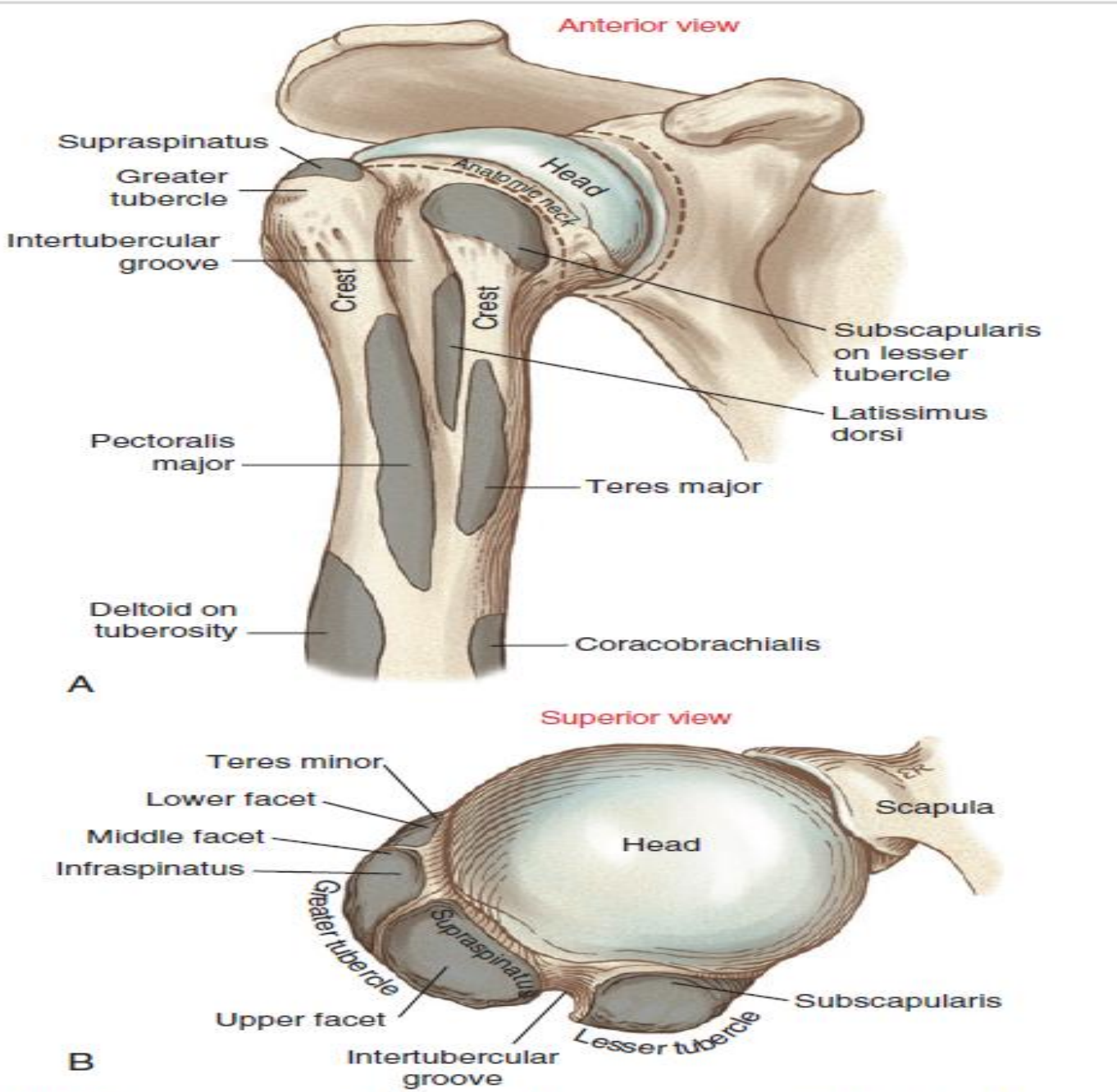
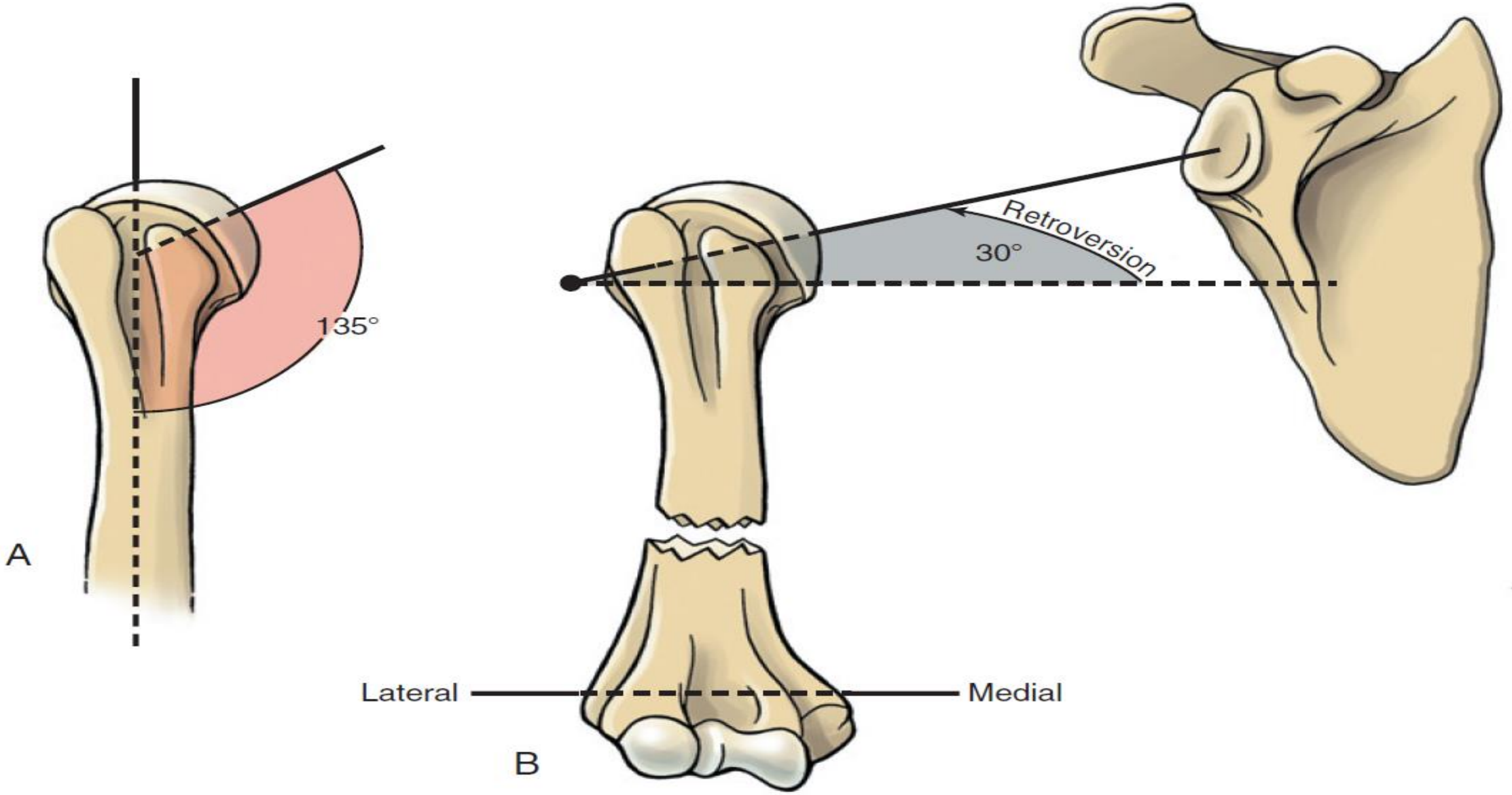
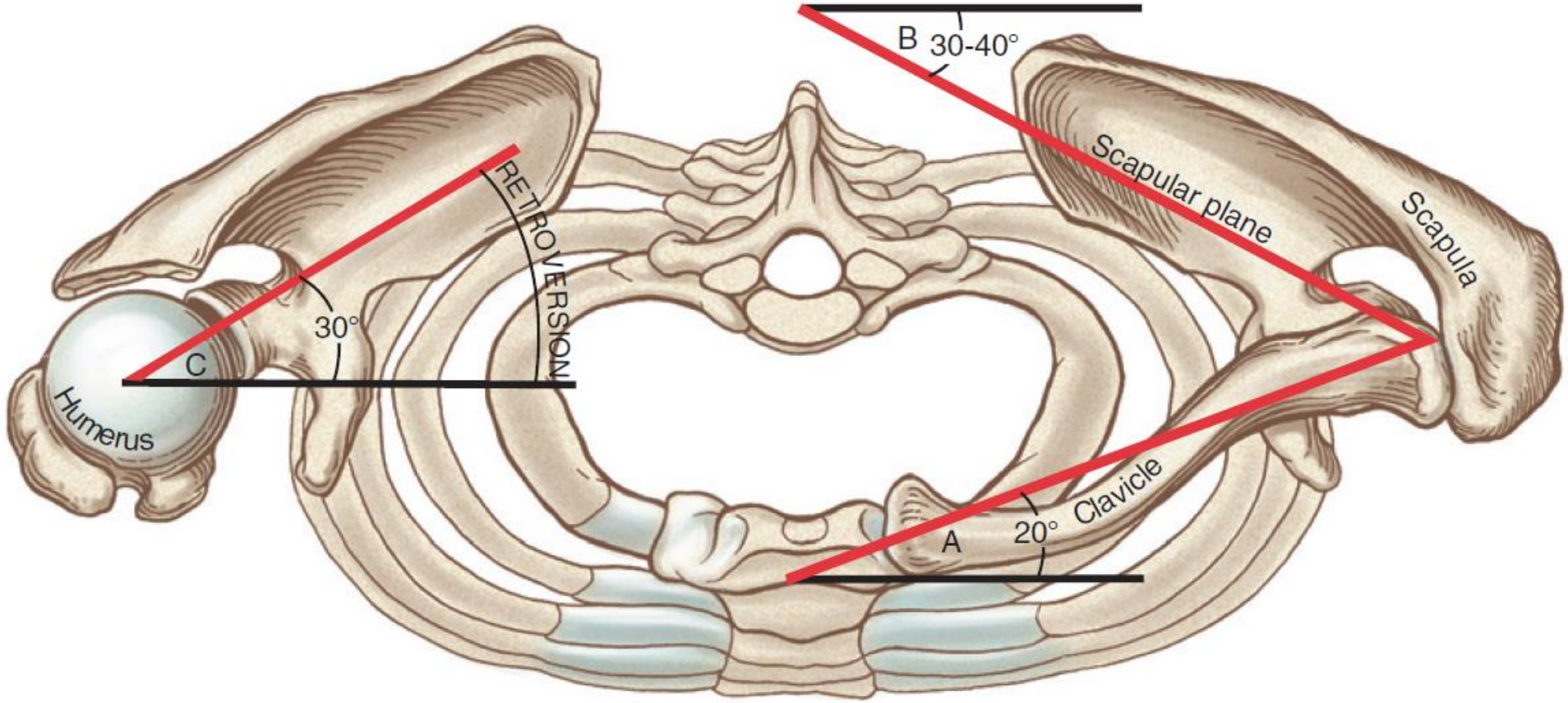


FIG. 5.7 Anterior (A) and superior (B) aspects of the right humerus. The dashed line in (A) shows the capsular attachments around the gleno-humeral joint. Distal attachment of muscles is shown in gray.



The right humerus showing a 135-degree “angle of inclination” between the shaft and head of the humerus in the frontal plane (A) and the retroversion of the humeral head relative to the distal humerus (B).

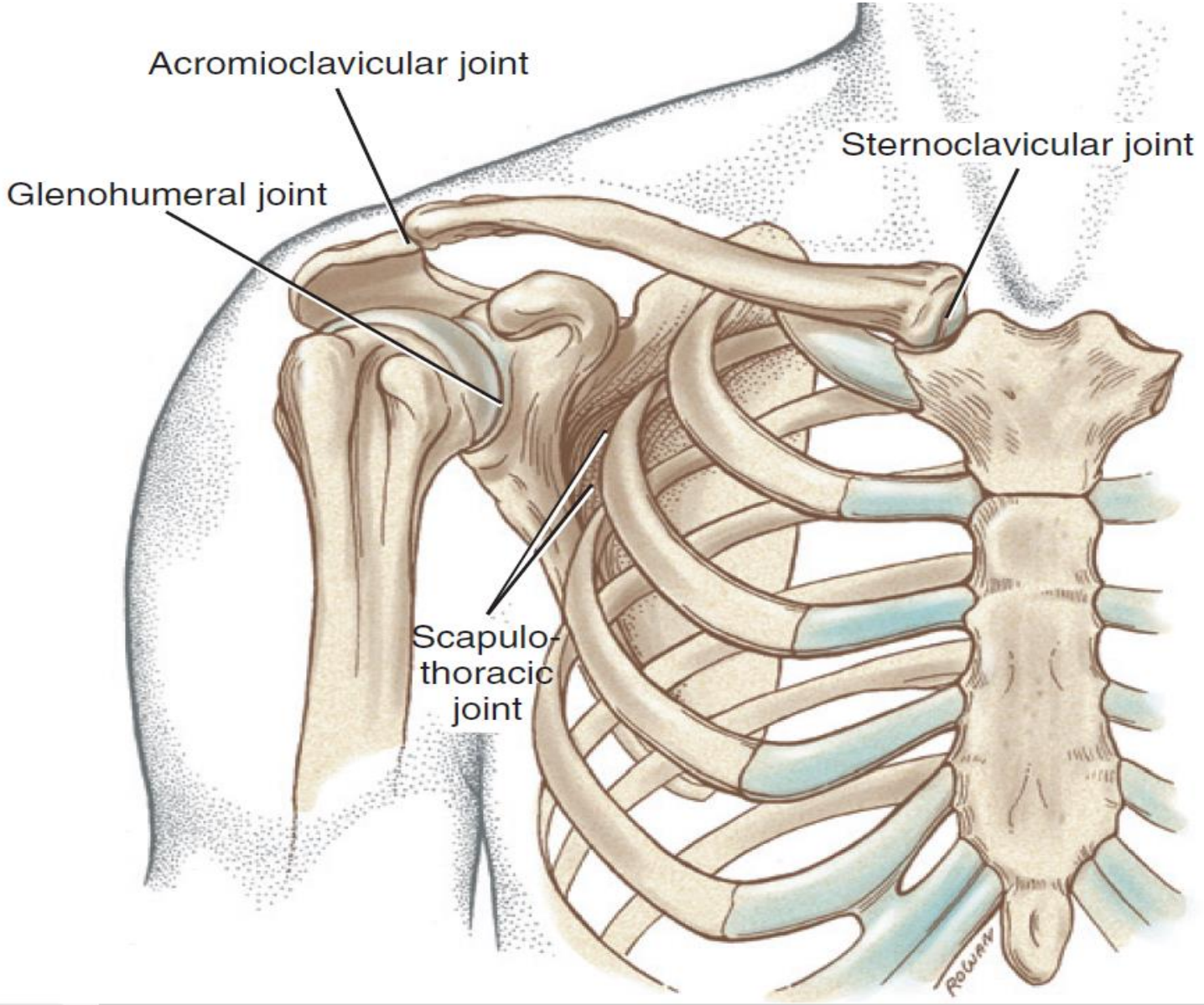


Superior view of both shoulders in the anatomic position. Angle A: The orientation of the clavicle deviated about 20 degrees posterior to the frontal plane. Angle B: The orientation of the scapula (scapular plane) deviated about 30–40 degrees anterior to the frontal plane. Angle C: Retroversion of the humeral head about 30 degrees posterior to the medial-lateral axis at the elbow.

ARTHROLOGY

Four Joints within the Shoulder Complex

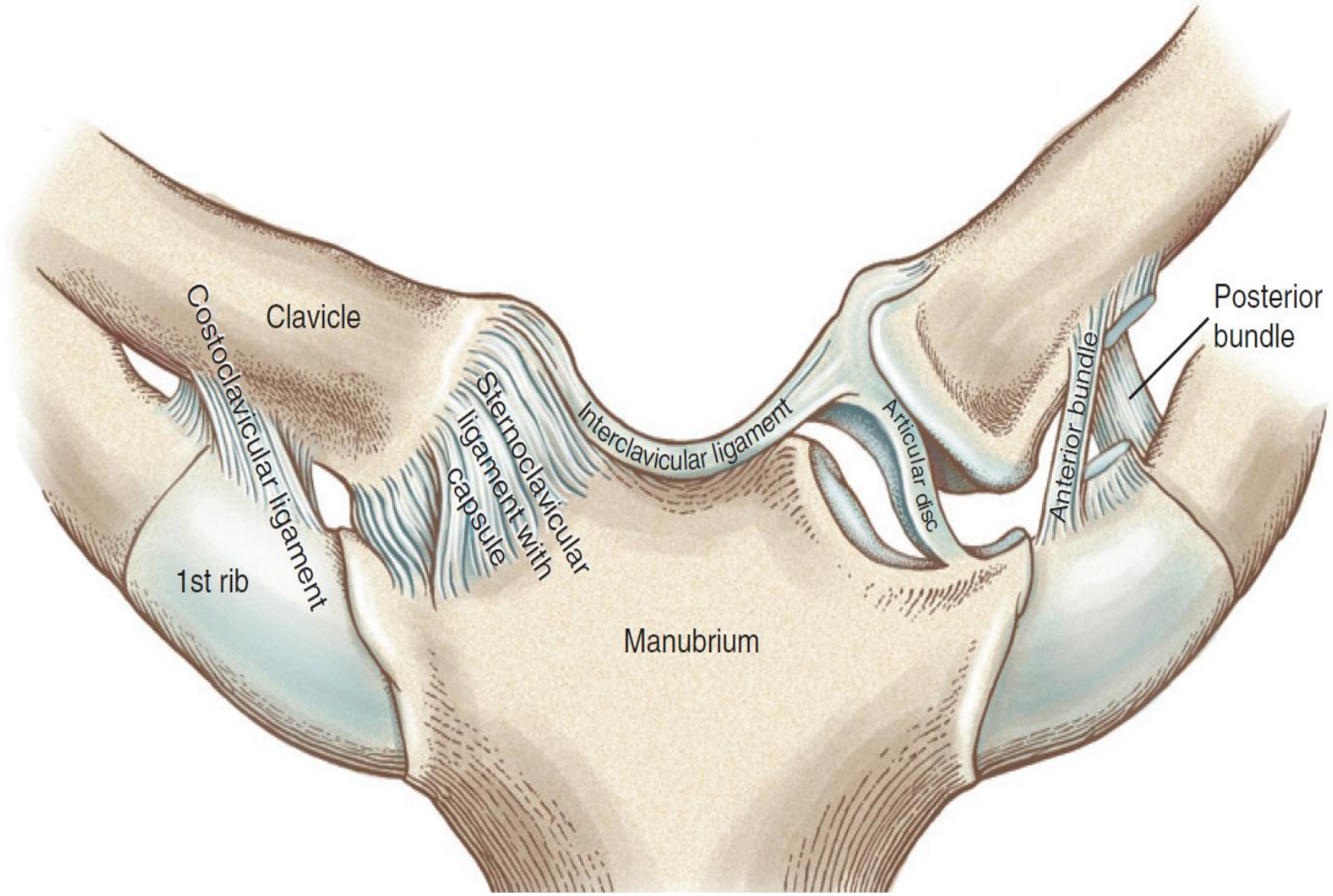
- Sternoclavicular
- Acromioclavicular
- Scapulothoracic
- Glenohumeral



Sternoclavicular Joint

The sternoclavicular (SC) joint is a complex articulation, involving the medial end of the clavicle, the clavicular facet on the sternum, and the superior border of the cartilage of the first rib

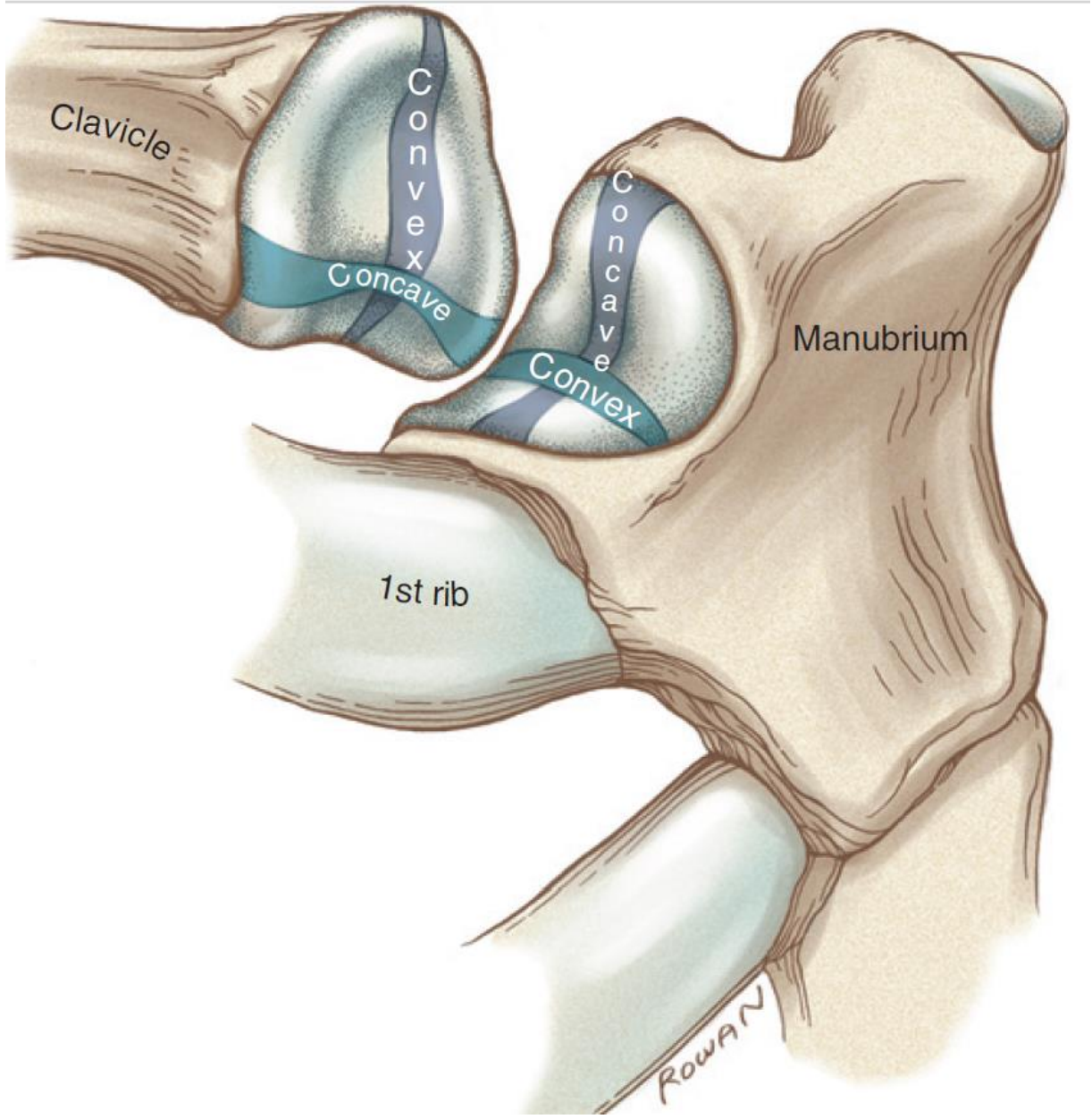
linking the appendicular skeleton with the axial skeleton.



The sternoclavicular joints. The capsule and lateral section of the anterior bundle of the costoclavicular ligament have been removed on the left side.

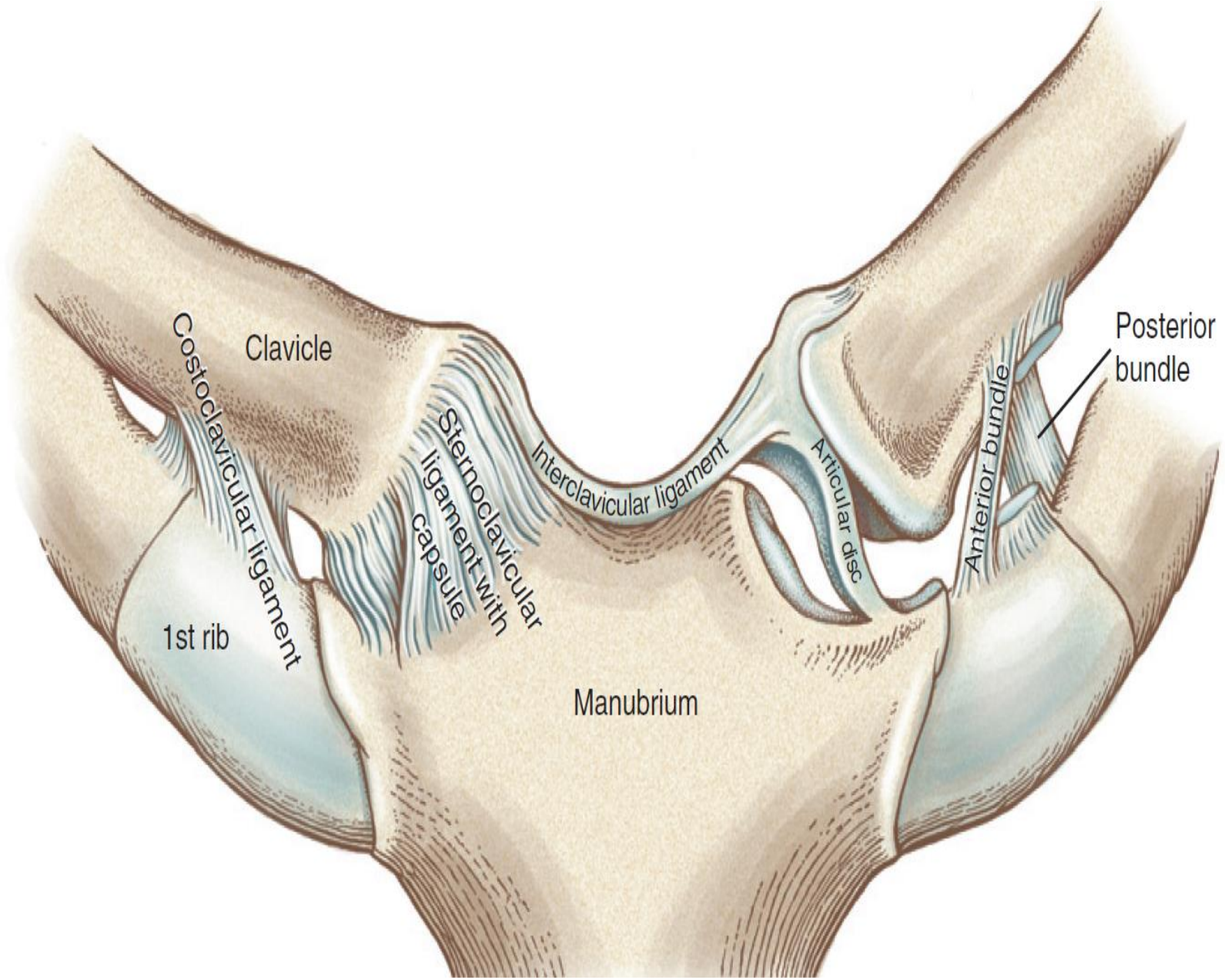
an irregular saddle-shaped articular surface.

- the medial end of the clavicle is usually convex along its longitudinal diameter and slightly concave along its transverse diameter.
- The clavicular facet on the sternum typically is reciprocally shaped, with a slightly concave longitudinal diameter and a slightly convex transverse diameter.



the Sternoclavicular Joint stabilizers

- Anterior and posterior sternoclavicular joint ligaments
- Interclavicular ligament
- Costoclavicular ligament
- Articular disc (fully formed in only about 50% of a sample of cadaver Specimens)
- Sternocleidomastoid, sternothyroid, sternohyoid, and subclavius muscles



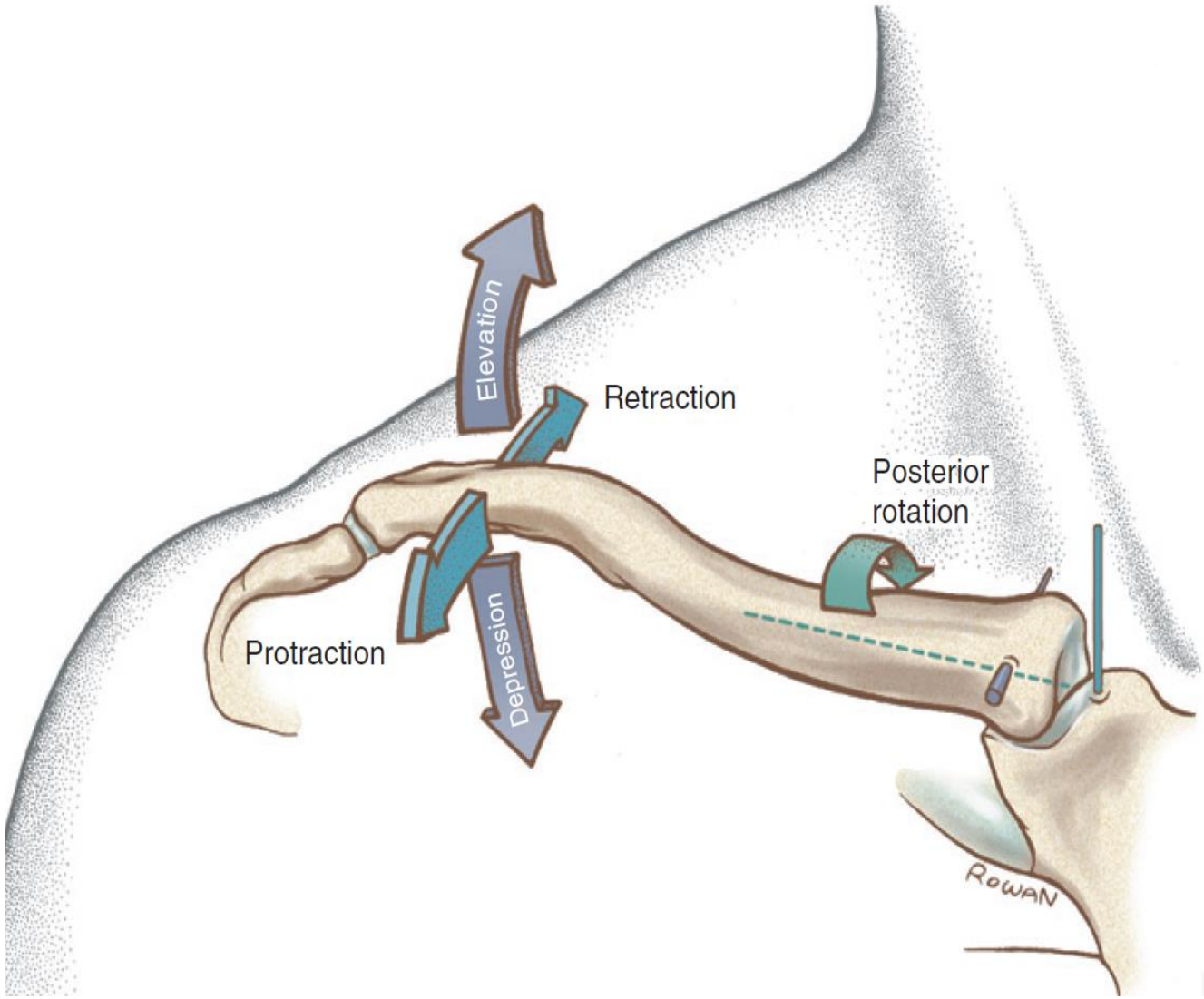
Sternoclavicular OSTEO-KINEMATICS

The primary purpose of these movements is to place the scapula in an optimal position to accept the head of the humerus.

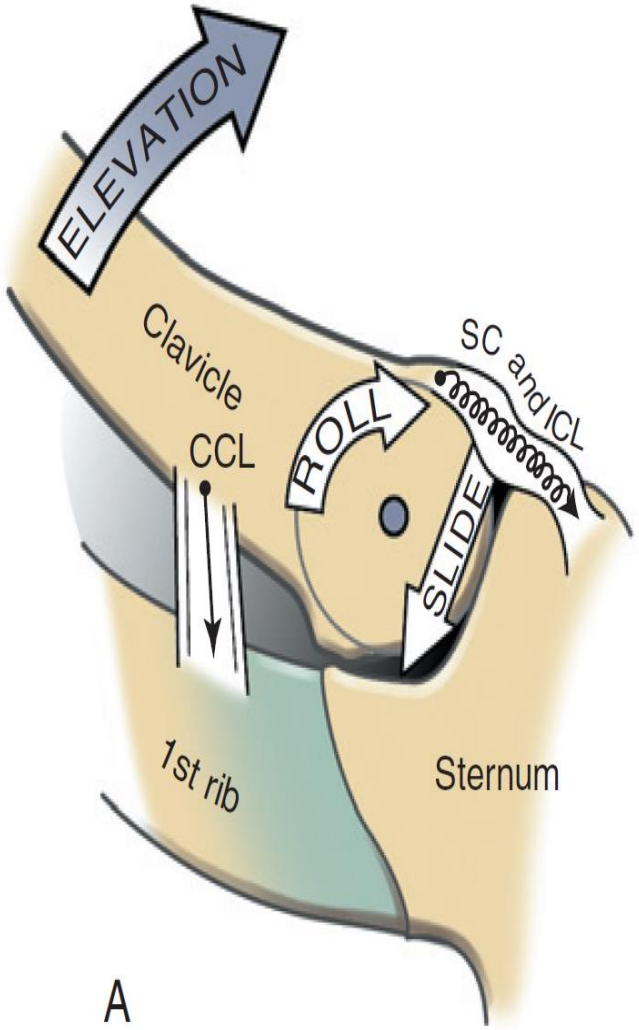
Elevation and Depression
Maximums of approximately 45 degrees of elevation and 10 degrees of depression

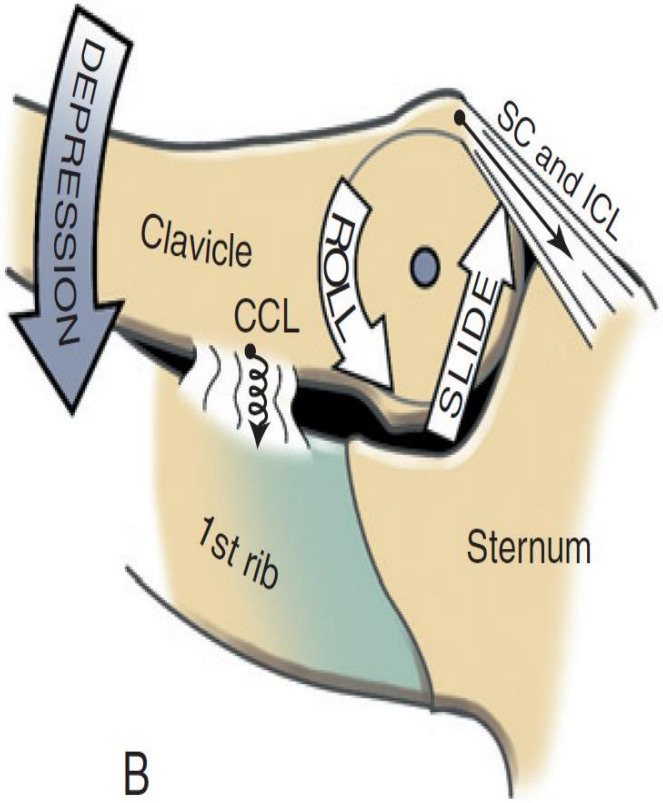
Protraction and Retraction
A maximum of 15 to 30 degrees of motion have been reported in each direction.

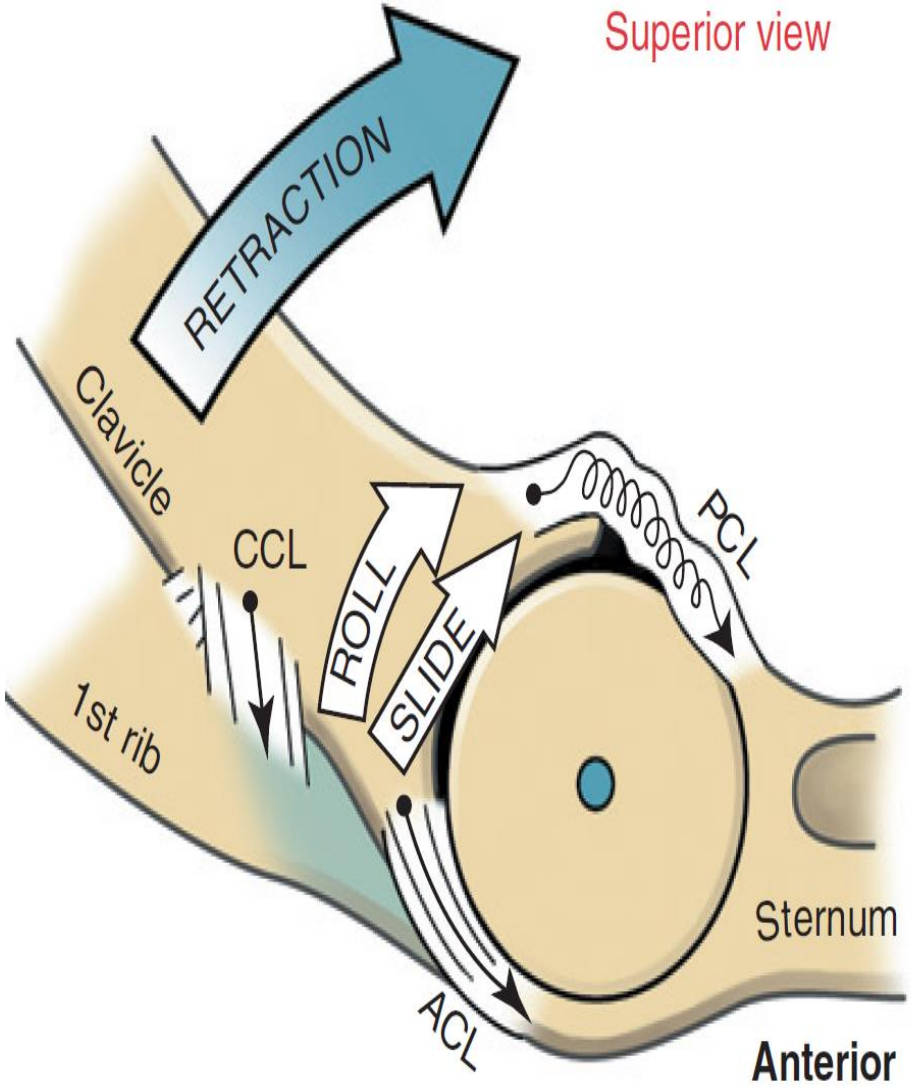
Axial (Longitudinal) Rotation of the Clavicle
the clavicle rotates *posteriorly* 20 to 35 degrees.



Sternoclavicular arthro-KINEMATICS

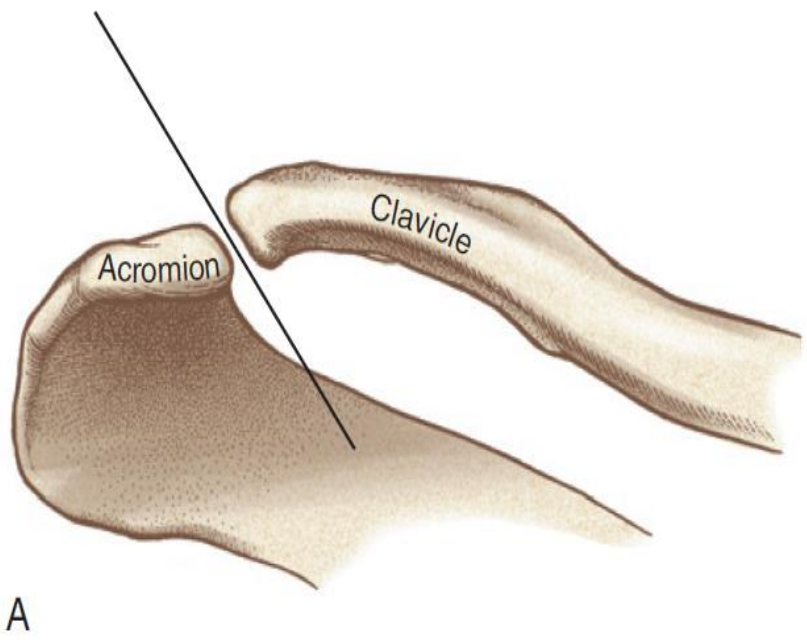


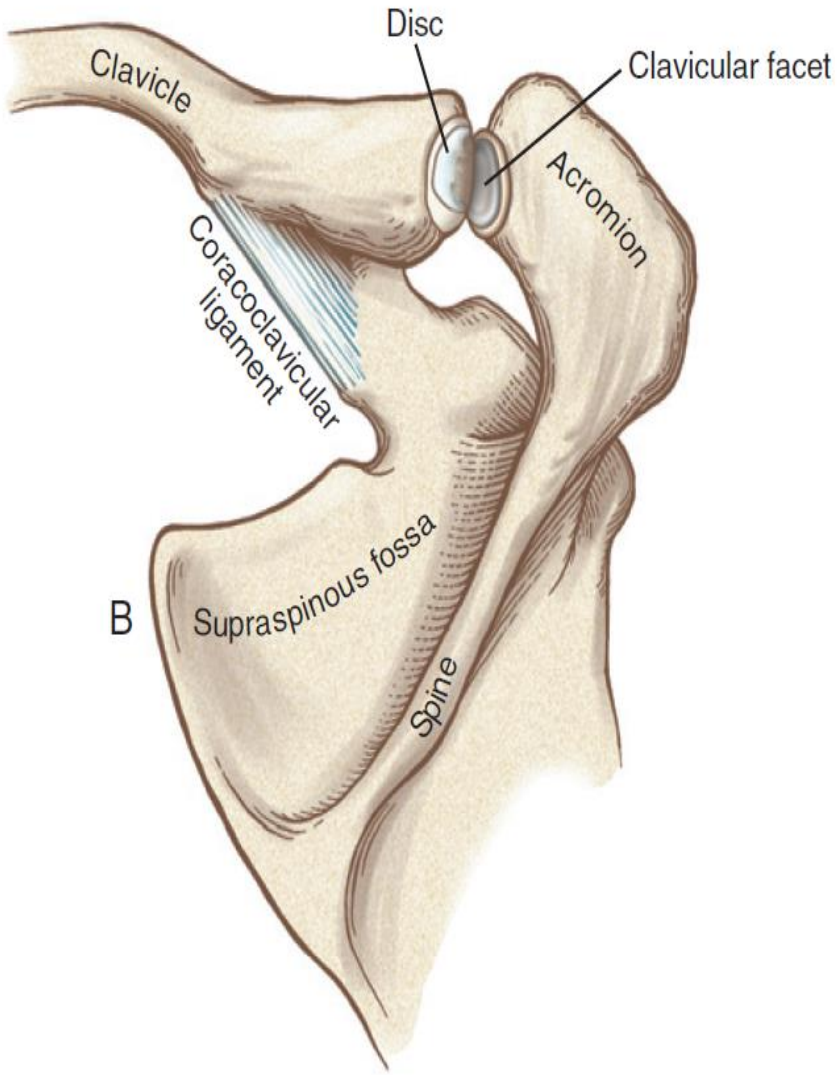




acromioclavicular Joint

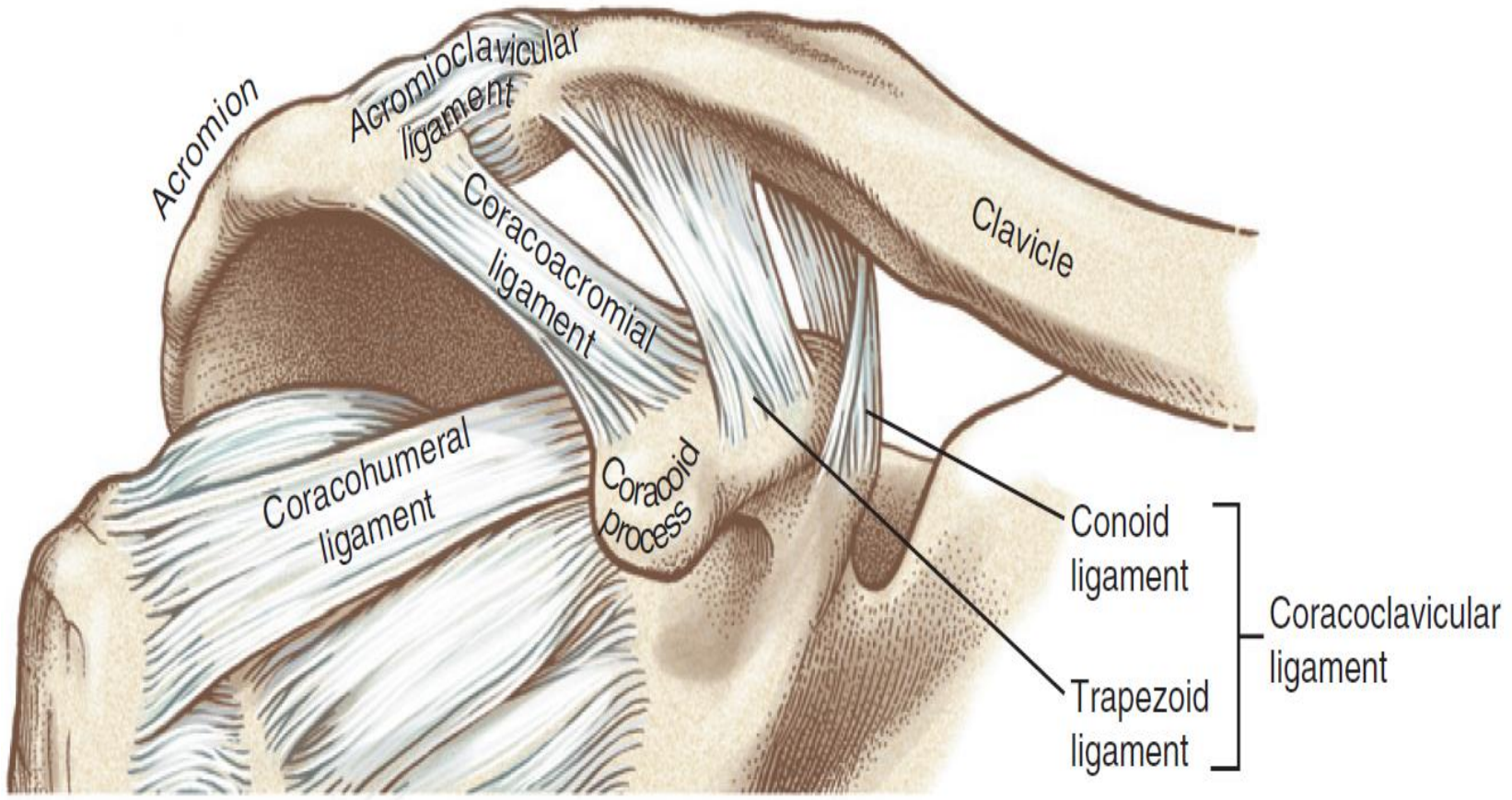
articulation between the lateral end of the clavicle and the acromion of the scapula





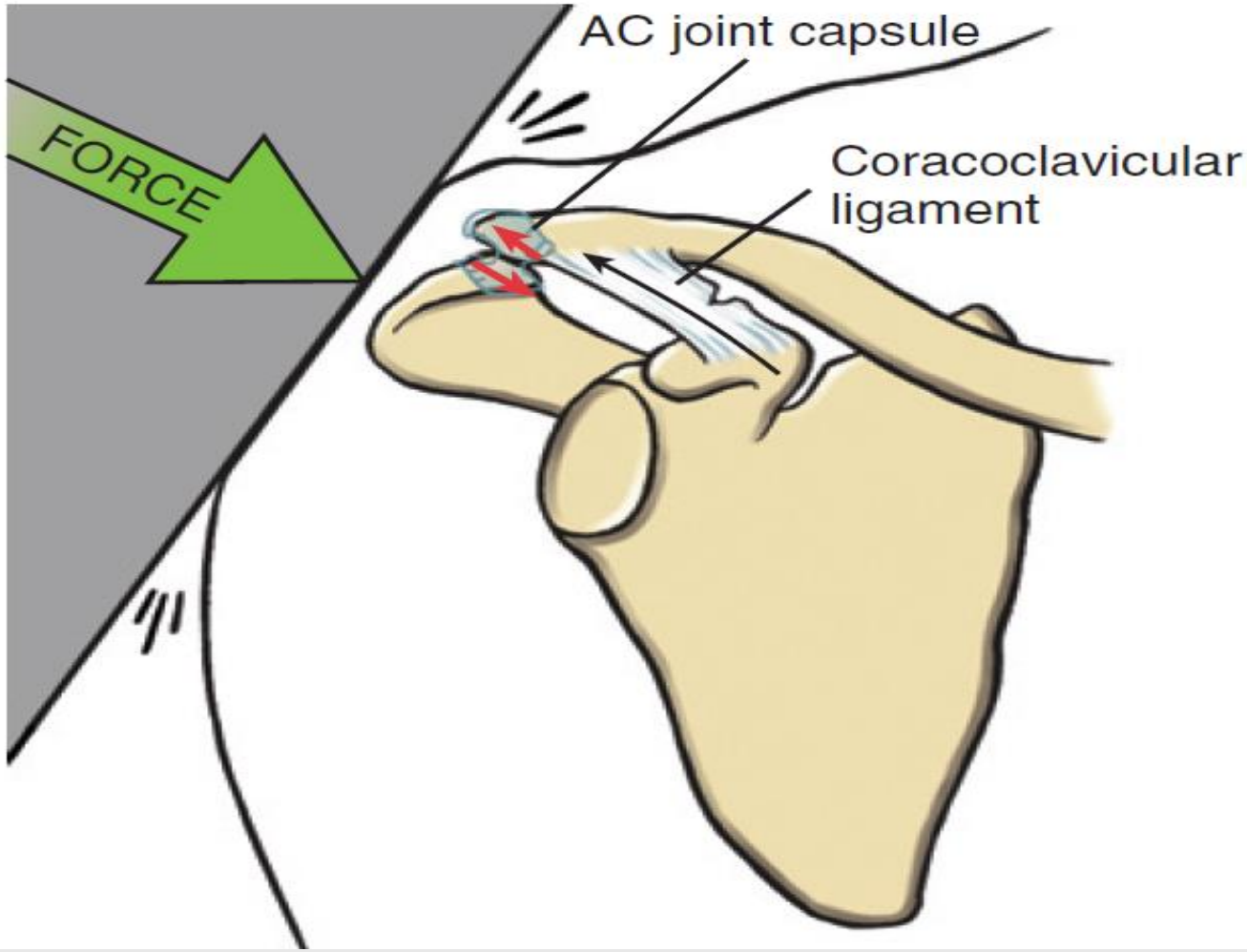
the Acromioclavicular Joint stabilizers

- Superior and inferior acromioclavicular joint ligaments
- Coracoclavicular ligament
- Articular disc (when present)
- Deltoid and upper trapezius



Acromioclavicular Joint Dislocation

The AC joint is inherently susceptible to dislocation because of the sloped nature of the articulation and the high probability of receiving large shearing forces.

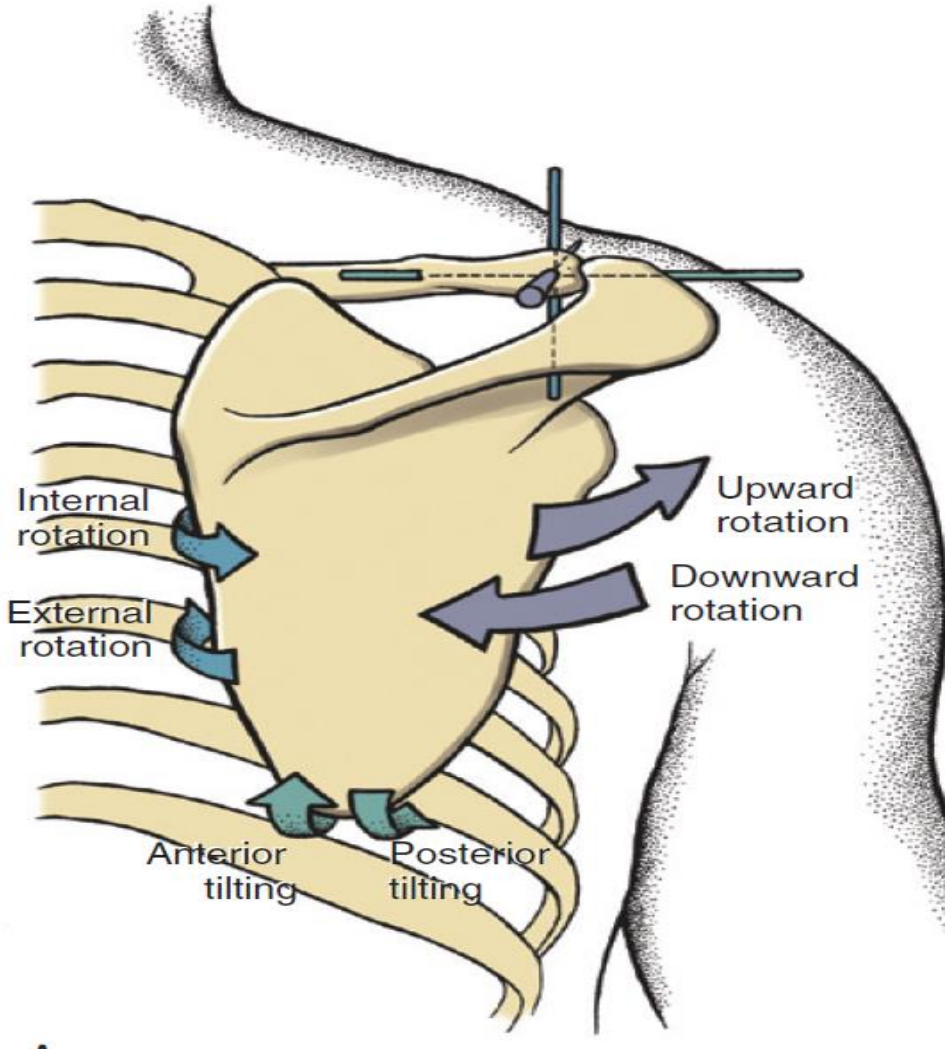


An anterior view of the shoulder striking a firm surface with the force of the impact directed at the acromion. The resulting shear force at the acromioclavicular *(AC)* joint is depicted by red arrows. Note the increased tension and partial tearing of the AC joint capsule and coracoclavicular ligament.

ACROMIO-CLAVICULAR JOINT OSTEO-KINEMATICS

The primary motions
Upward and Downward Rotation

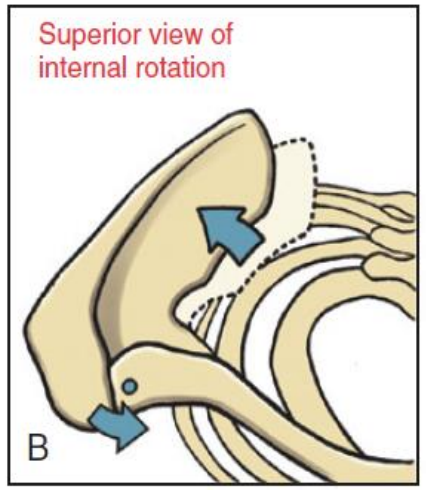
- Upward rotation motion occurs as a natural component of abduction or flexion of the shoulder.
- Reports vary widely, but up to 30 degrees of upward rotation at the AC joint occur as the arm is raised fully over the head (a significant component of the overall upward rotation at the scapulothoracic joint)
- Downward rotation is a motion mechanically associated with shoulder adduction or extension.
- The upward and downward rotation of the scapula is a frontal plane motion.

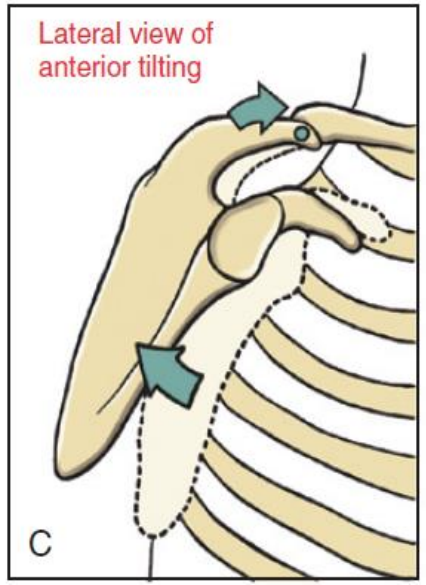


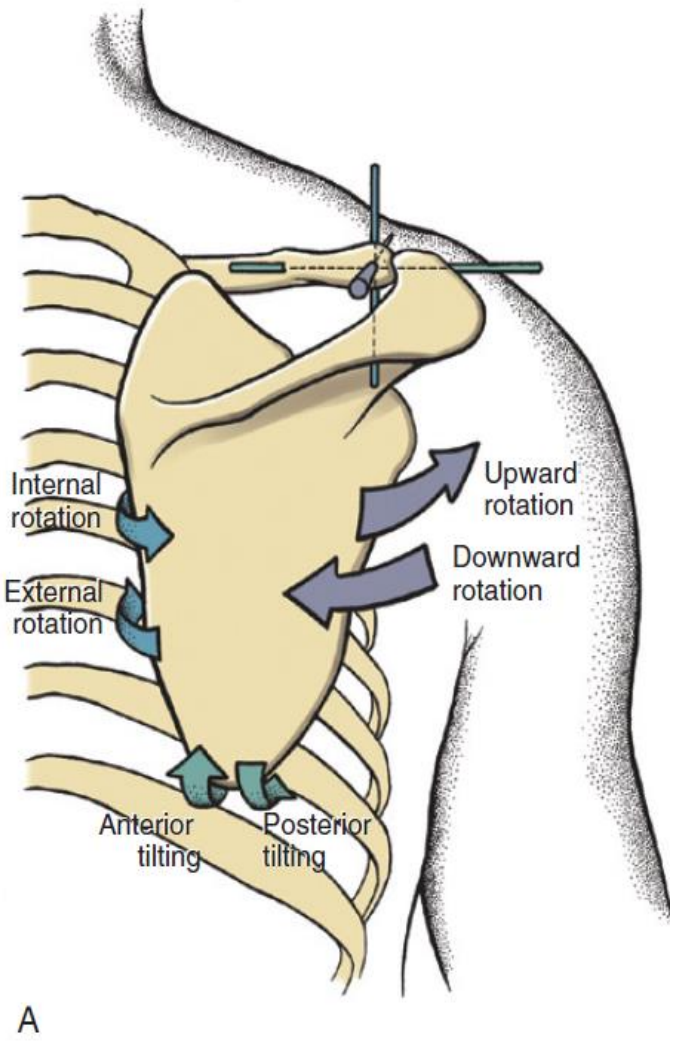
Horizontal and Sagittal Plane "Rotational Adjustment Motions" at the Acromioclavicular Joint

- **internal rotation and external rotation**
- **Anterior tilting and posterior tilting**

- pivoting or twisting type motions of the scapula around the lateral end of the clavicle.
- These so-called "rotational adjustment motions" optimally align the scapula against the thorax, as well as add to the total amount of its motion.





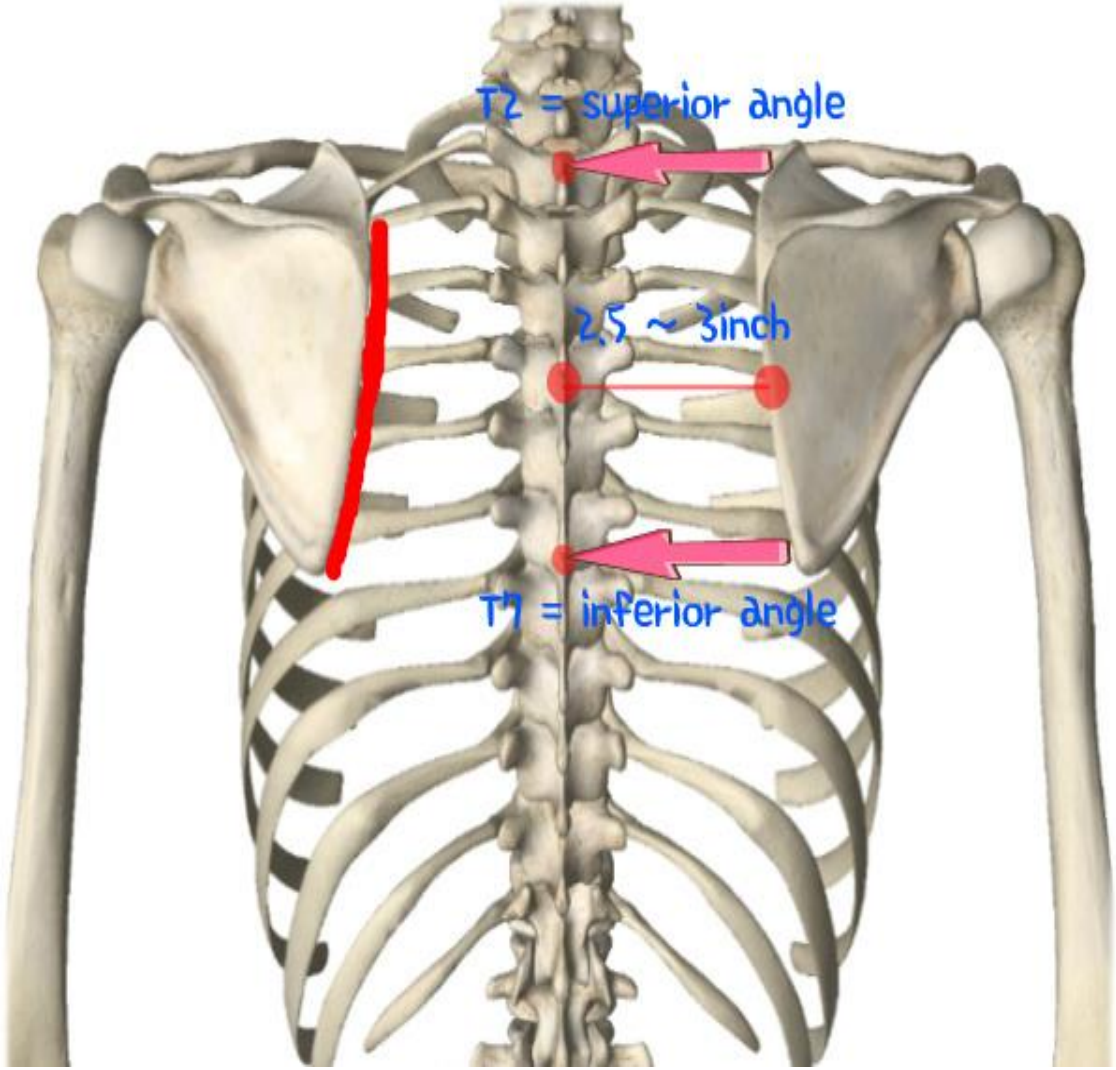


Scapulothoracic Joint

The scapulothoracic joint is not a true joint per se but rather a point of contact between the anterior surface of the scapula and the posterior-lateral wall of the thorax

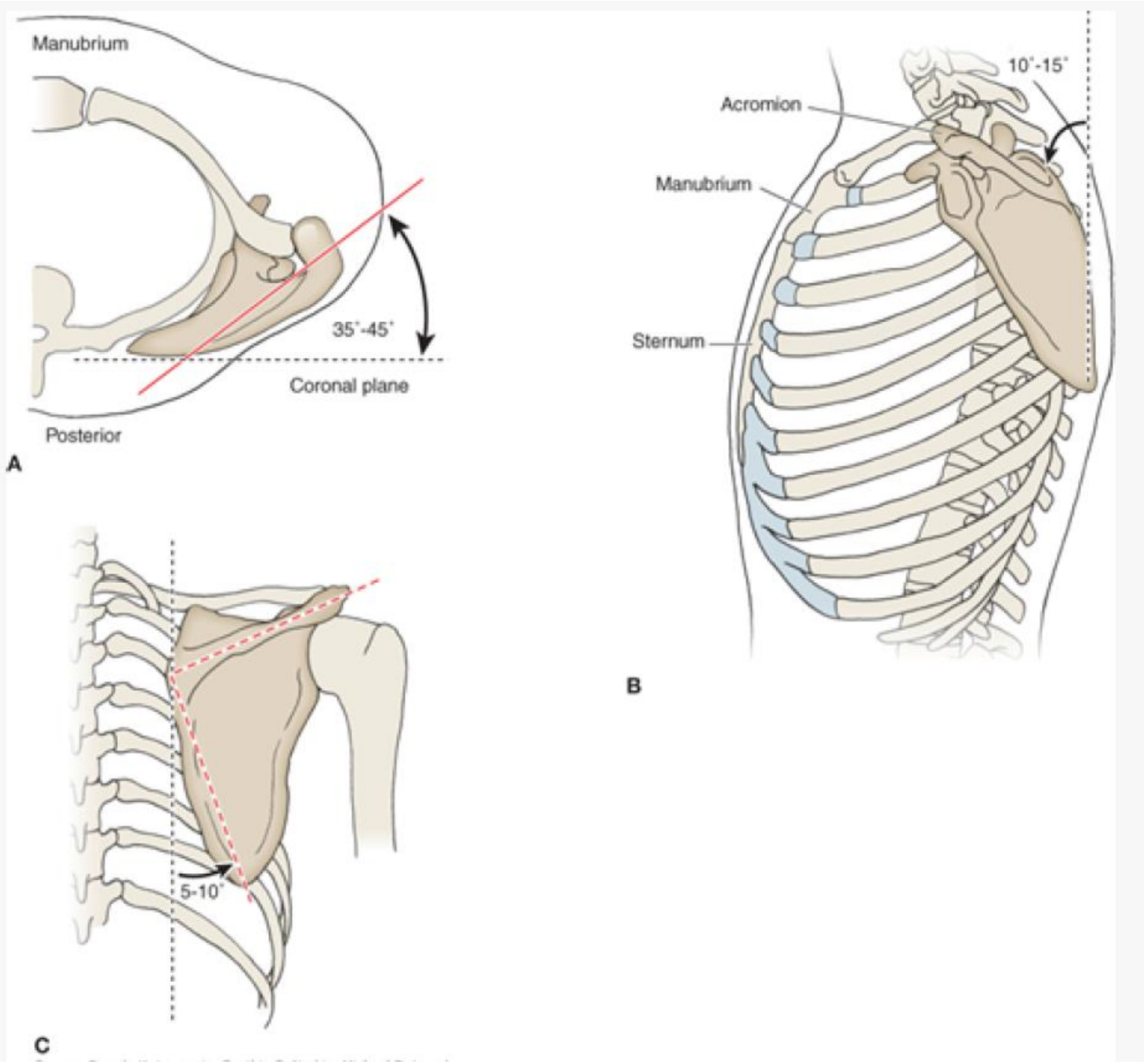
In the anatomic position, the scapula is usually positioned

- between 2nd and 7th ribs
- the medial border located about 6 cm lateral to the spine.



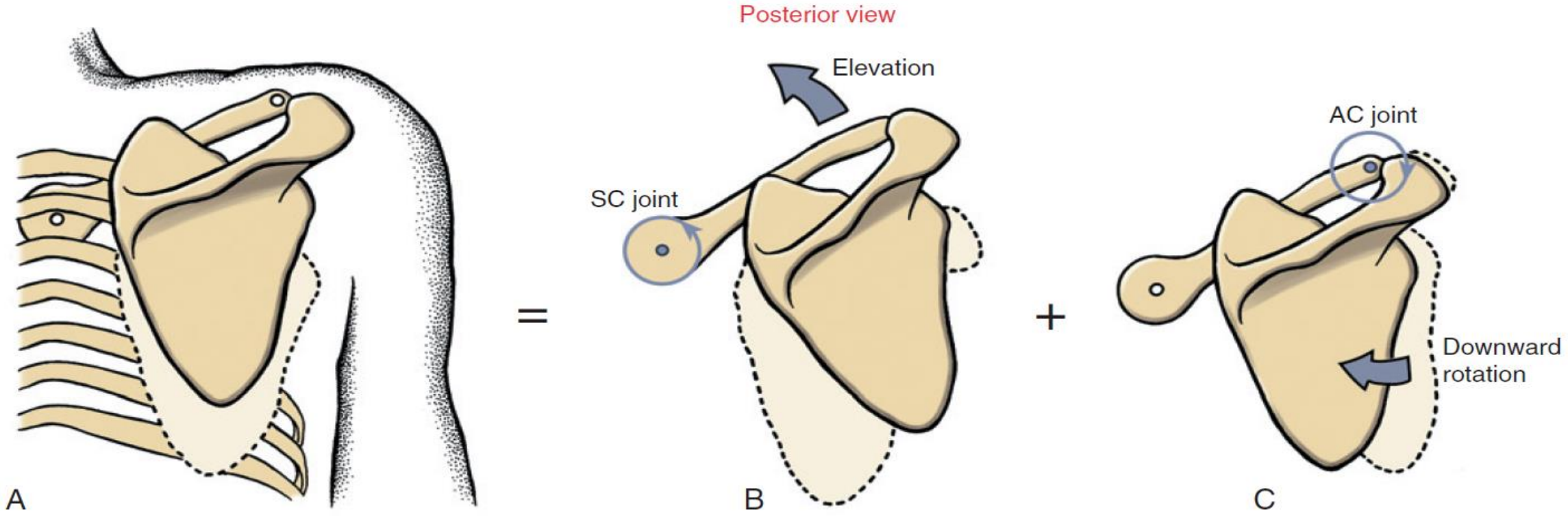
<u>the average “resting” posture of the scapula</u>

- about 10 degrees of anterior tilt
- 5 to 10 degrees of upward rotation
- about 30–40 degrees of internal rotation (*plane of the scapula).*



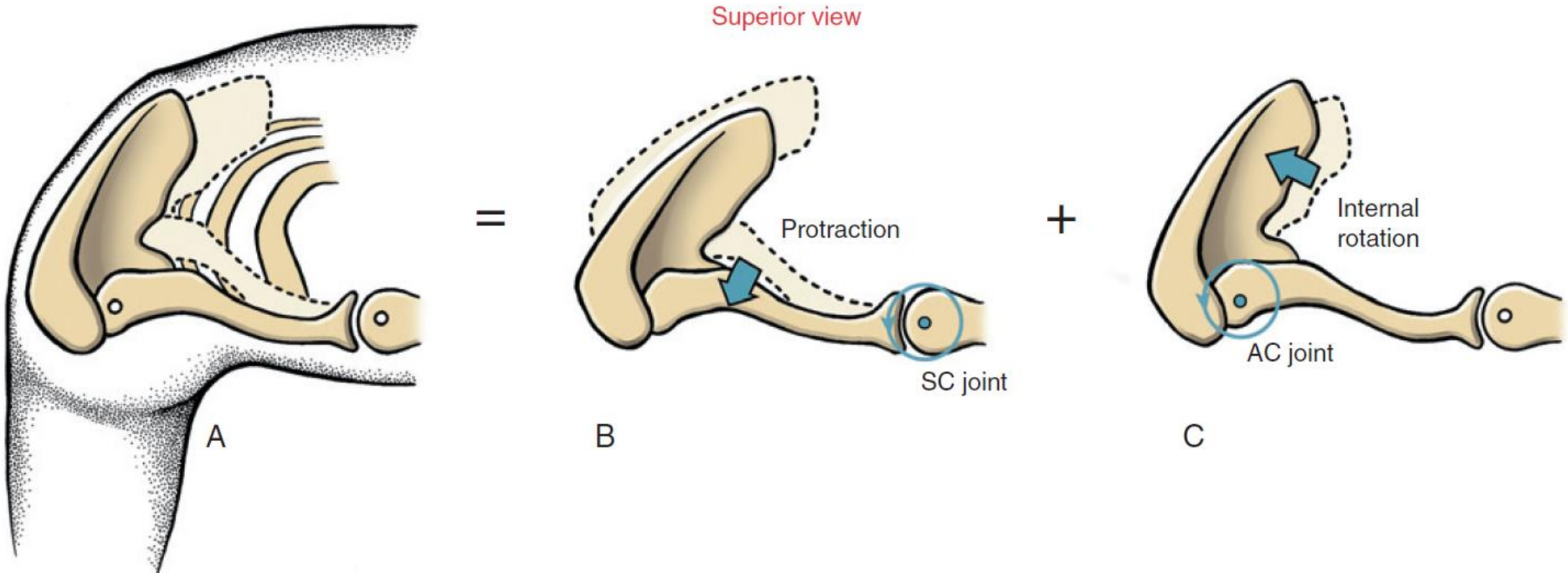
Scapulothoracic Joint KINEMATICS

Elevation and Depression



(A) Scapulothoracic elevation shown as a summation of (B) elevation at the sternoclavicular joint and (C) downward rotation at the acromioclavicular joint.

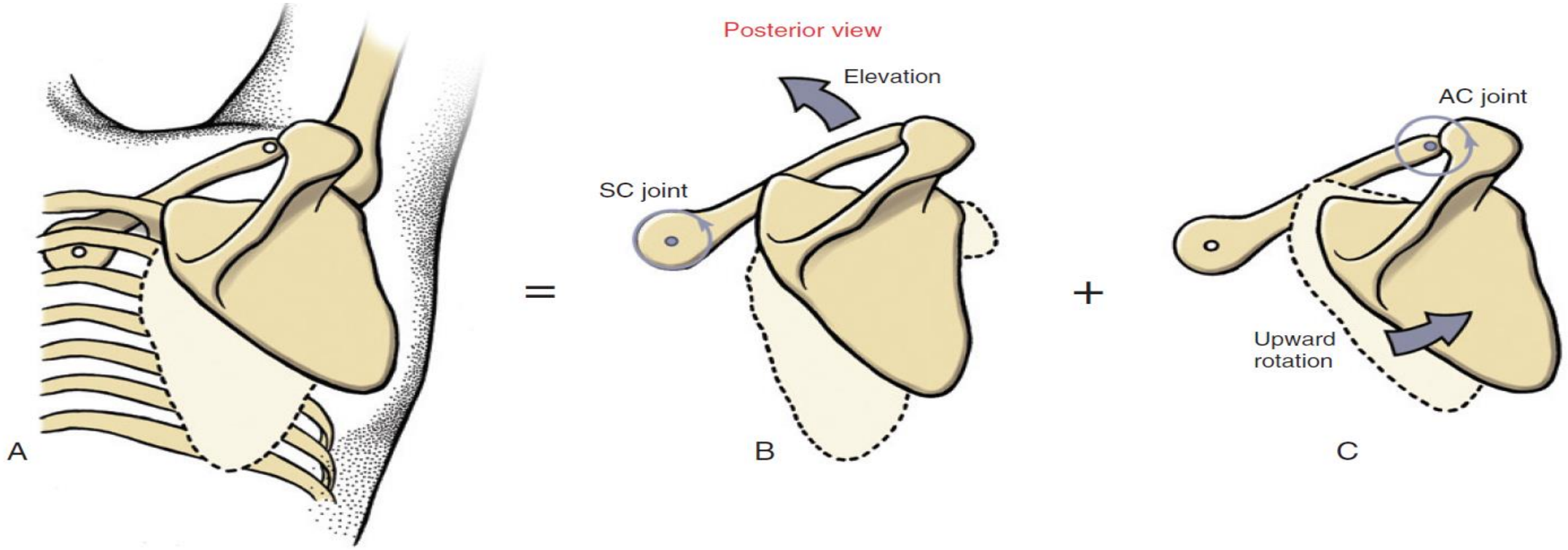
Protraction and Retraction



(A) Scapulothoracic protraction shown as a summation of (B) protraction at the sternoclavicular joint and (C) slight internal rotation at the acromioclavicular joint.

Upward and Downward Rotation

the full 60 degrees of upward rotation at the scapulothoracic joint



(A) Scapulothoracic upward rotation shown as a summation of (B) elevation at the sternoclavicular joint and (C) upward rotation at the acromioclavicular joint.

The Functional Importance of Full Upward Rotation of the Scapulothoracic Joint

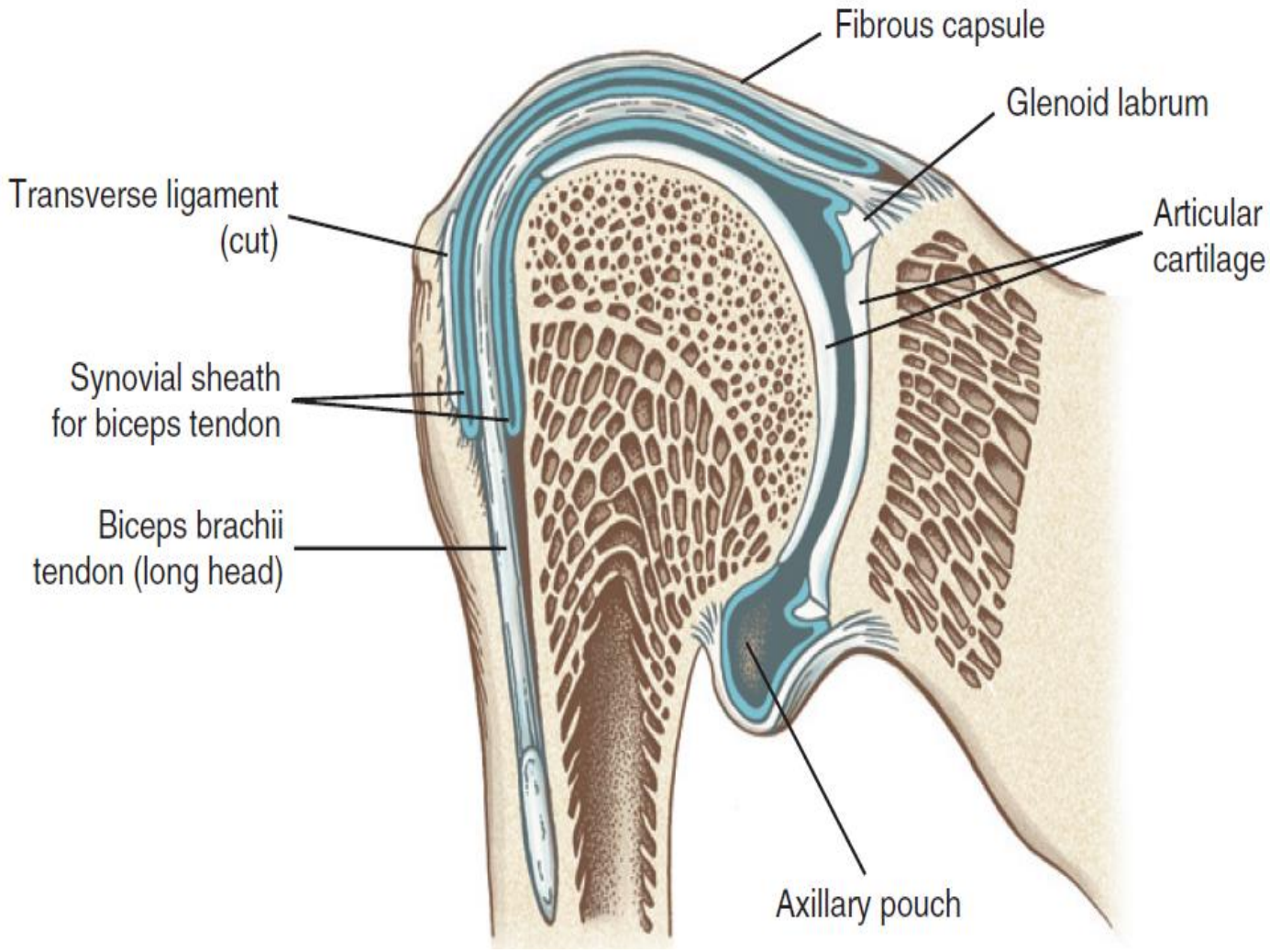
A fully upward rotated scapula is an important component of shoulder elevation approximately one third of the near 180 degrees of shoulder abduction or flexion.

The upward rotation of the scapula that occurs during full shoulder abduction serves at least three important functions.

- *First,* the upwardly rotated scapula projects the glenoid fossa upward and anterior-laterally, providing a structural base to maximize the upward and lateral reach of the upper limb.
- *Second,* the upwardly rotated scapula preserves the optimal length-tension relationship of the abductor muscles of the glenohumeral joint, such as the middle deltoid and supraspinatus.
- *Third,* the upwardly rotated scapula helps preserve the volume within the subacromial space: the area between the undersurface of the acromion and the humeral head

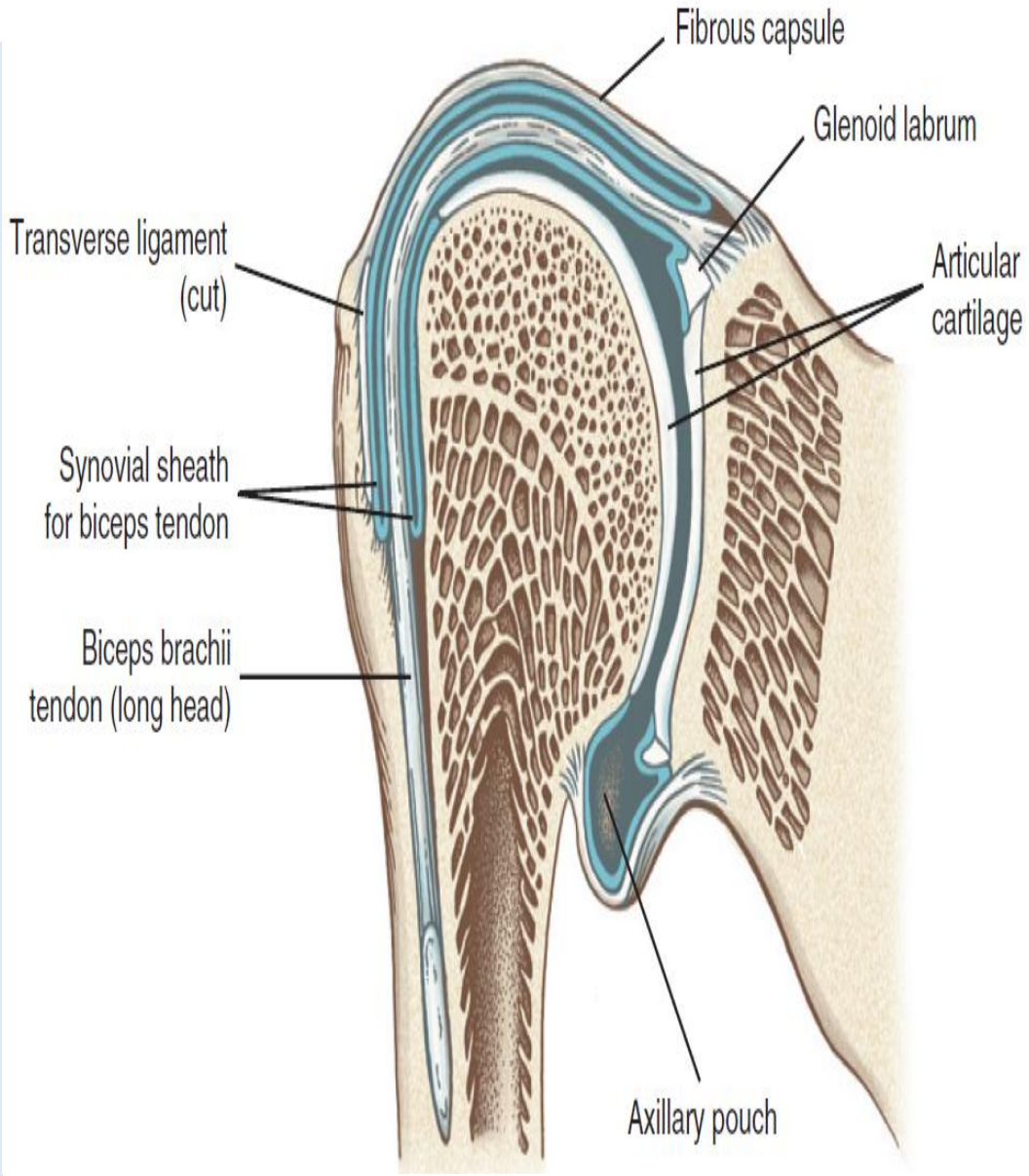
Glenohumeral Joint

articulation formed between the relatively large convex head of the humerus and the shallow concavity of the glenoid fossa



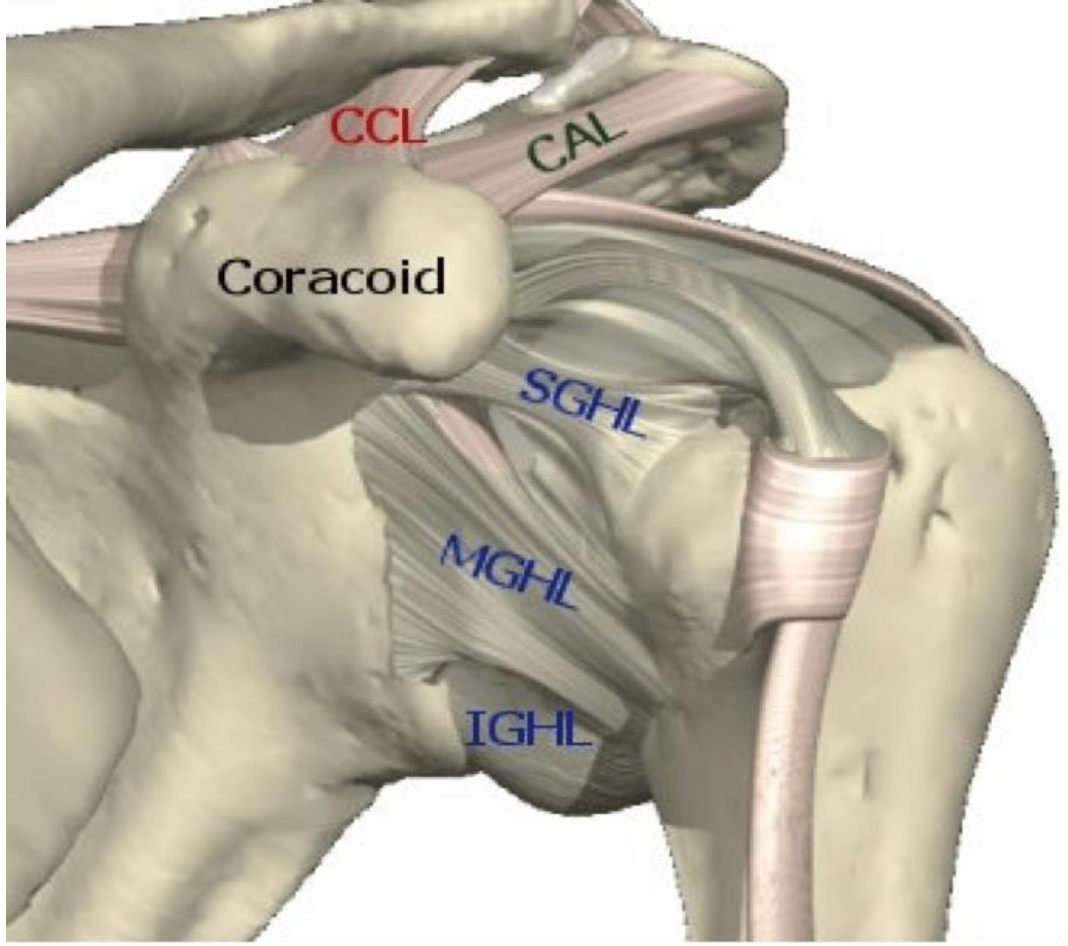
The GH joint *capsule*

- A relatively thin *fibrous capsule*
- The capsule attaches along the rim of the glenoid fossa and extends to the anatomic neck of the humerus.
- A *synovial membrane* lines the inner wall of the joint capsule.
- An extension of this synovial membrane lines the intracapsular portion of the tendon of the long head of the biceps brachii. This synovial membrane continues to surround the biceps tendon as it exits the joint capsule and descends into the intertubercular (i.e., bicipital) groove.
- The potential volume of space within the GH joint capsule is about twice the size of the humeral head. The loose-fitting and expandable capsule allows extensive mobility to the GH joint.
- In the anatomic or adducted position, the inferior portion of the capsule appears as a slackened or redundant recess called the *axillary pouch*



- The stabilizing function of the capsule is minimal at less than 90 of humeral motion when only the superior segment of the capsule is under any significant tension. The blending of the rotator cuff tendons into the capsule and ligaments results in some ability to actively influence tension of the capsule and ligaments through muscle contraction.
- Toward the end range of humeral motion, however, the capsule becomes passively tight and has been demonstrated to actually produce rather than restrict humeral head center translations

the Glenohumeral Joint's Capsular Ligaments



The superior glenohumeral ligament

- slightly taut in and near the anatomic position
- resisting external rotation and inferior and anterior translations of the humeral head.
- slackens significantly at abduction beyond 35–45 degrees

Middle glenohumeral ligament

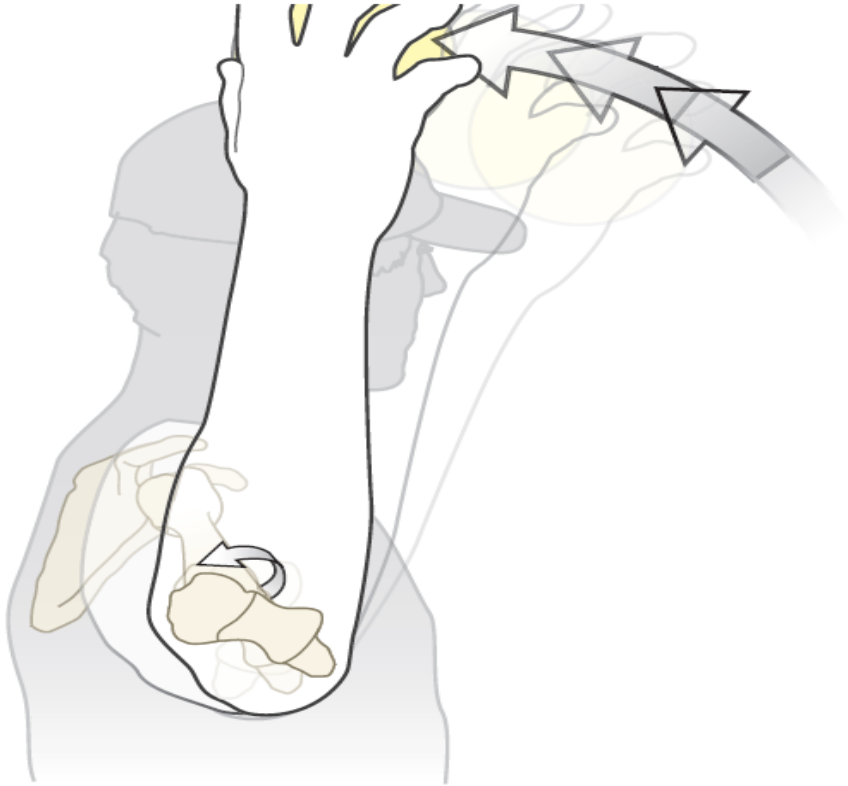
- resisting Anterior translation of the humeral head, especially in about 45–90 degrees of abduction; external rotation
- Slackens at internal rotation

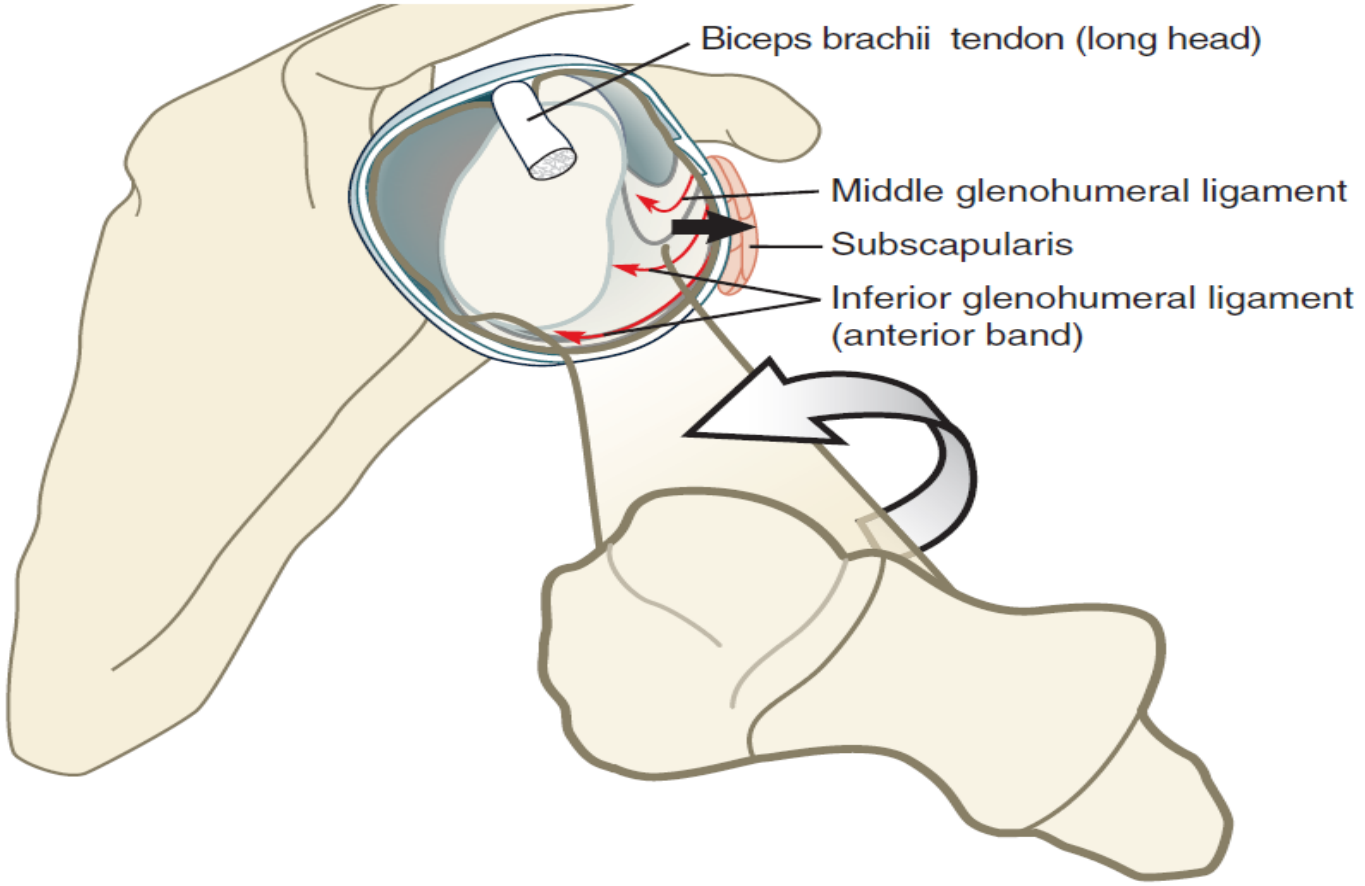
inferior glenohumeral ligament

- The hammock-like inferior capsular ligament
- (three parts: anterior band, posterior band, and connecting axillary pouch)
- Become tight at

✓ Axillary pouch: 90 degrees of abduction, combined with anterior-posterior and inferior translations
✓ Anterior band: 90 degrees of abduction and full external rotation; anterior translation of humeral head
✓ Posterior band: 90 degrees of abduction and full internal rotation

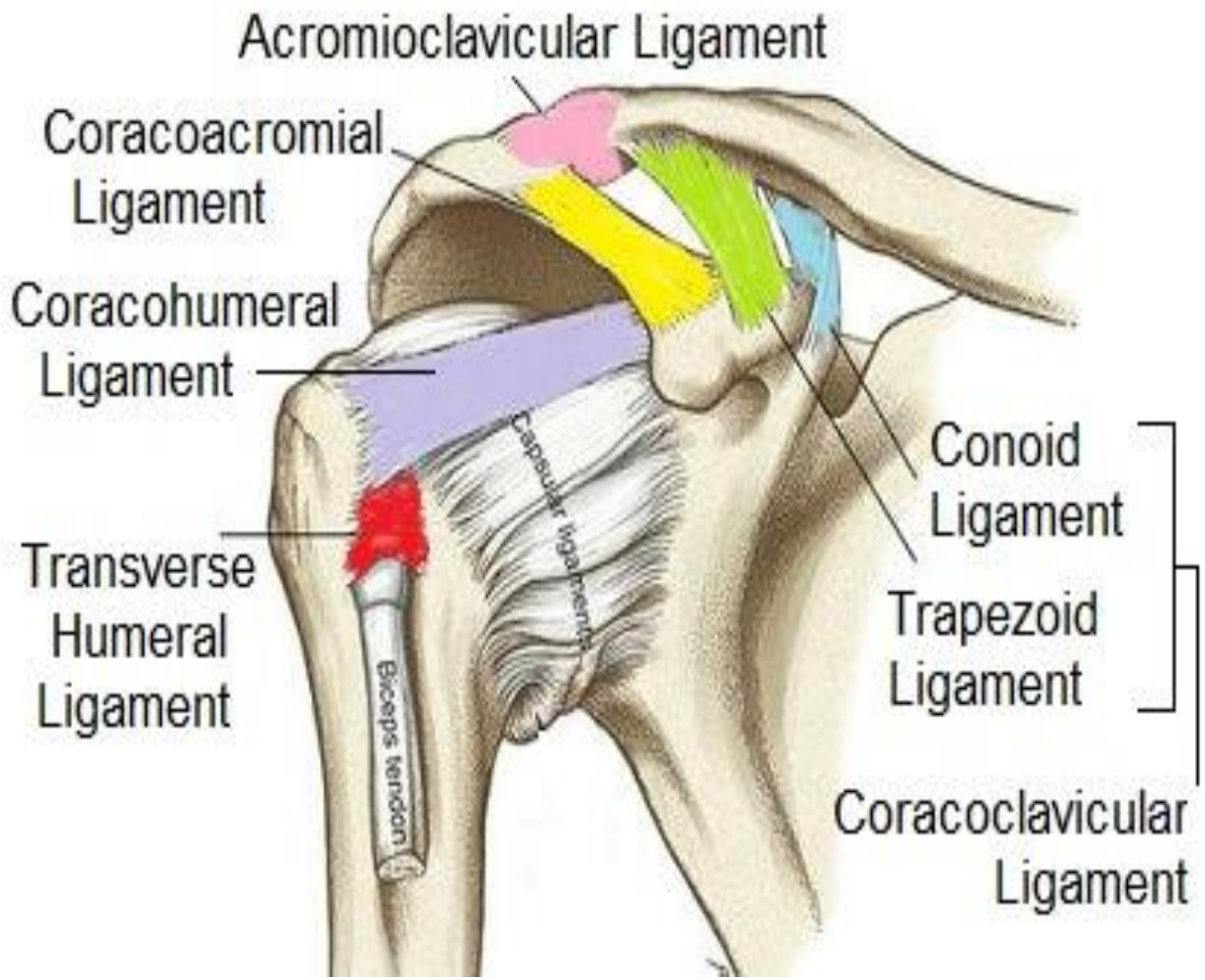
Forceful and dynamic activities involving *abduction* and *external rotation* specifically stress the anterior band of the inferior capsule. Such stress, for example, may occur during the “cocking phase” of throwing a baseball





Coracohumeral ligament

- relatively taut in the anatomic position.
- provides restraint to inferior translation and external rotation of the humeral head

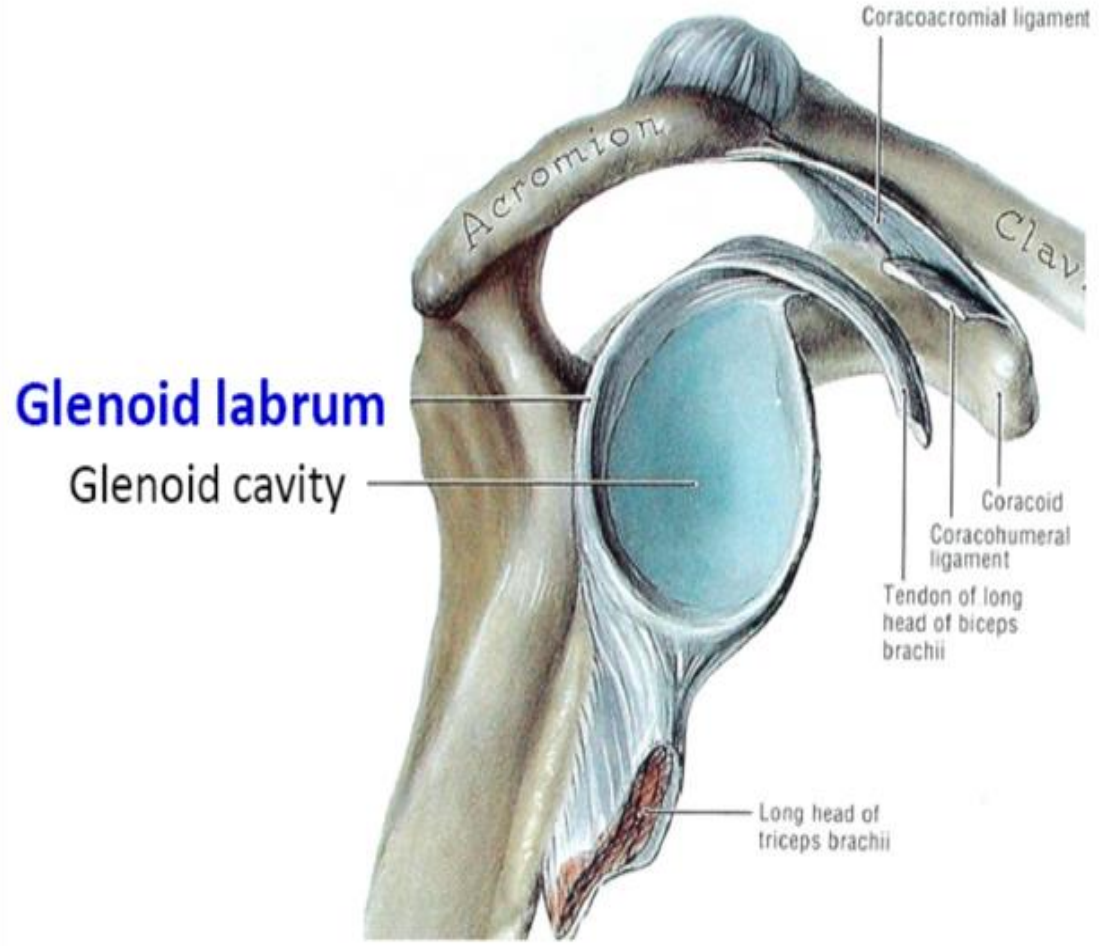


Glenoid Labrum

- a triangular fibrocartilaginous ring, or lip
- About 50% of the overall depth of the glenoid fossa has been attributed to the glenoid labrum.

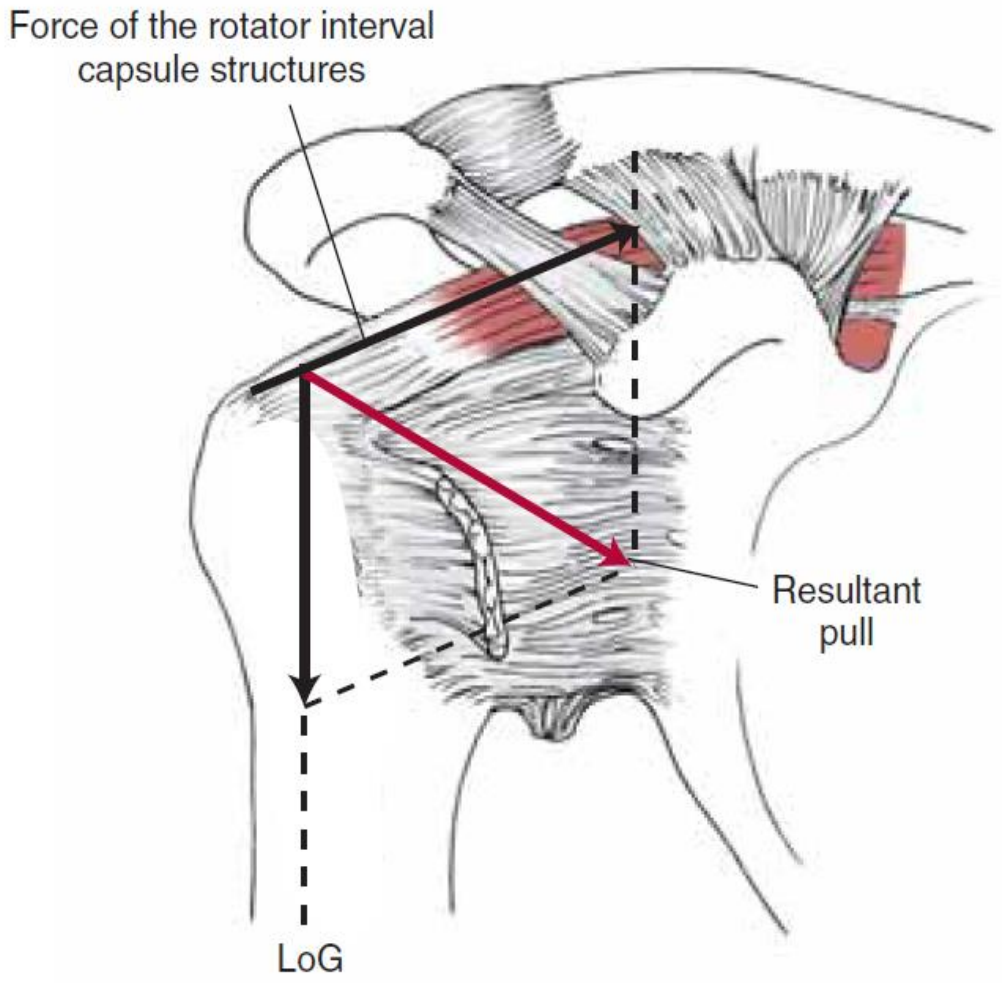
why the glenoid labrum is so frequently involved in shoulder pathology?

- the superior part of the glenoid labrum is only loosely attached to the adjacent glenoid rim.
- approximately 50% of the fibers of the tendon of the long head of the biceps are direct extensions of the superior glenoid labrum; the remaining 50% arise from the supraglenoid tubercle. Exceedingly large or repetitive forces within the biceps tendon can partially detach the loosely secured superior labrum from its near–12 o'clock position on the glenoid rim.



Static Stabilization of the Glenohumeral Joint

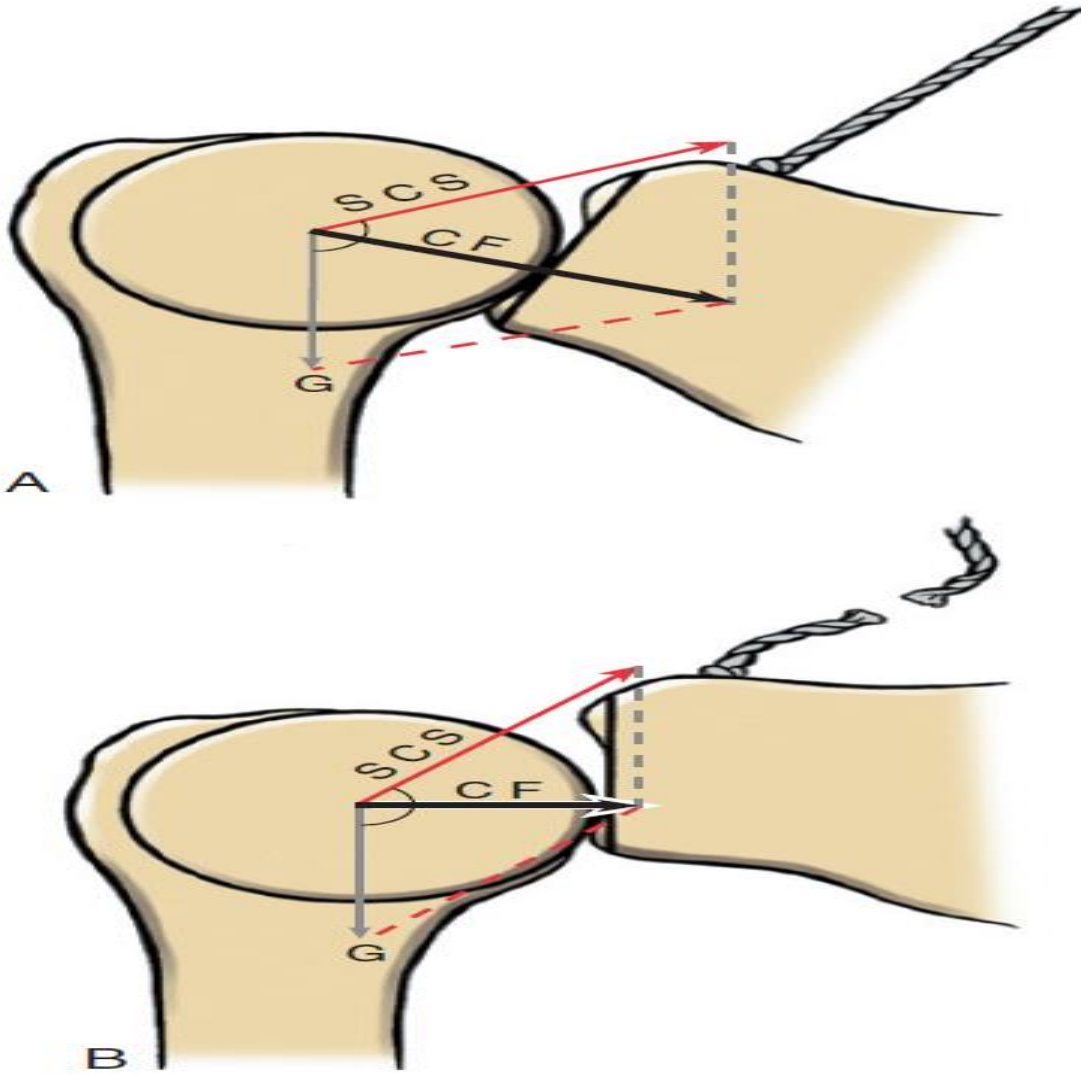
1. passive tension in the rotator interval capsule
2. the capsule has an airtight seal, which produces negative intra-articular pressure. This pressure creates a relative vacuum that resists inferior humeral translation
3. a slight upward tilt of the glenoid fossa will produce a partial bony block against humeral inferior translation.



SCAPULOTHORACIC POSTURE AND ITS EFFECT ON STATIC STABILITY

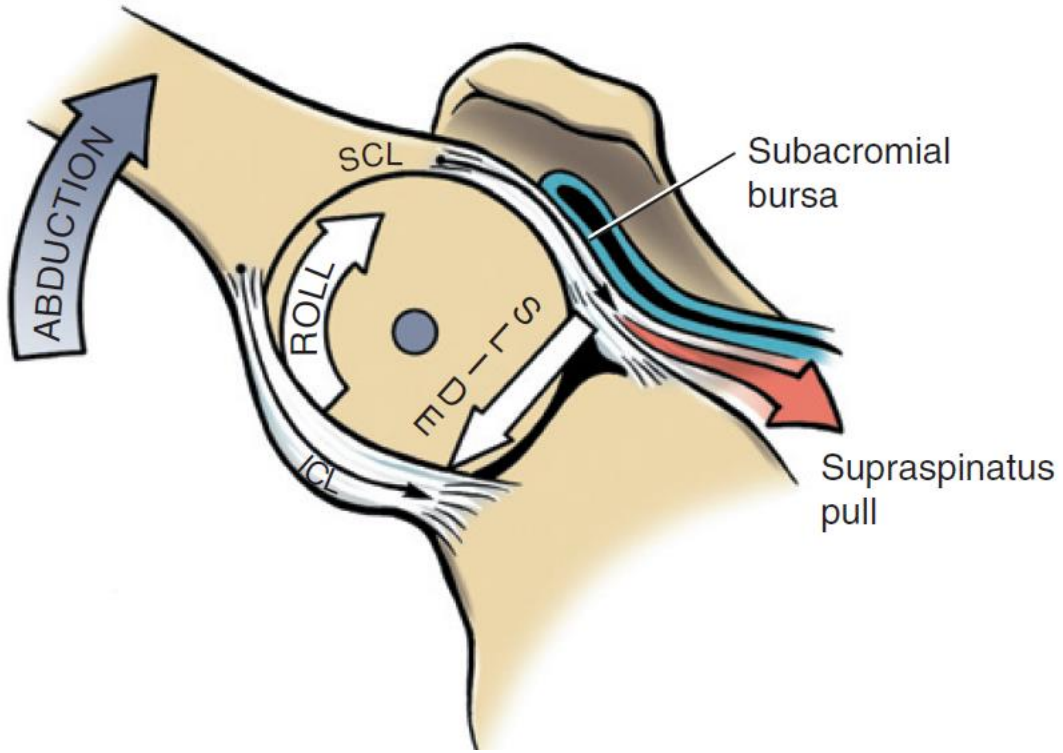
(A) The rope indicates a muscular force that holds the glenoid fossa in a slightly upward-rotated position. In this position the passive tension in the taut superior capsular structure *(SCS)* is added to the force produced by gravity *(G),* yielding the compression force *(CF).* The compression force applied against the slight incline of the glenoid "locks" the joint.

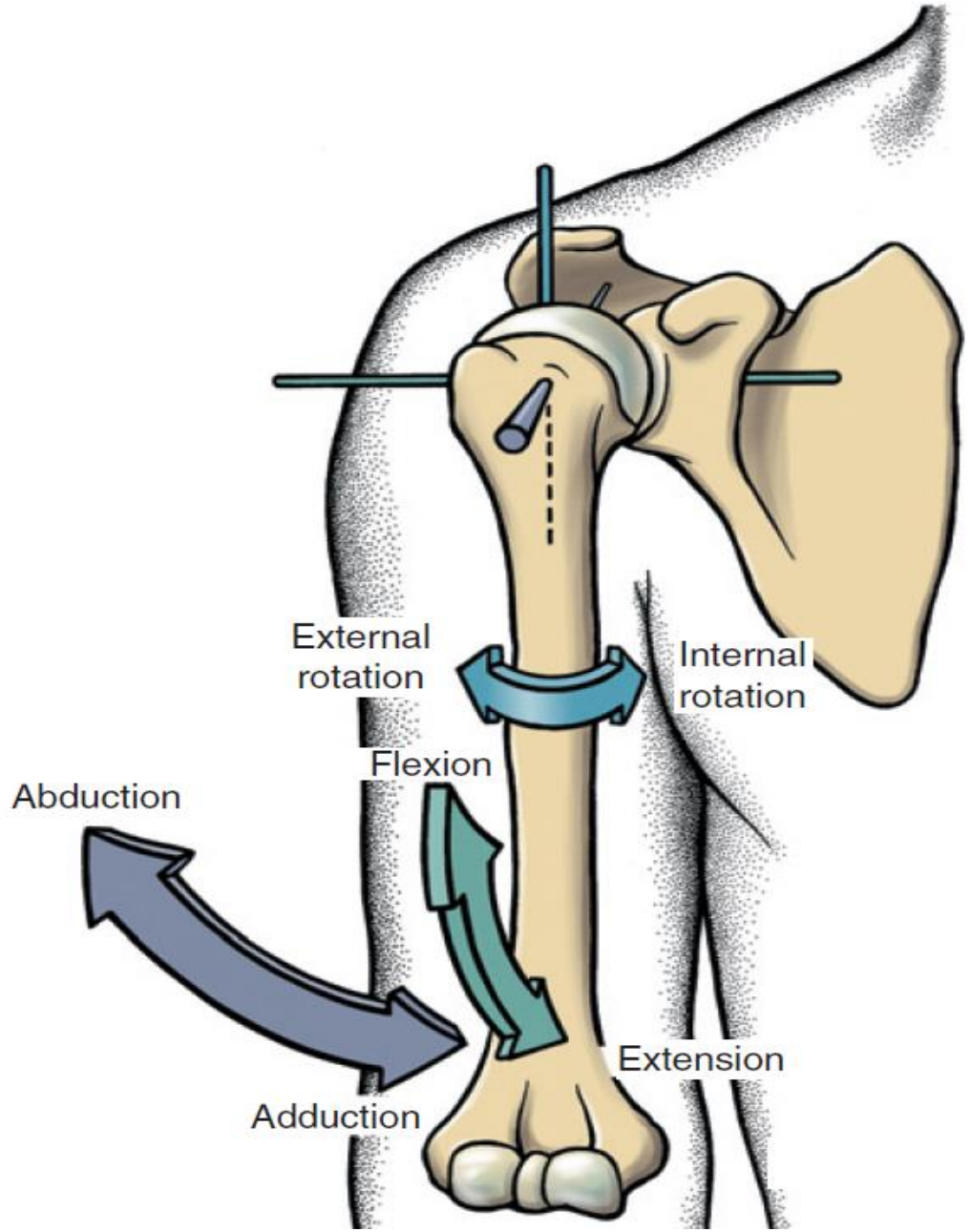
(B) With a loss of upward rotation posture of the scapula (indicated by the cut rope), the change in angle between the SCS and G vectors reduces the magnitude of the compression force across the GH joint. As a consequence, the head of the humerus may slide down the now vertically oriented glenoid fossa. The dashed lines indicate the parallelogram method of adding force vectors.



Glenohumeral KINEMATICS

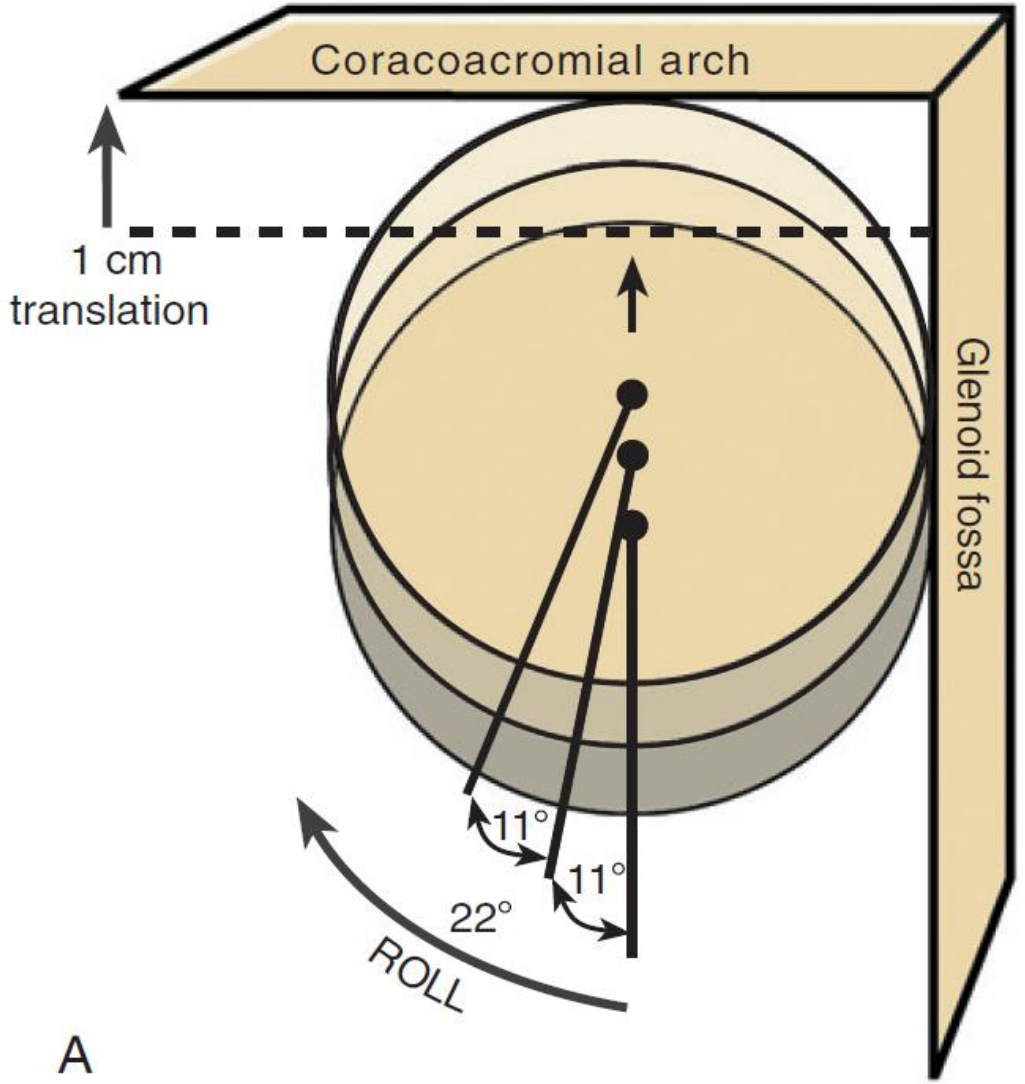
Abduction and Adduction





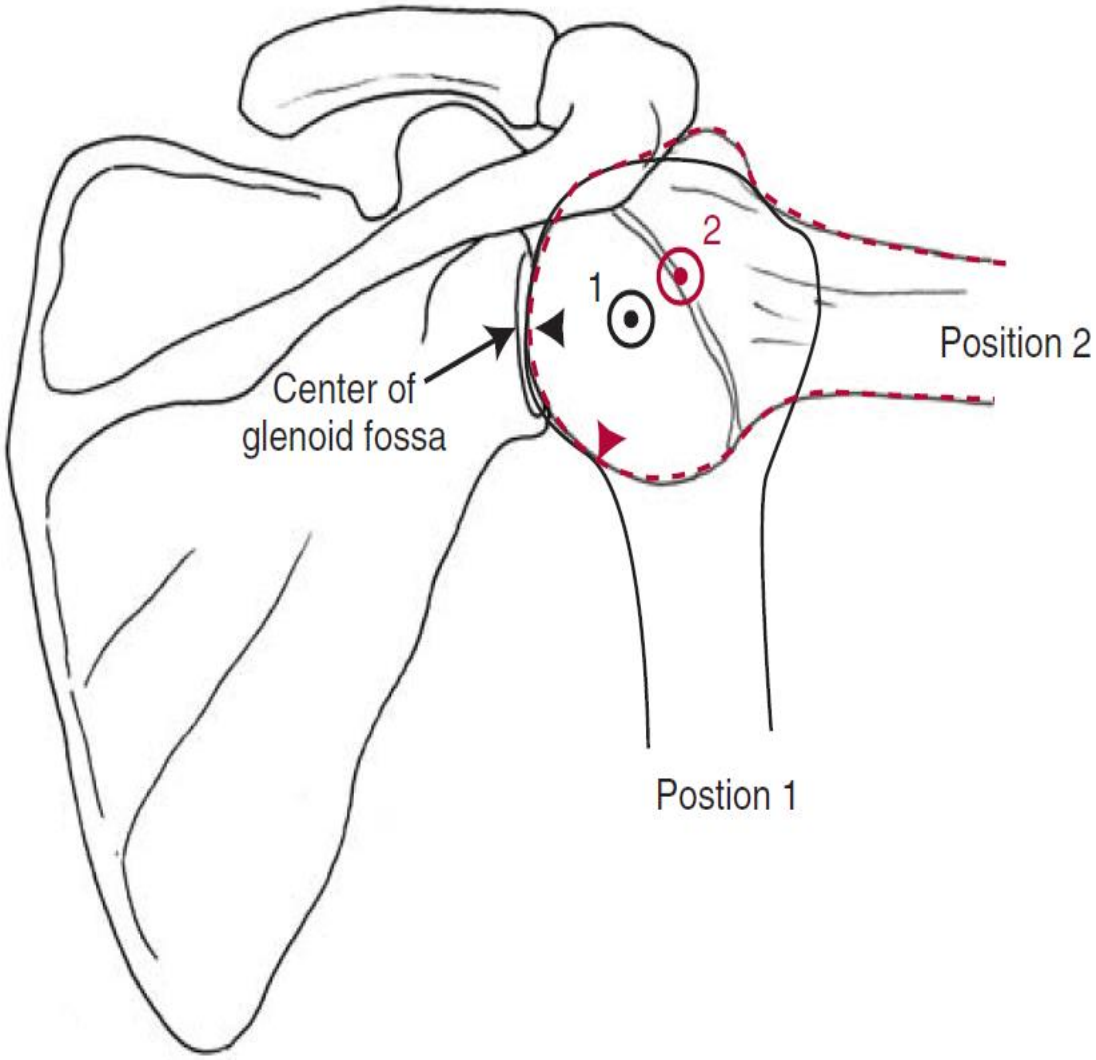
Clinical Relevance of Roll-and-Slide Arthrokinematics at the Glenohumeral Joint

An adult-sized humeral head that is rolling up a glenoid fossa *without* a concurrent inferior slide would translate through the 10-mm subacromial space after only 22 degrees of GH joint abduction



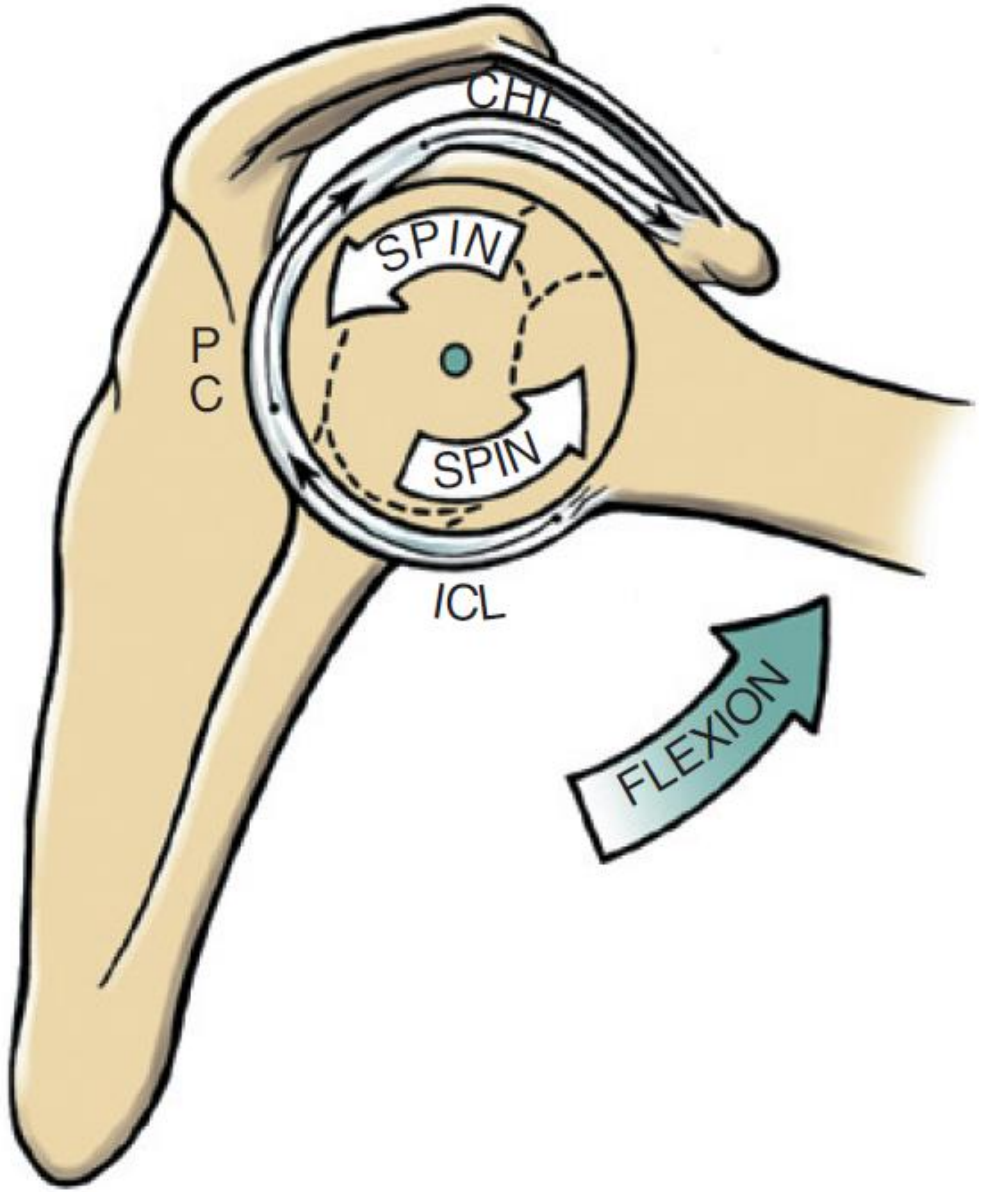
It appears that the humeral head center of rotation still moves somewhat superiorly (translates upwardly 1 to 2 mm) until about 60 of active elevation motion on the glenoid fossa in spite of the downward sliding

All studies of active translations show smaller magnitudes of motion (5 mm) during active motions than is available in a passive laxity examination, in which translations up to 20 mm have been reported. These data support that rotator cuff forces help to stabilize and center the humeral head on the glenoid fossa.



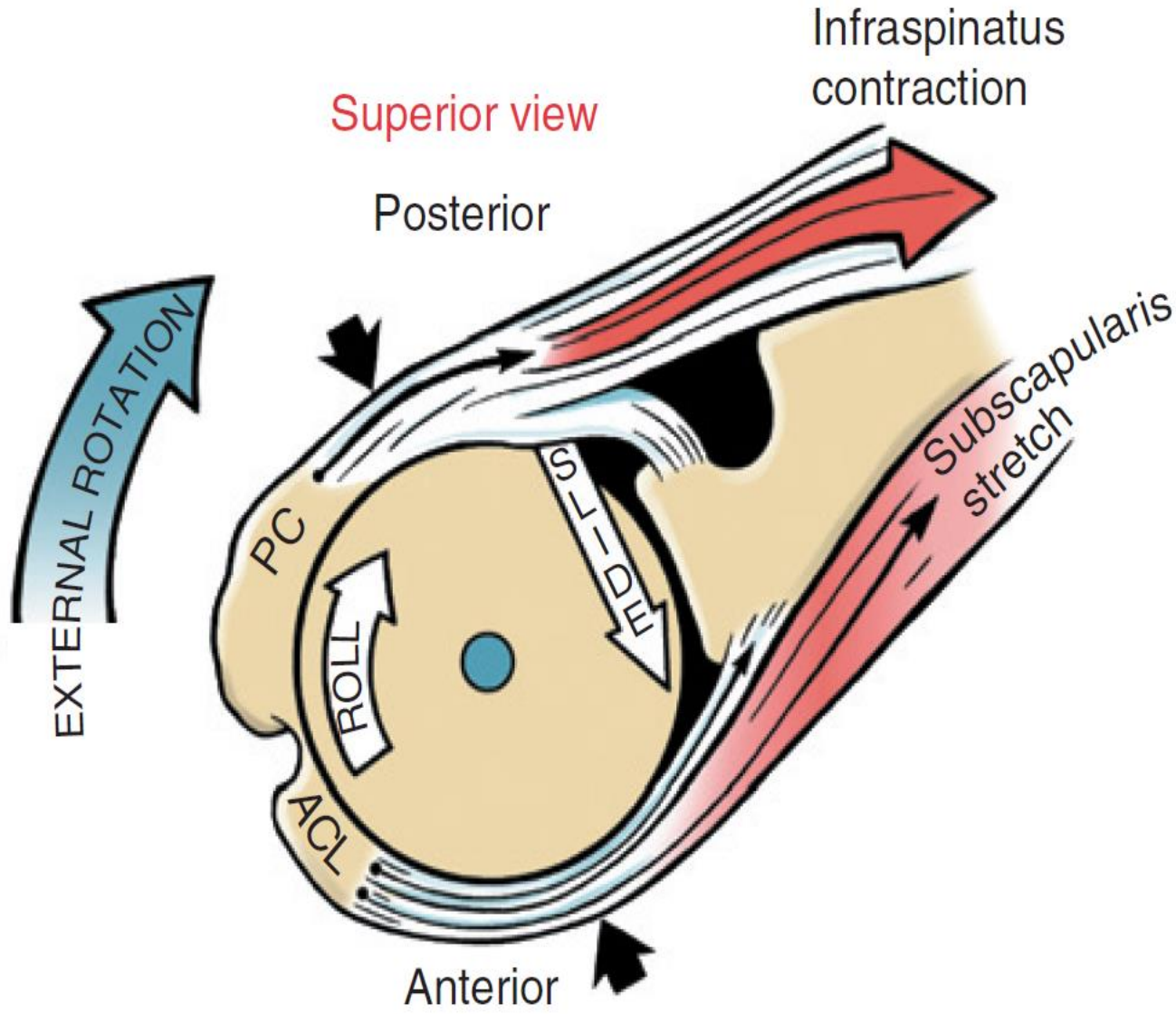
Flexion and Extension

A point on the head of the humerus is shown spinning around a point on the glenoid fossa. Stretched structures are shown as *long thin arrows*. *PC,* posterior capsule; *ICL,* inferior capsular ligament; *CHL,* coracohumeral ligament.



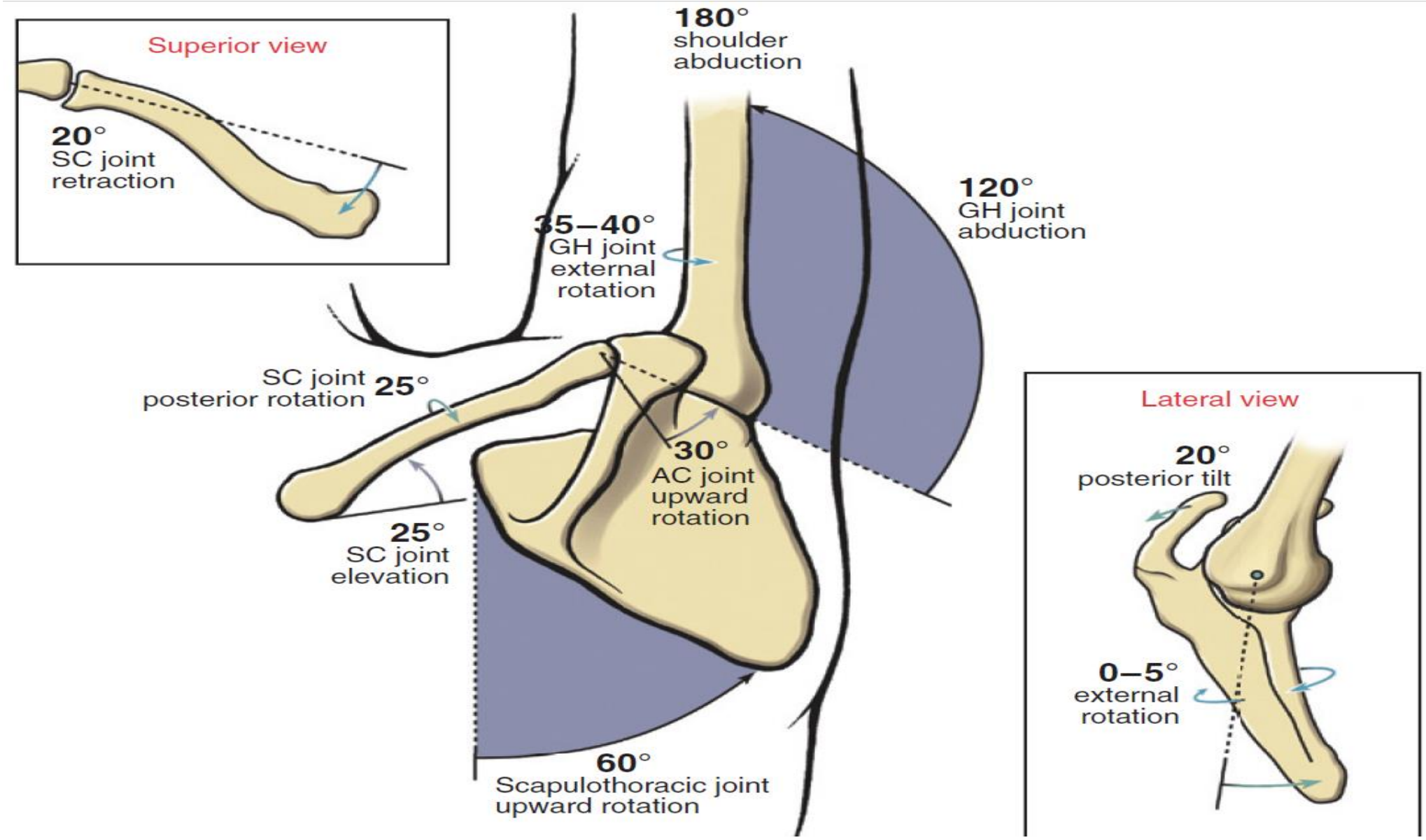
Internal and External Rotation

The arthrokinematics of external rotation The humeral head simultaneously rolls posteriorly and slides anteriorly on the glenoid fossa



Rotation of the GH joint from a position of about 90 degrees of abduction, however, requires primarily a spinning motion between a point on the humeral head and the glenoid fossa.

Overall Kinematics of Shoulder Abduction: Establishing Six Kinematic Principles of the Shoulder Complex



Six Kinematic Principles Associated with Full Abduction of the Shoulder

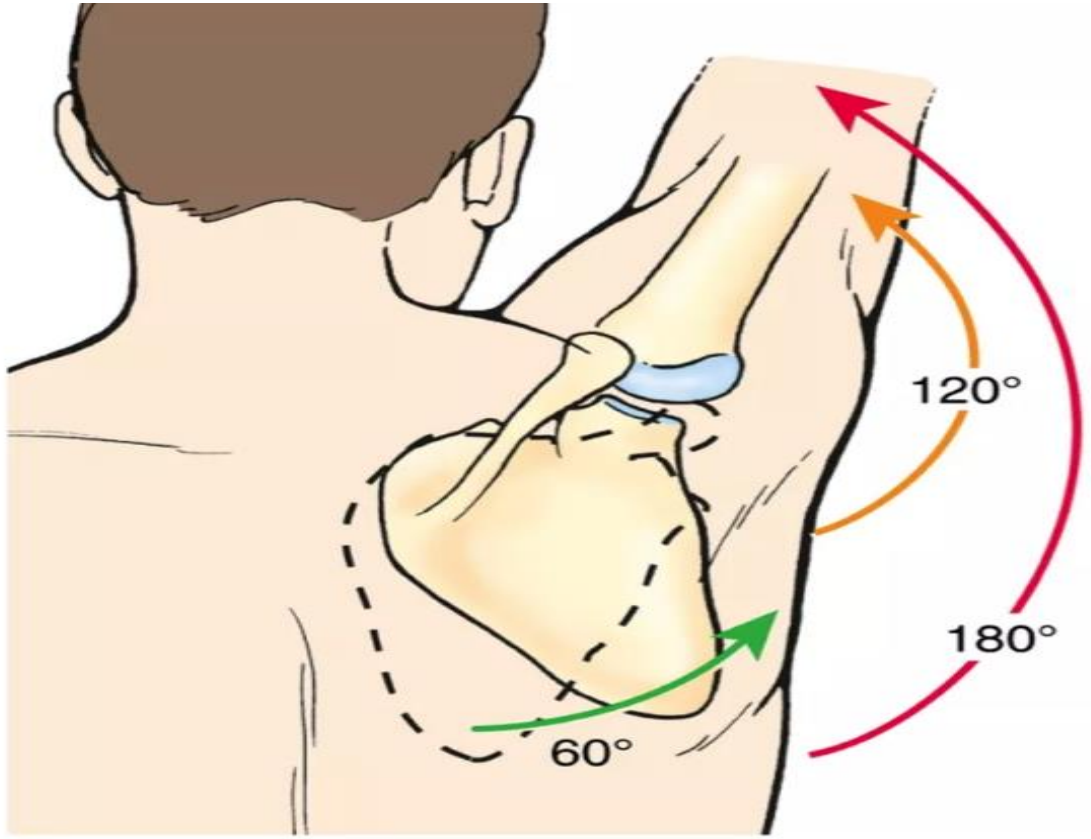
- **Principle 1:** Based on a generalized 2 : 1 scapulohumeral rhythm, active shoulder abduction of about 180 degrees occurs as a result of simultaneous 120 degrees of glenohumeral (GH) joint abduction and 60 degrees of scapulothoracic upward rotation.
- **Principle 2:** The 60 degrees of upward rotation of the scapula during full shoulder abduction is the result of a simultaneous elevation at the sternoclavicular (SC) joint combined with upward rotation at the acromioclavicular (AC) joint.
- **Principle 3:** The clavicle retracts at the SC joint during shoulder abduction.
- **Principle 4:** The upwardly rotating scapula posteriorly tilts and, less consistently, externally rotates slightly during full shoulder abduction.
- **Principle 5:** The clavicle posteriorly rotates around its own axis during shoulder abduction.
- **Principle 6:** The GH joint externally rotates during shoulder abduction.

Scapulohumeral Rhythm

Scapulohumeral rhythm serves two purposes:

1.It preserves the length-tension relationships of the glenohumeral muscles.

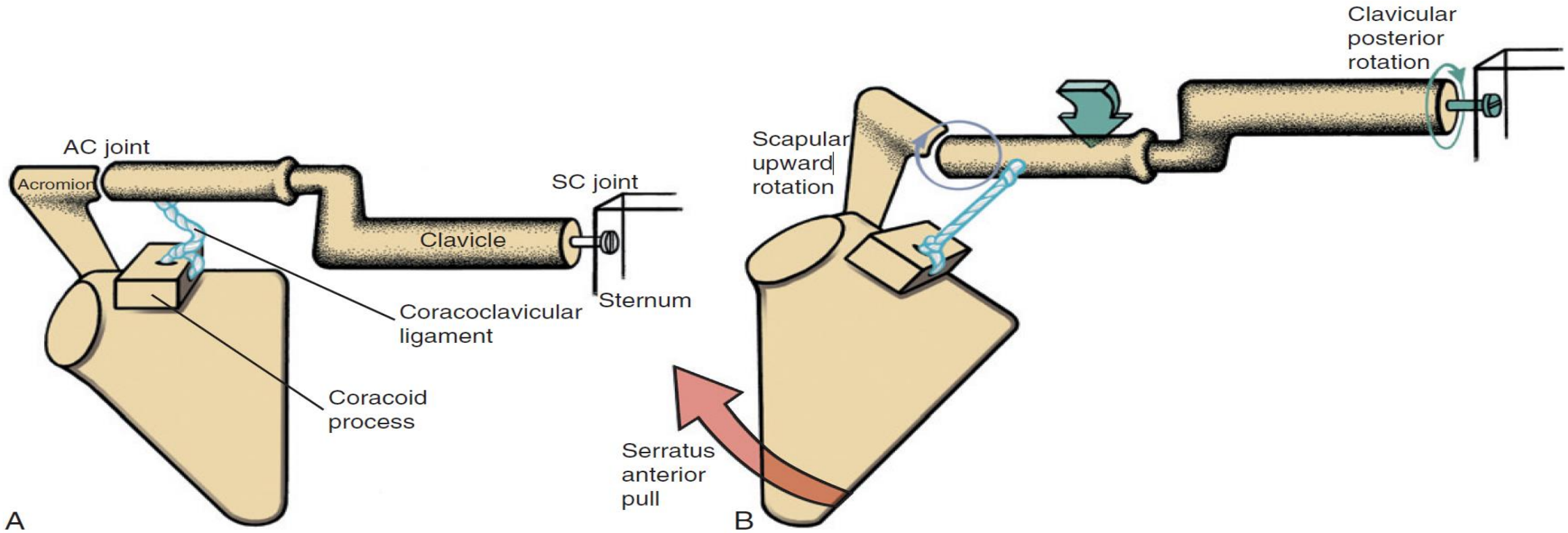
2.It prevents impingement between the humerus and the acromion.



Scapulo-humeral rhythm. The scapula and humerus move in 1:2 ratio. When the arm is abducted 180 degrees, 60 degrees occurs by rotation of the scapula, and 120 degrees by rotation of the humerus at the shoulder joint.

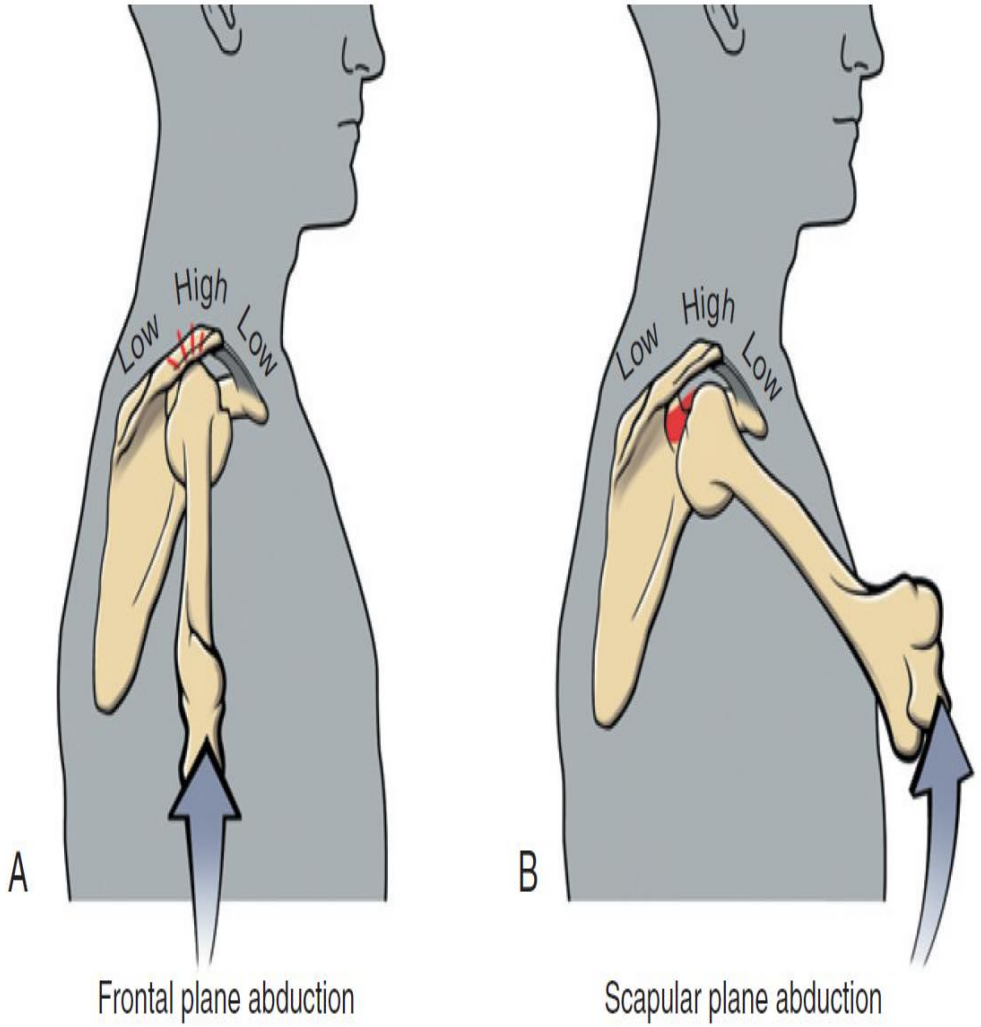
The mechanics of posterior rotation of the clavicle

At the early phases of shoulder abduction, the scapula begins to upwardly rotate at the AC joint, stretching the relatively stiff coracoclavicular ligament. The inability of this ligament to significantly elongate restricts further upward rotation at this joint. Tension within the stretched ligament is transferred to the conoid tubercle region of the clavicle, a point posterior to the bone's longitudinal axis. The application of this force rotates the crank-shaped clavicle posteriorly.



Shoulder Abduction in the Frontal Plane versus the Scapular Plane

- appears less mechanically coupled to an obligatory external rotation of the Impingement is avoided because scapular plane abduction places the apex of the greater tubercle under the relatively high point of the coracoacromial arch
- Abduction in the scapular plane also allows the naturally retroverted humeral head to be oriented more directly into the glenoid fossa
- . Abduction in the scapular plane allows the proximal and distal attachments of the supraspinatus muscle are also placed along a straight line.
- At scaption there is less restriction to motion because the capsule is less twisted than when the humerus is brought further back into the frontal plane

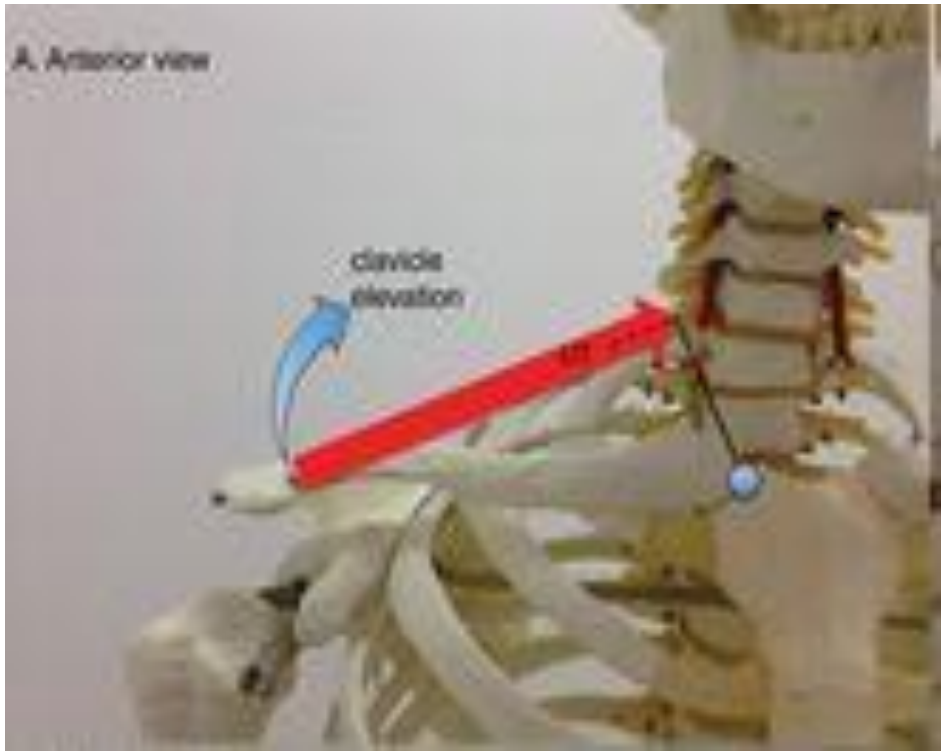


Muscles of the Scapulothoracic Joint

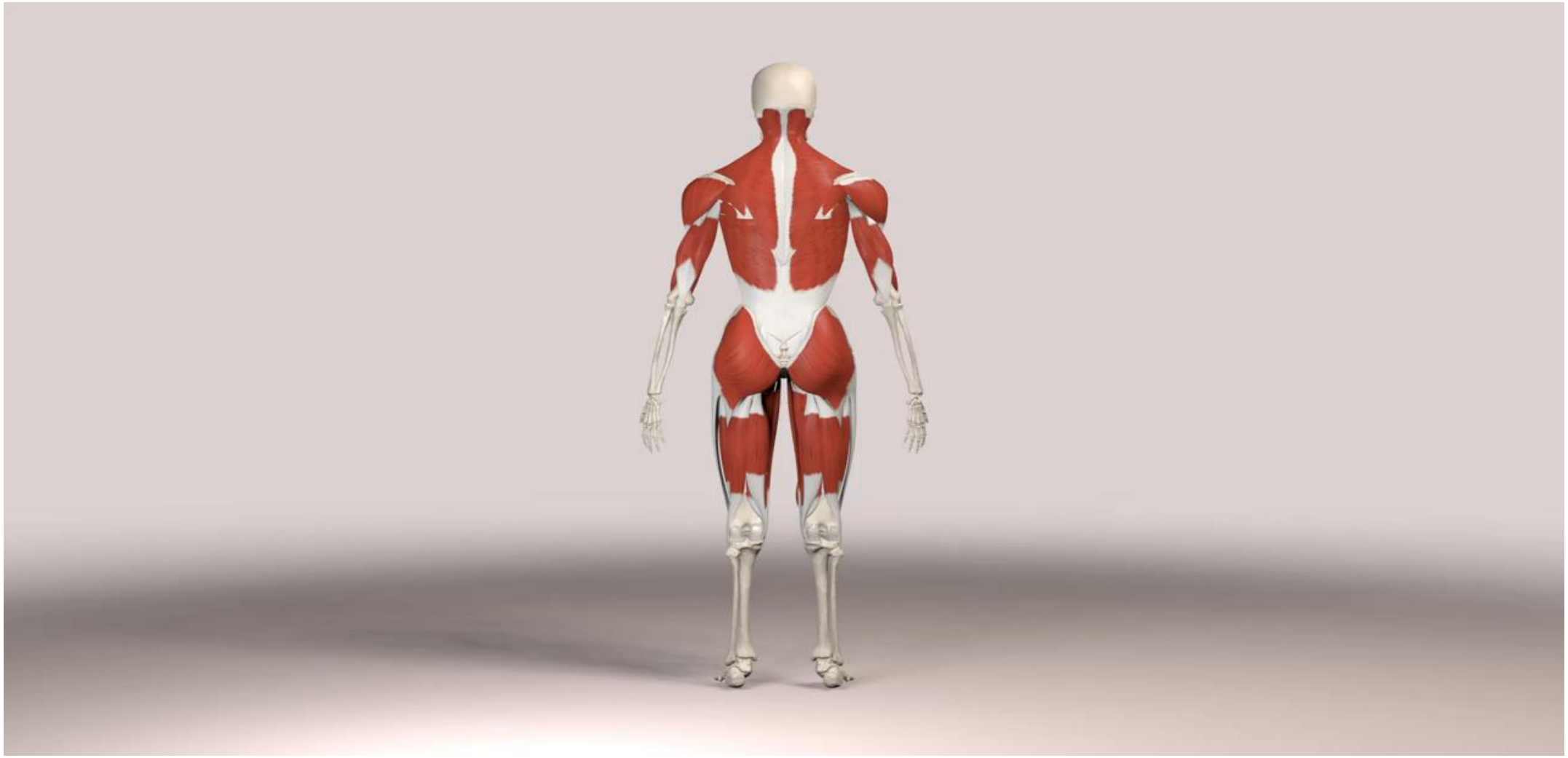
ELEVATORS

upper trapezius, levator scapulae,* and, *rhomboids

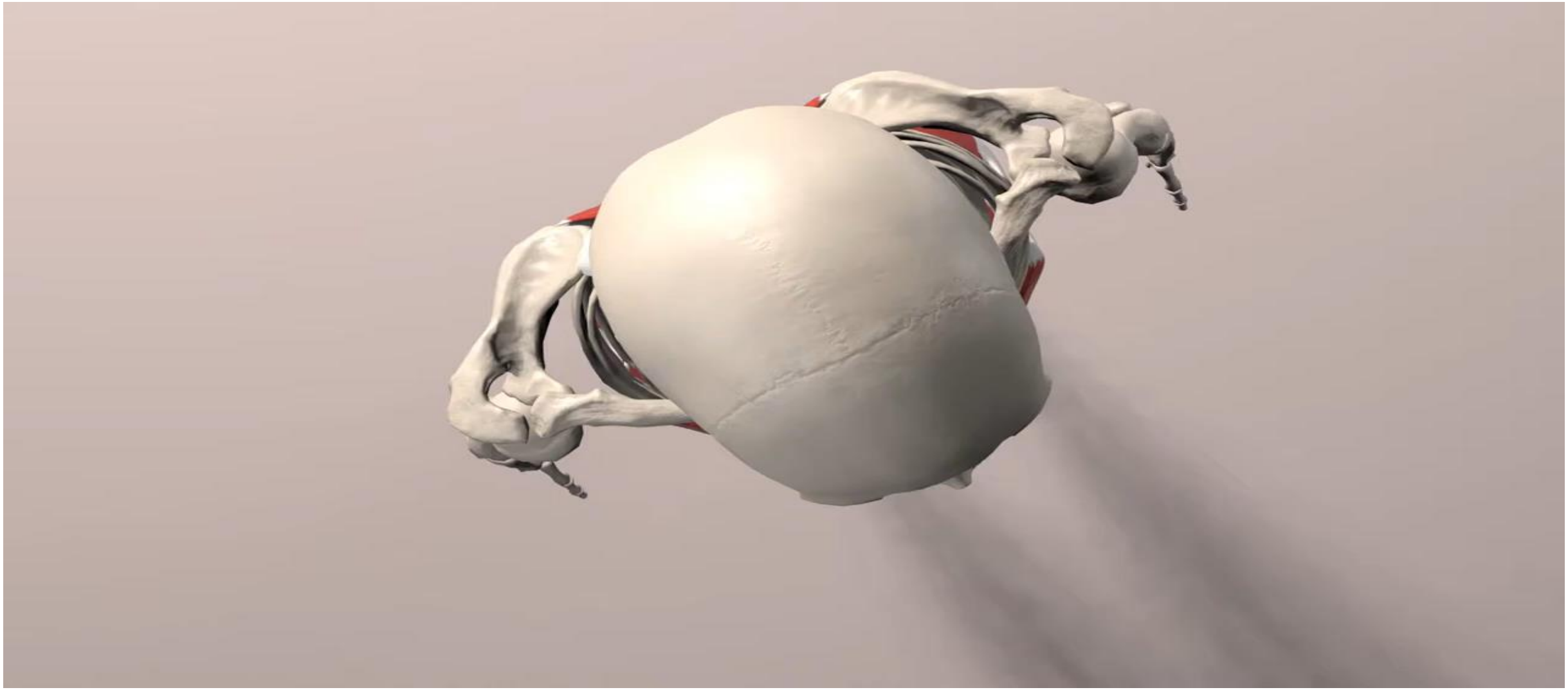
- these muscles support the posture of the shoulder “girdle”. Although variable, ideal posture of the shoulder, with the glenoid fossa facing slightly upward.
- The upper trapezius, by attaching to the lateral end of the clavicle, provides excellent leverage around the SC joint for maintenance of the ideal posture.



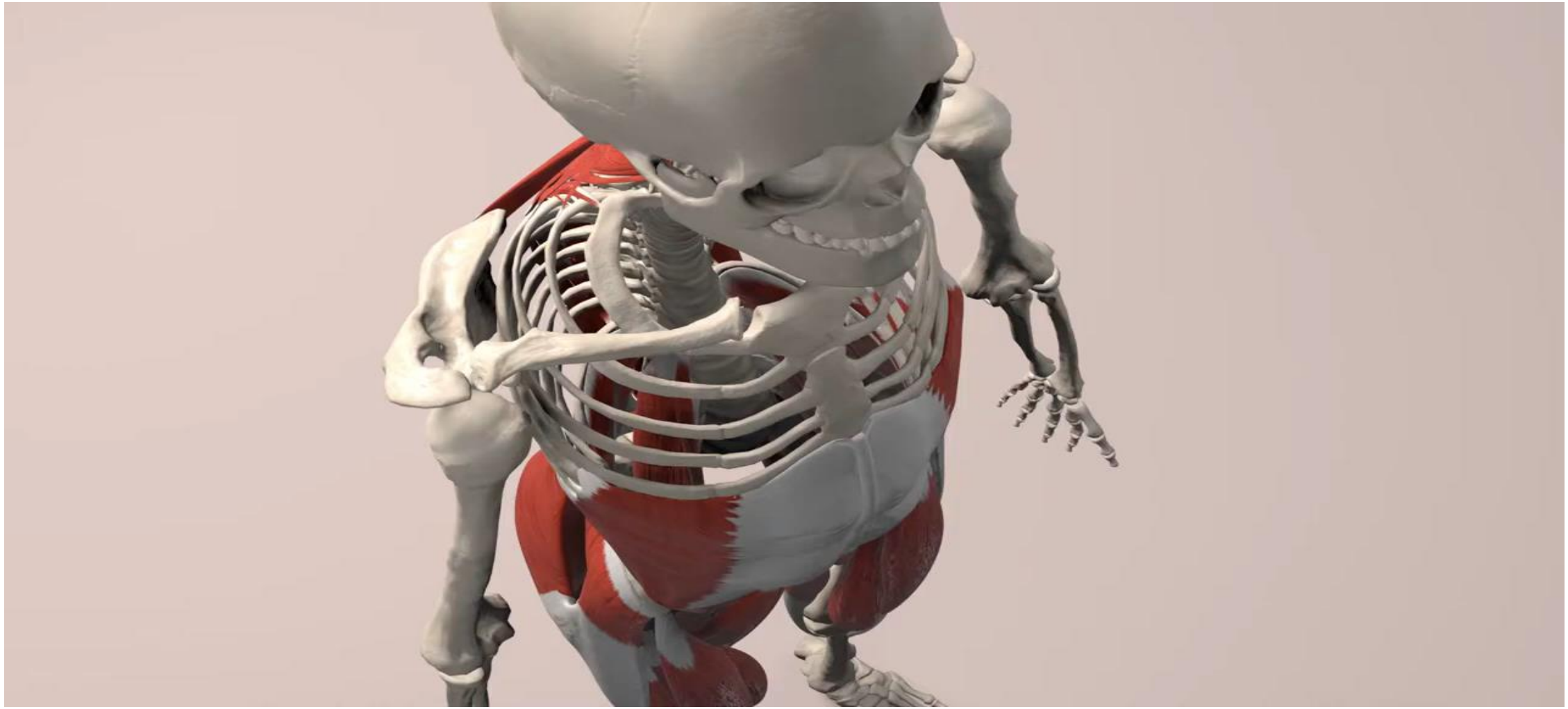
upper trapezius



levator scapulae



Rhomboids major

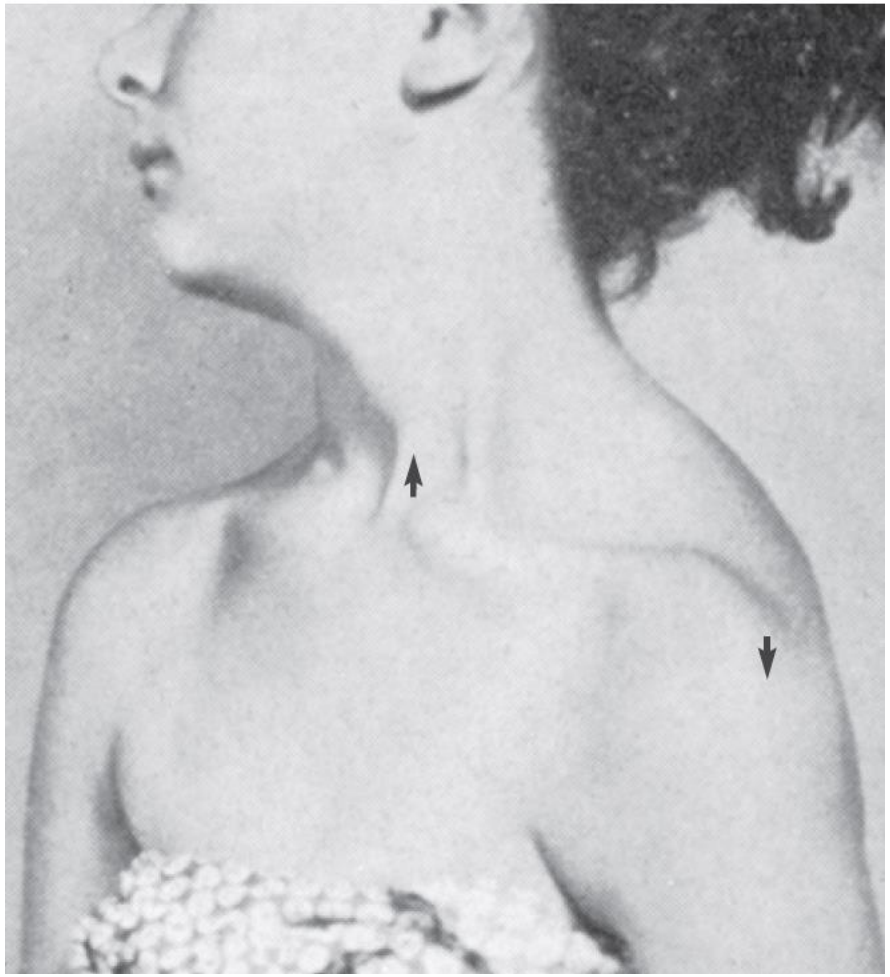


Rhomboids minor

paralysis of the upper trapezius may occur from damage to the spinal accessory nerve (cranial nerve XI) or following polio, after a stroke or from a disease such as muscular dystrophy, or Guillain-Barré syndrome. Allow for a posture typically includes a depressed, protracted, and excessively downwardly rotated scapula.

the posture of a girl with paralysis of her left upper trapezius caused by the polio virus.

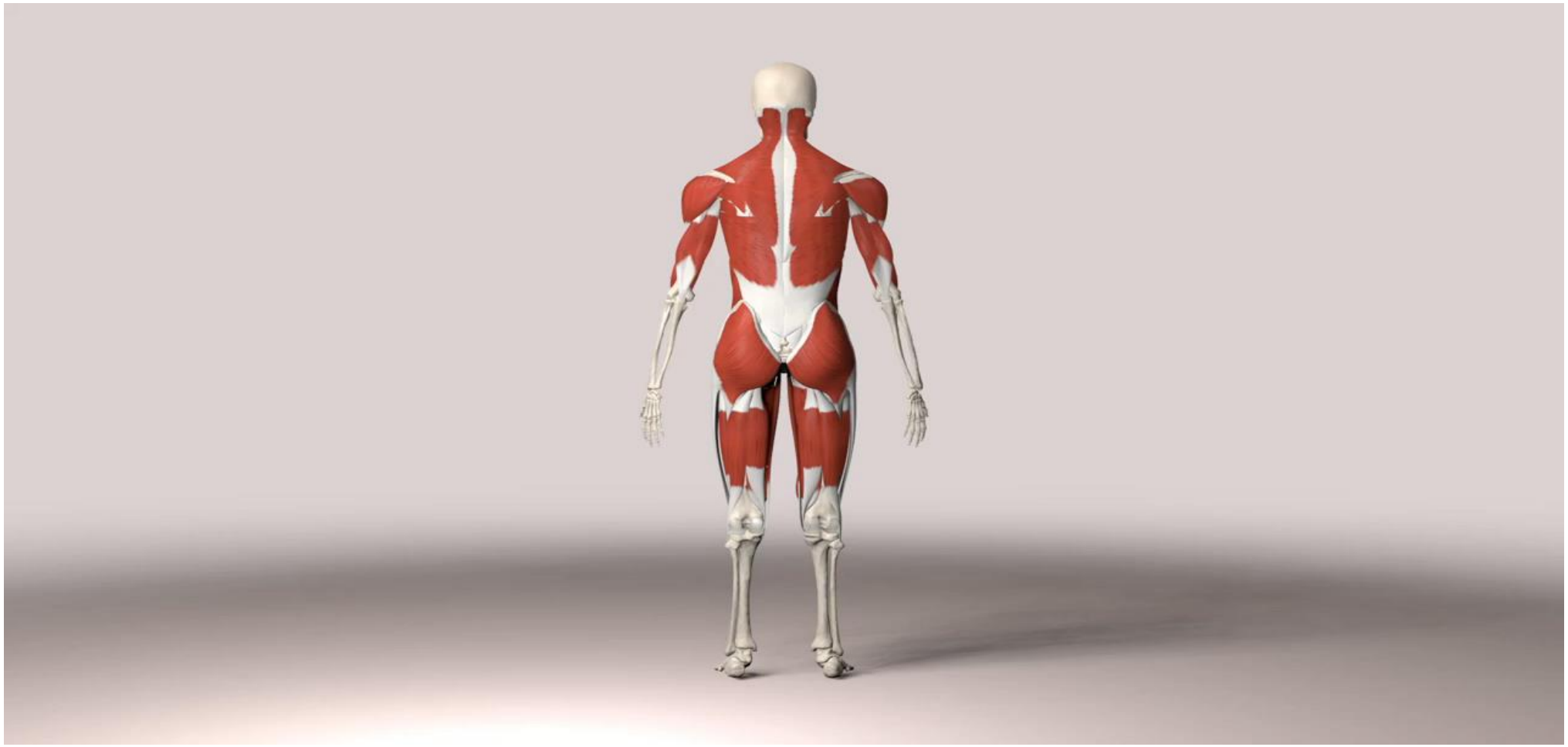
- Over time, a depressed clavicle has resulted in superior dislocation of the SC joint As the lateral end of the clavicle is lowered, the medial end is forced upward because of the fulcrum action of the underlying first rib. The depressed shaft of the clavicle may compress the subclavian vessels and part of the brachial plexus.
- With long-term paralysis of the trapezius, the glenoid fossa loses its upwardly rotated position, allowing the humerus to slide inferiorly.



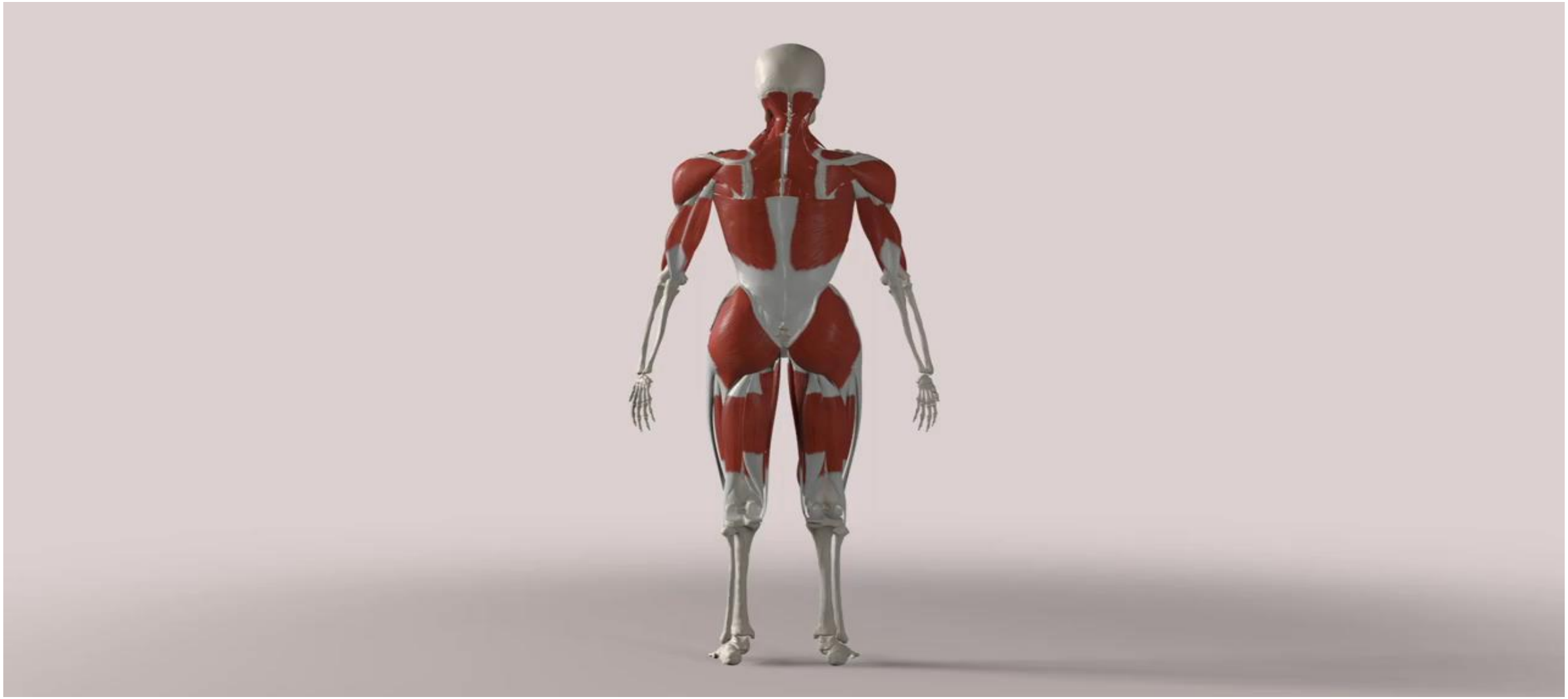
DEPRESSORS

Lower trapezius, latissimus dorsi, pectoralis minor, **and the** ***subclavius***

Lower trapezius



latissimus dorsi

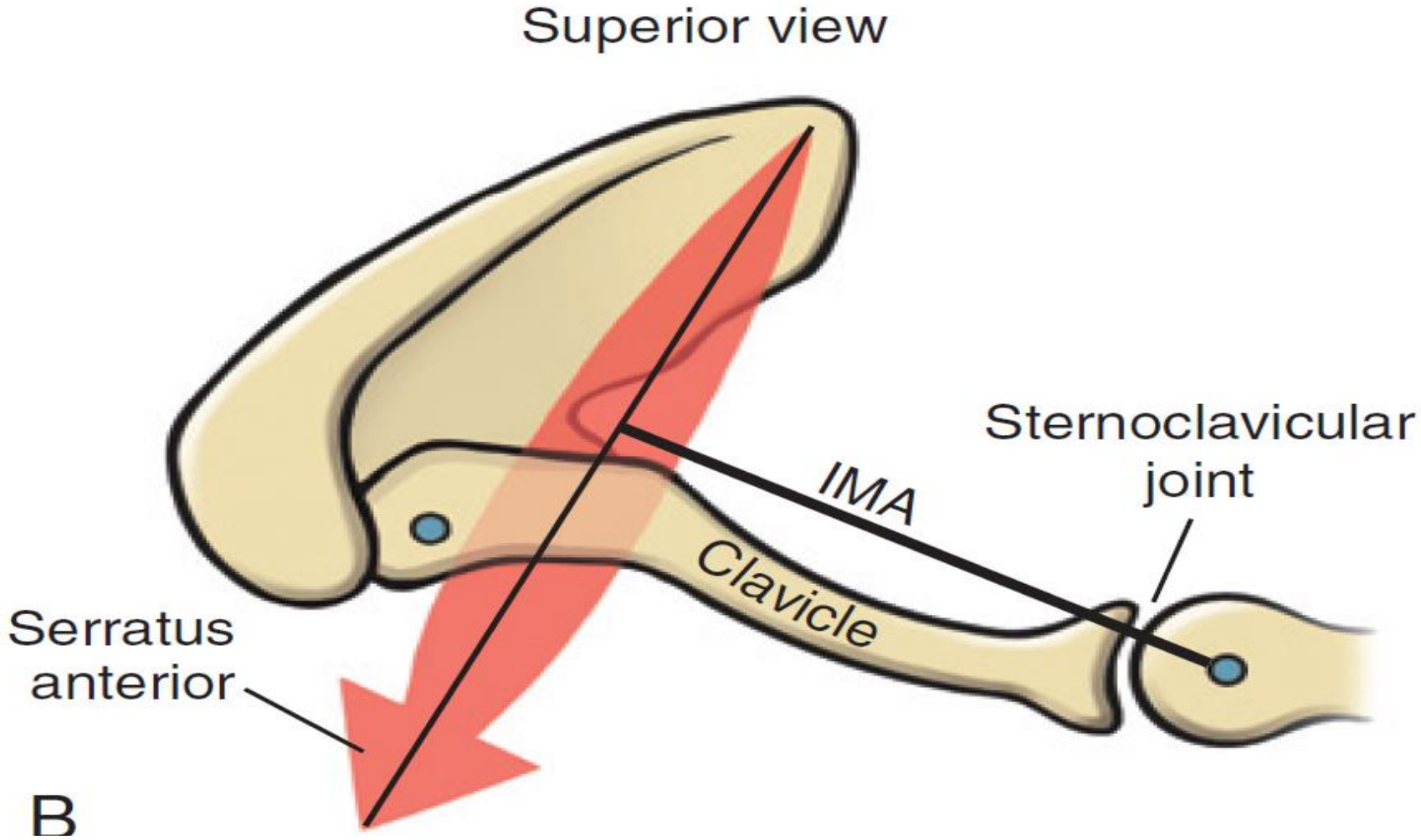


pectoralis minor

PROTRACTORS

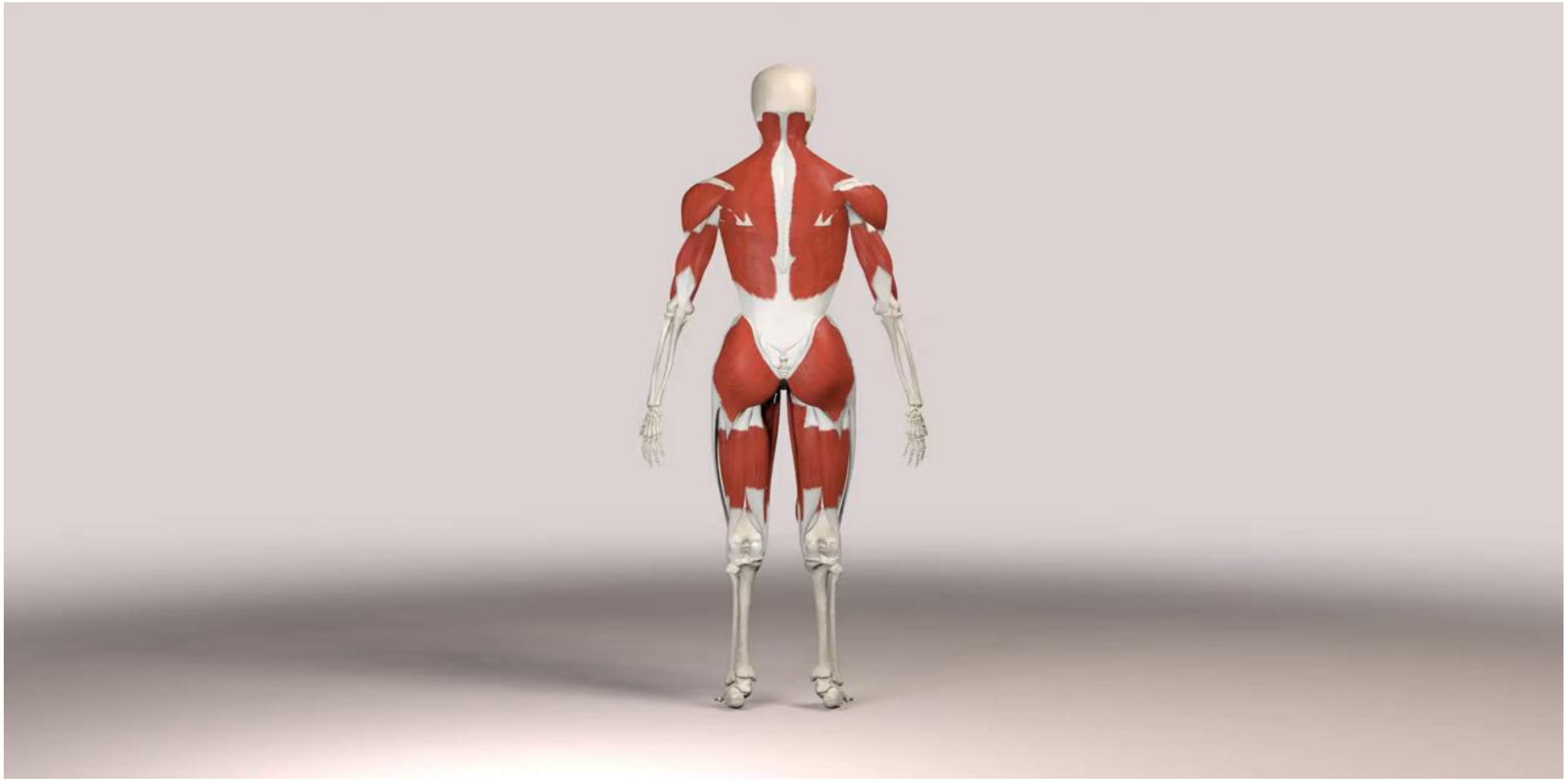
serratus anterior

The *serratus anterior* has excellent leverage for protraction around the SC joint's vertical axis of rotation

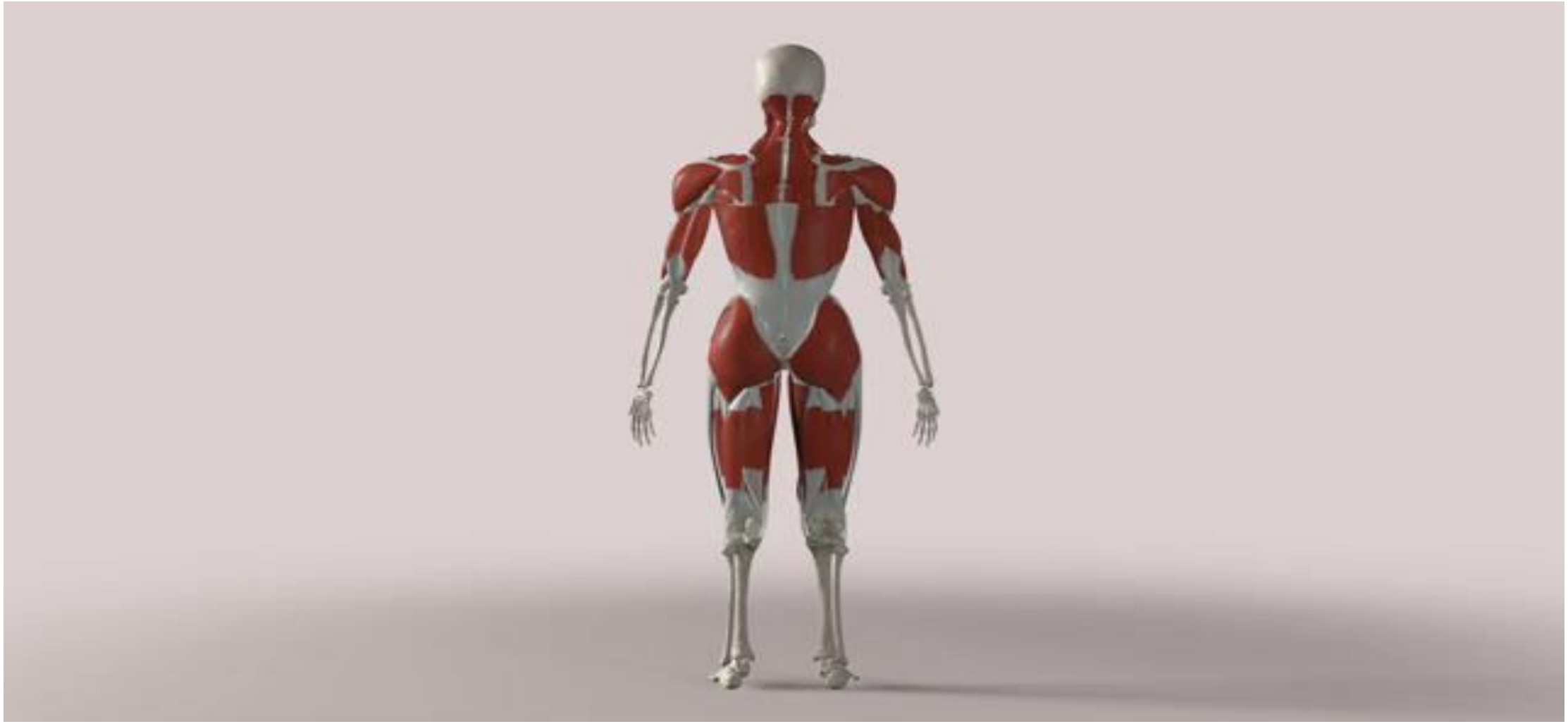


RETRACTORS

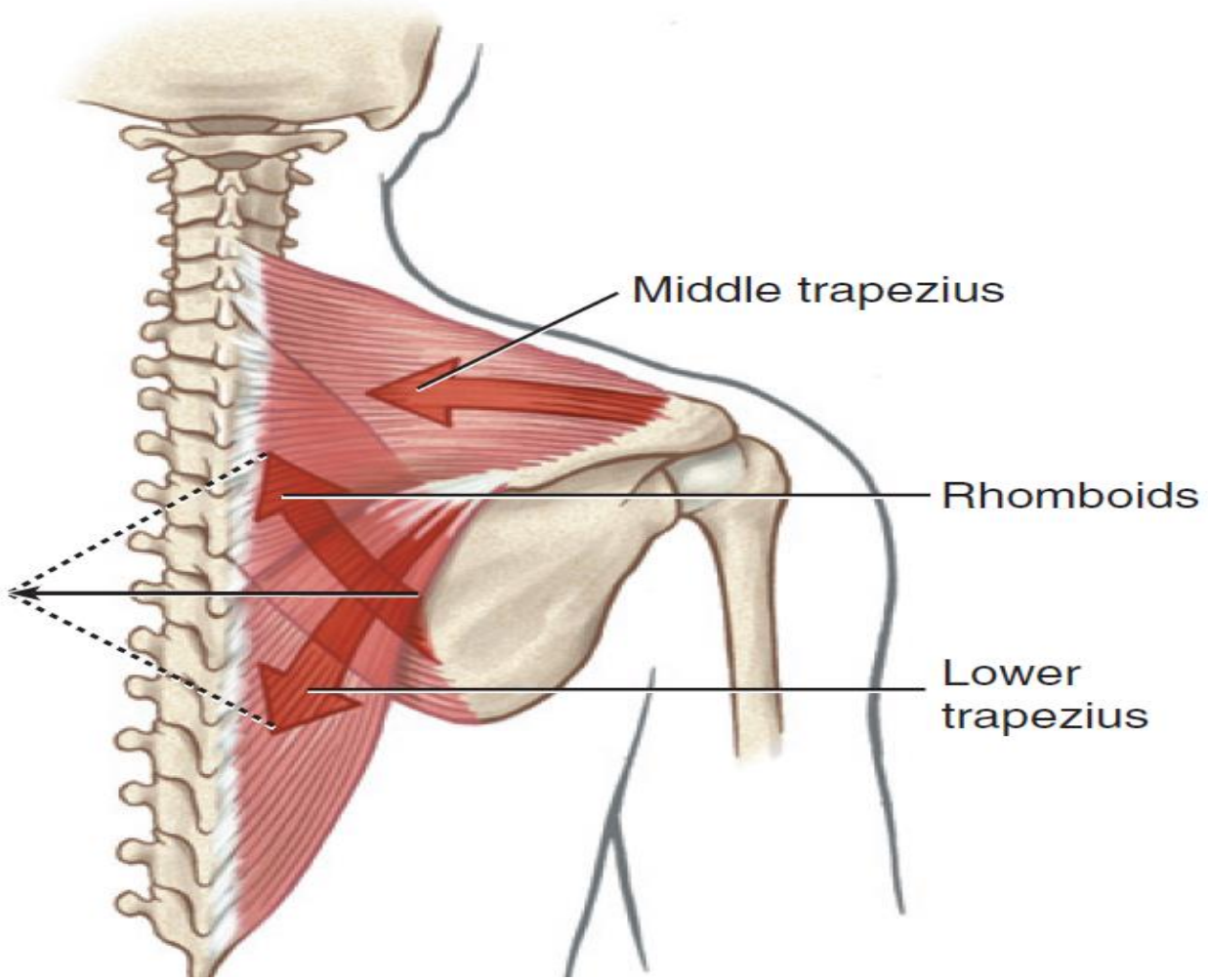
the *middle trapezius*



Latissimus Dorsi Functions: Scapula retraction



the elevation tendency of the rhomboids is neutralized by the depression tendency of the lower trapezius. The lines of force of both muscles combine, however, to produce pure retraction



Muscles That Elevate the Arm

1. muscles that elevate (i.e., abduct or flex) the humerus at the GH joint
2. scapular muscles that control the upward rotation of the scapulothoracic joint
3. rotator cuff muscles that control the dynamic stability and arthrokinematics at the GH joint.

Glenohumeral Muscles

- Anterior and middle deltoid
- Supraspinatus
- Coracobrachialis
- Biceps brachii

SCAPULOTHORACIC MUSCLES

- Serratus anterior
- Trapezius

ROTATOR CUFF MUSCLES

- Supraspinatus
- Infraspinatus
- Teres minor
- Subscapularis

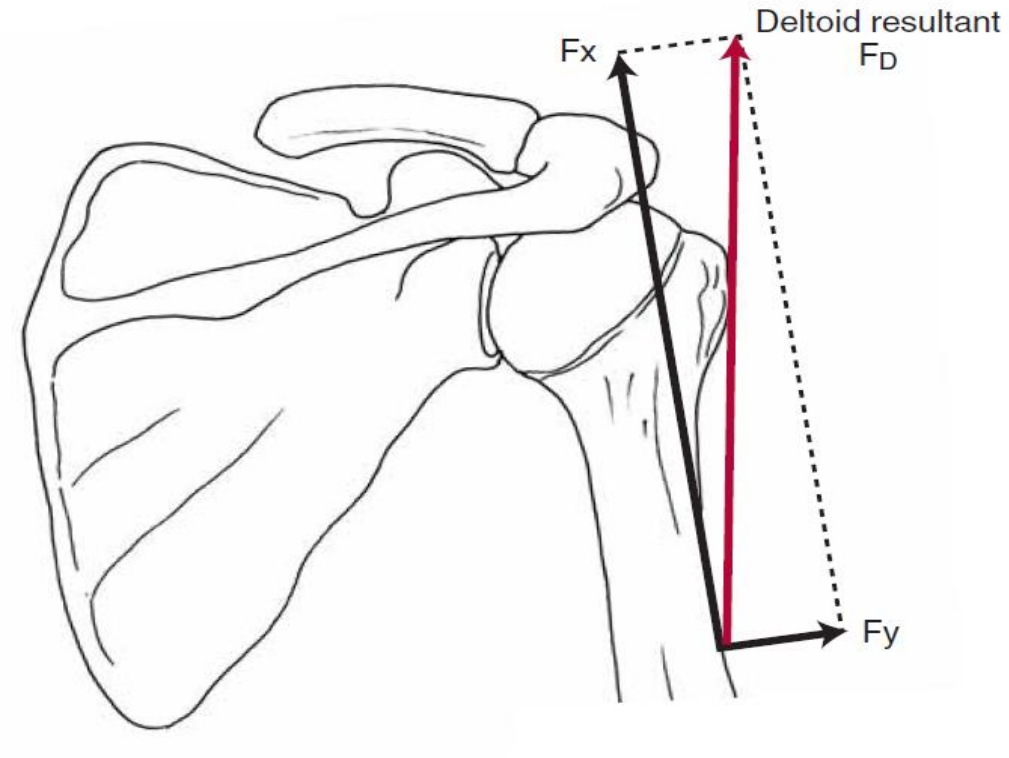
MUSCLES THAT ELEVATE THE ARM AT THE GLENOHUMERAL JOINT

- The anterior and middle deltoid and supraspinatus muscles are activated at the onset of abduction
- reaching a maximum level of activation between 60 and 90 degrees of abduction—a point where the external torque due to the weight of the arm approaches its greatest level

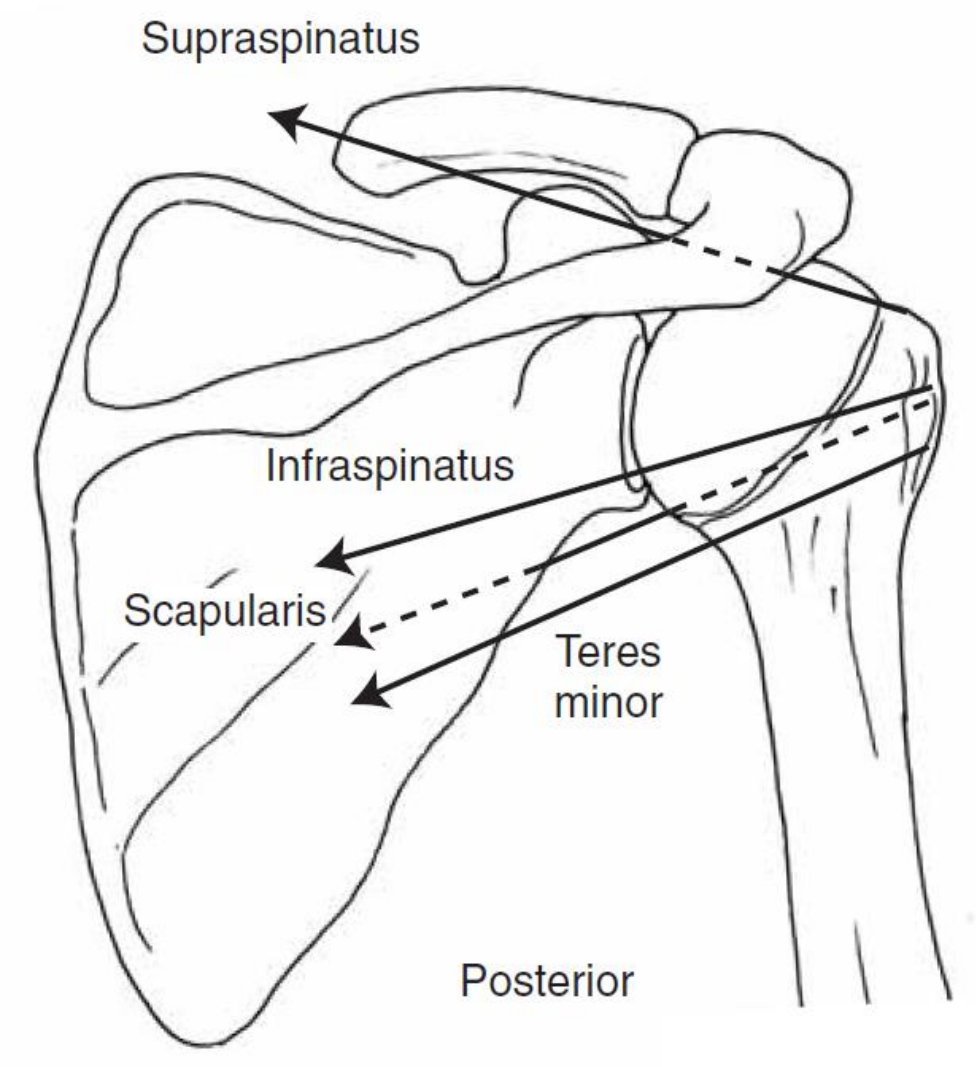
Research indicates that the middle deltoid and supraspinatus have nearly equal cross-sectional areas and moment arms for abduction. As expected, therefore, each muscle produces about equal shares of the total abduction torque at the GH joint.

The Deltoid and Glenohumeral Stabilization

The resultant (FD) resolves into a very large translatory component (Fx) and a small rotatory component (Fy) so that an isolated contraction of the deltoid would cause the deltoid to produce more superior translation than does rotation of the humerus.

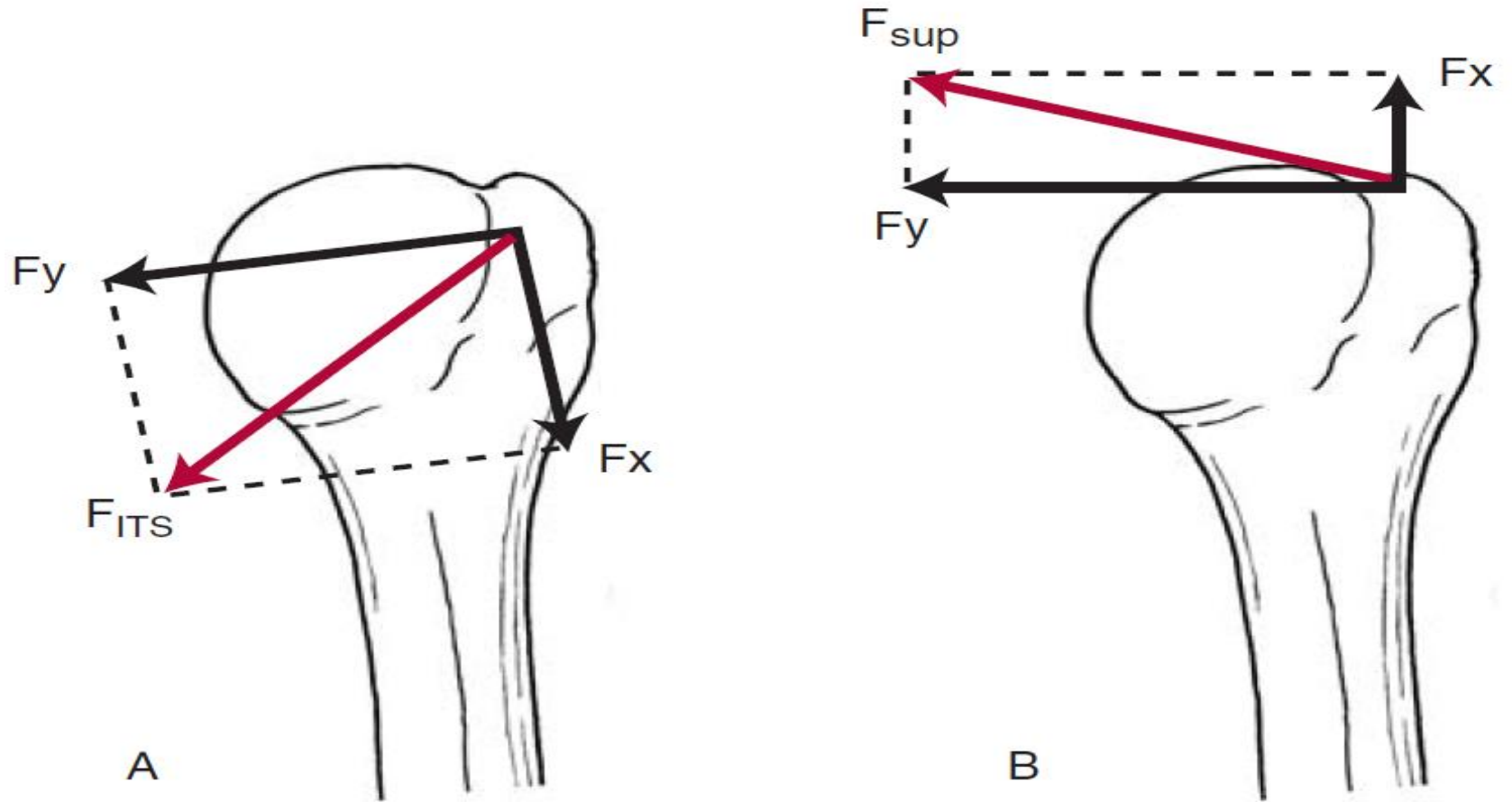


The Rotator Cuff and Glenohumeral Stabilization



The action line of the four segments of the rotator cuff

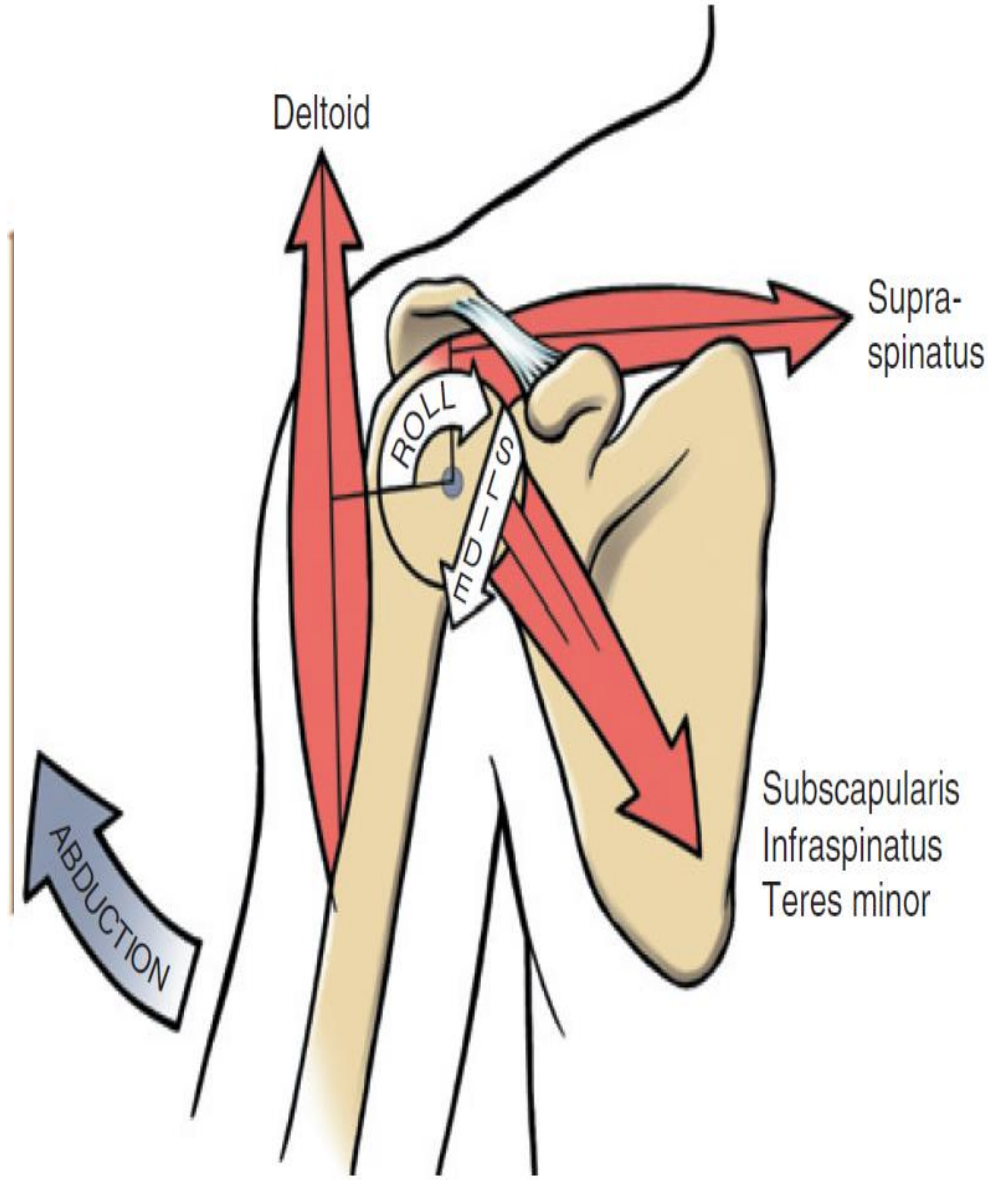
A. The infraspinatus, teres minor, and subscapularis muscles individually or together have a similar line of pull. The rotatory component (Fy) compresses as well as rotates, and the translatory component (Fx) helps offset the superior translatory pull of the deltoid.
B. The supraspinatus has a superiorly directed translatory component (Fx) and a rotatory component (Fy) that is more compressive than that of the other rotator cuff muscles and can independently abduct the humerus.



Muscular Force Couples

the deltoid rotator cuff force couple

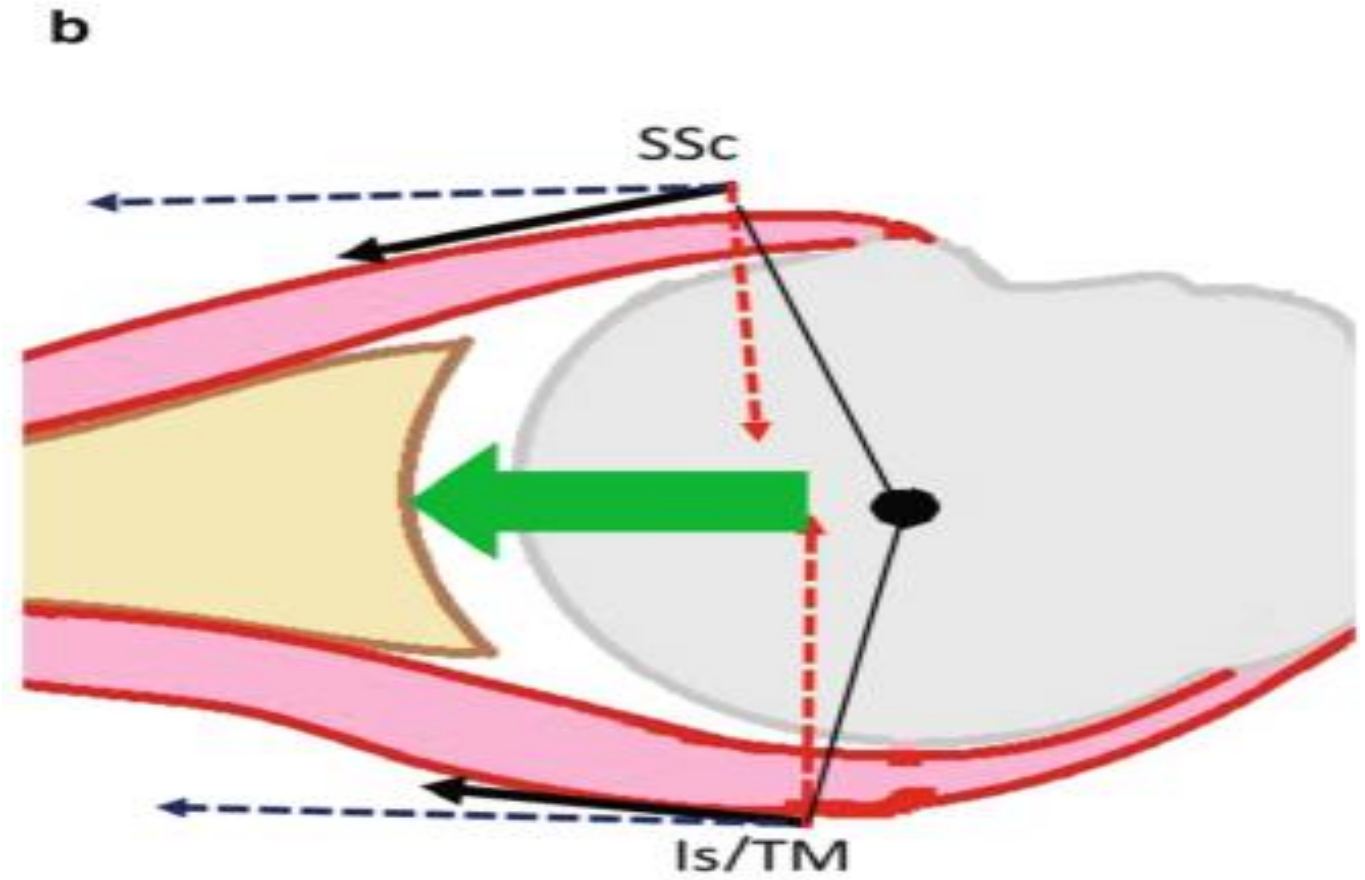
- deltoid force causes a superior shear force of the humeral head
- The infraspinatus, teres minor, and subscapularis thus form a force couple with the deltoid and act to stabilize the humeral head on the glenoid fossa, allowing the deltoid and supraspinatus to act as abductors of the humerus
- The supraspinatus has a small superior shear component, but its main function is compression because of the horizontal orientation of the muscle fibers



- With the deltoid paralyzed, the supraspinatus muscle is generally capable of fully abducting the GH joint, although the abduction torque is much reduced. Similarly, (Gravity acts as a stabilizing synergist to the supraspinatus by offsetting the small upward translatory pull of the muscle)
- with the supraspinatus paralyzed or its tendon completely ruptured, full abduction is often difficult, albeit achievable.
- Full active abduction is normally not possible with paralysis of both the deltoid and the supraspinatus.

Anterior-posterior rotator cuff force couples

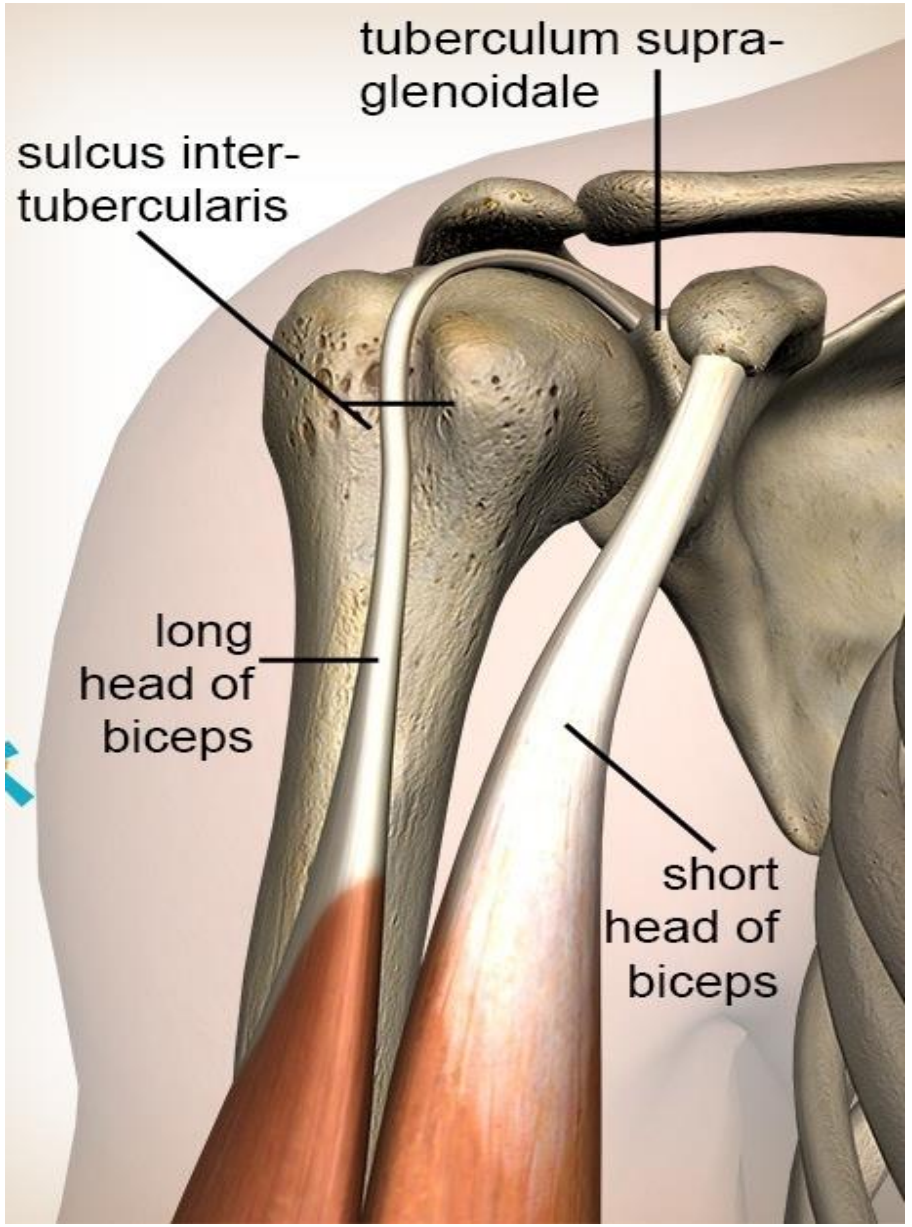
Transverse-plane force couples: the subscapularis (SSc) pulls forward and the infraspinatus and teres minor (Is/TM) pull backward.



Vertical and anteroposterior forces cancel each other (red arrows) and the remaining medializing forces (blue arrows) produce a net resultant force (green arrow) that compresses the head toward the center of the glenoid

The Long Head of the Biceps Brachii and Glenohumeral Stabilization

- (5th rotator cuff).
- preventing upward migration of the head of the humerus
- Pagnani and colleagues hypothesized that the long head may produce its effect by tightening the relatively loose superior labrum and transmitting increased tension to the superior and middle GH ligaments

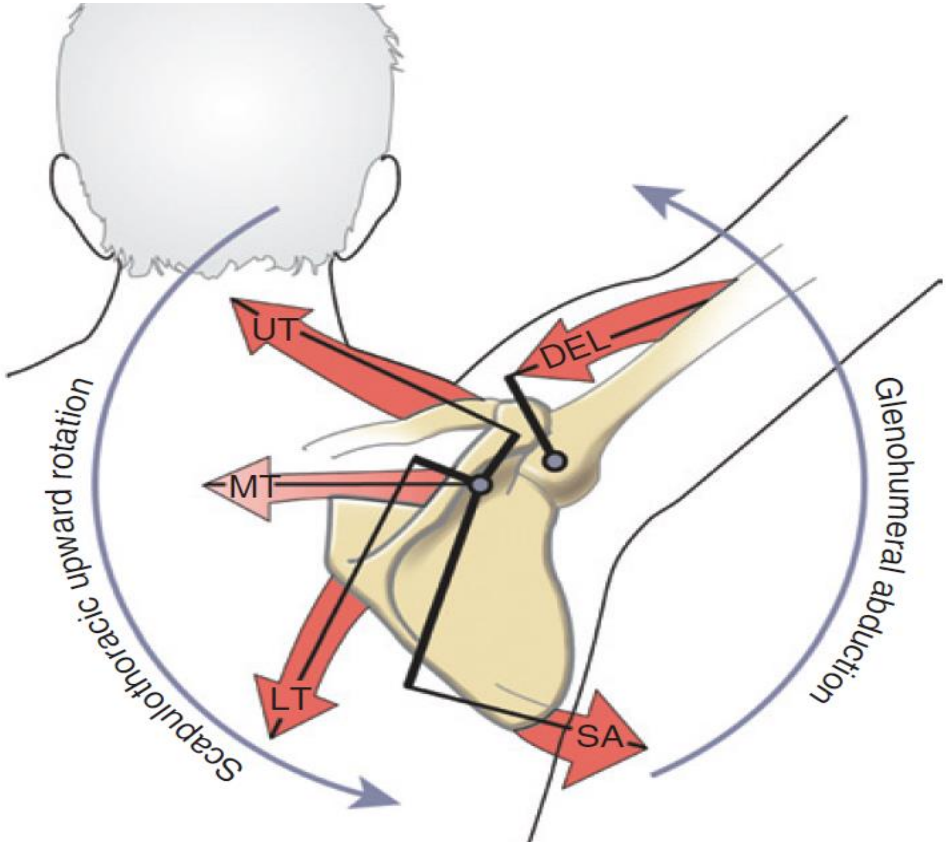


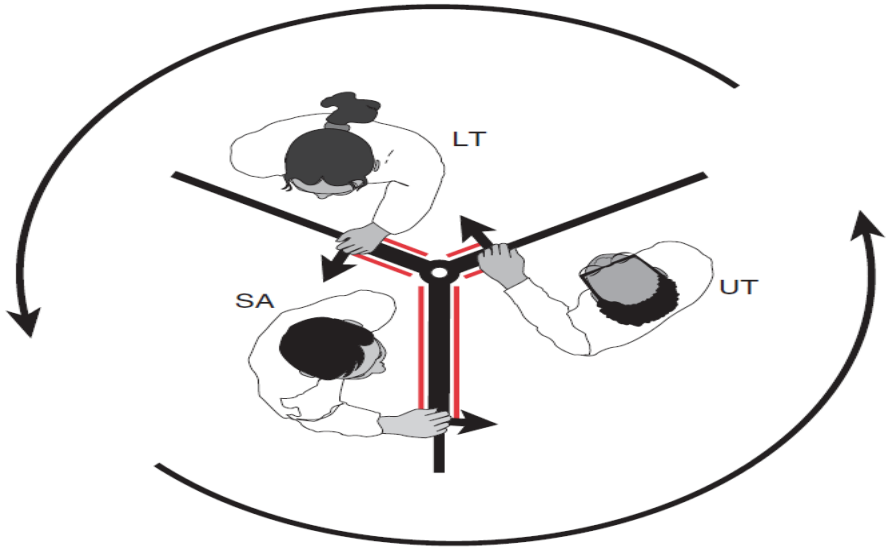
UPWARD ROTATORS AT THE SCAPULOTHORACIC JOINT

Trapezius and Serratus Anterior Interaction (force couple) during Upward Rotation of the Scapula

the lower fibers of the serratus anterior are the most effective upward rotators of the force-couple, primarily because of their larger moment arm for this action

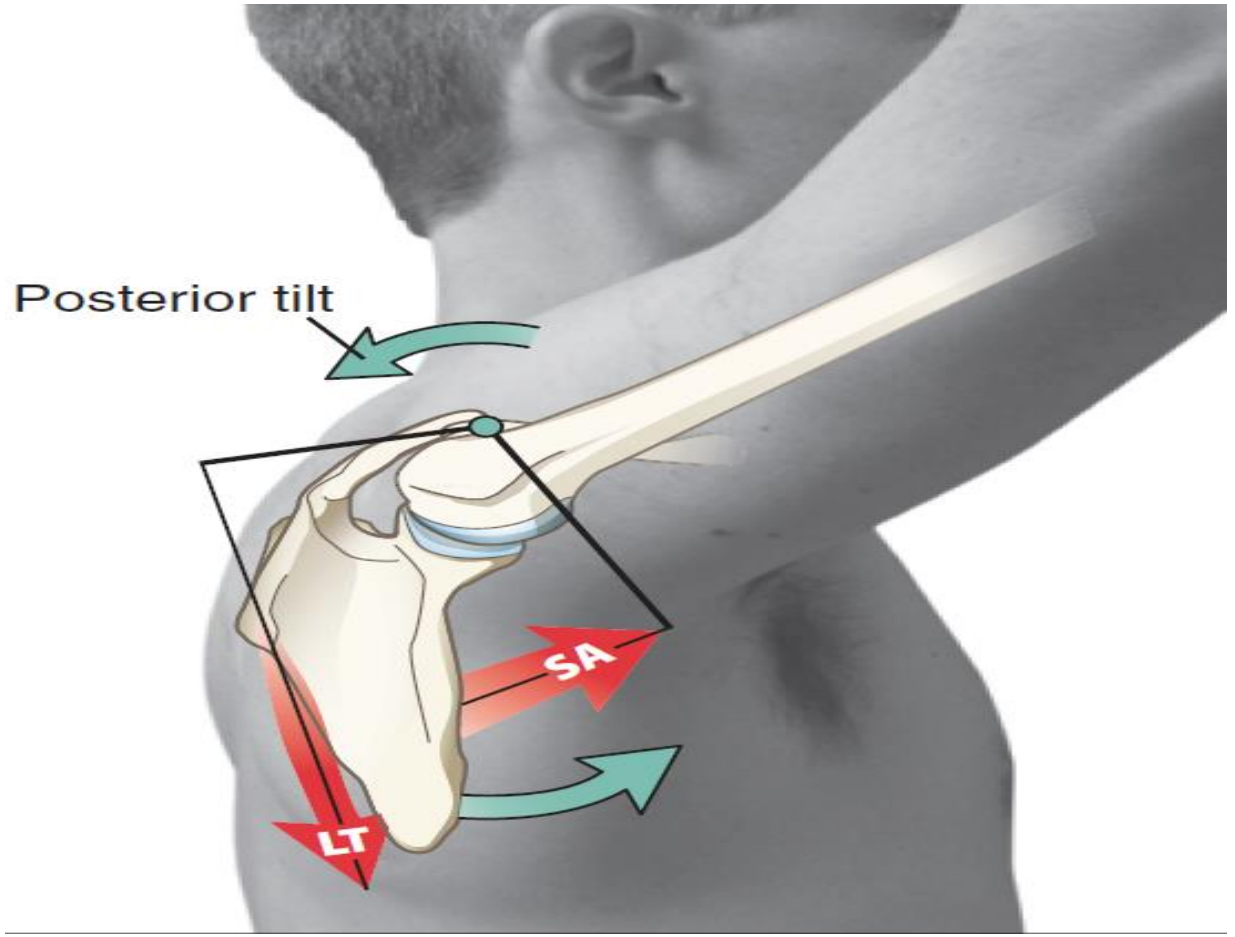
the line of force of the middle trapezius runs *through* the rotating scapula's axis of rotation. In this case, the middle trapezius is robbed of its leverage to contribute to an upward rotation torque.





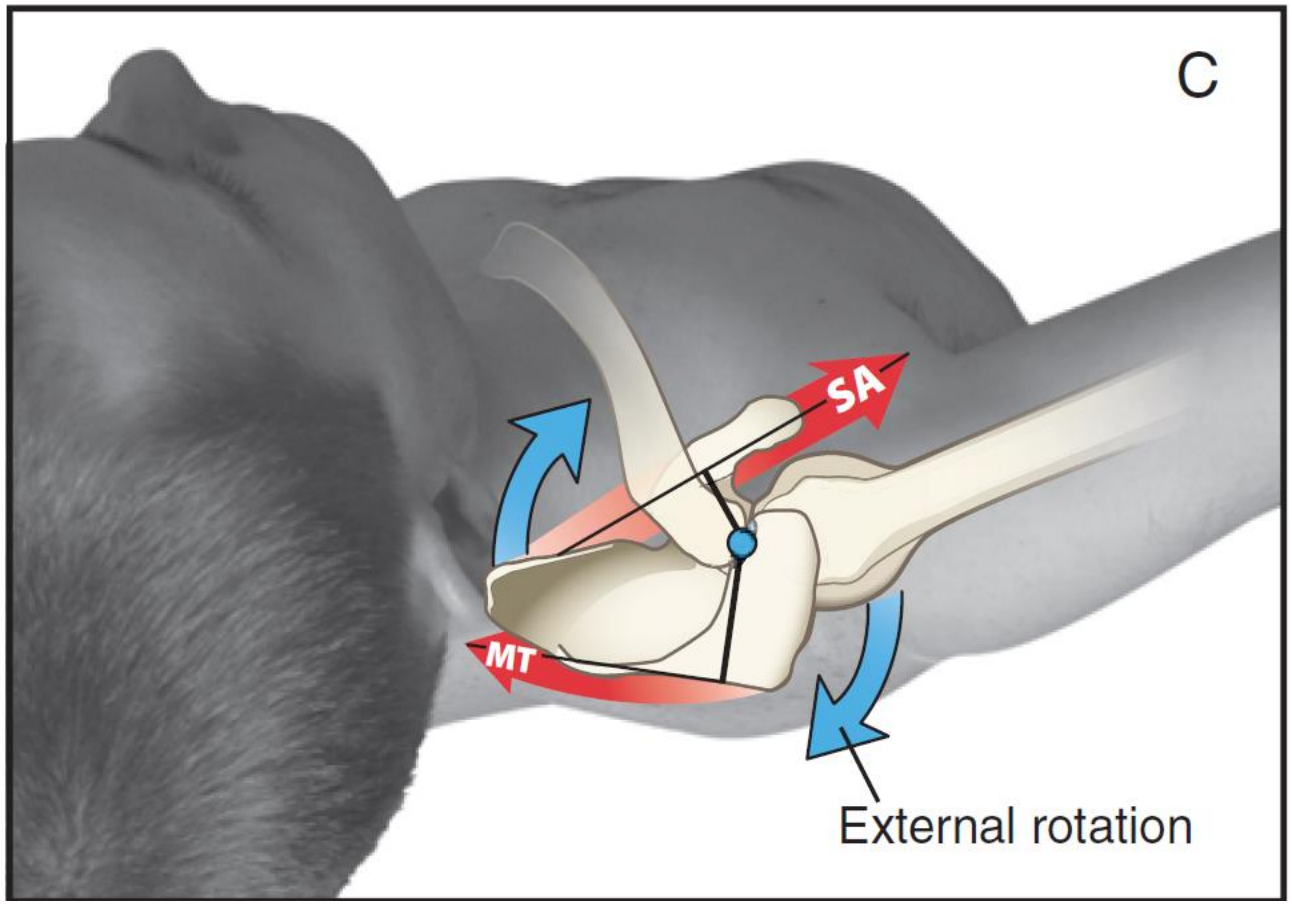
Scapular posterior tilt force couple

- The serratus anterior (SA) and lower trapezius (LT) act in a force-couple to posteriorly tilt the upwardly rotating scapula relative to the axis of rotation at the AC joint
- the lower trapezius (LT) pulls inferiorly on the scapula, as fibers of the serratus anterior (SA) pull anterior-laterally on the scapula.



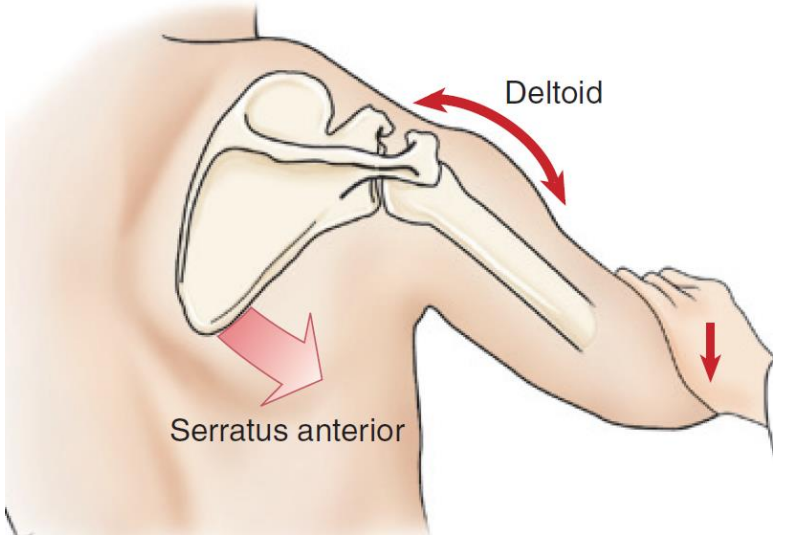
Scapular external rotation force couple

- The serratus anterior (SA) and middle trapezius (MT) act in a force-couple to externally rotate the upwardly rotating scapula relative to the axis of rotation at the AC joint
- The middle trapezius (MT) pulls medially on the scapula as fibers of the serratus anterior pull anterior-laterally on the medial border of the scapula.



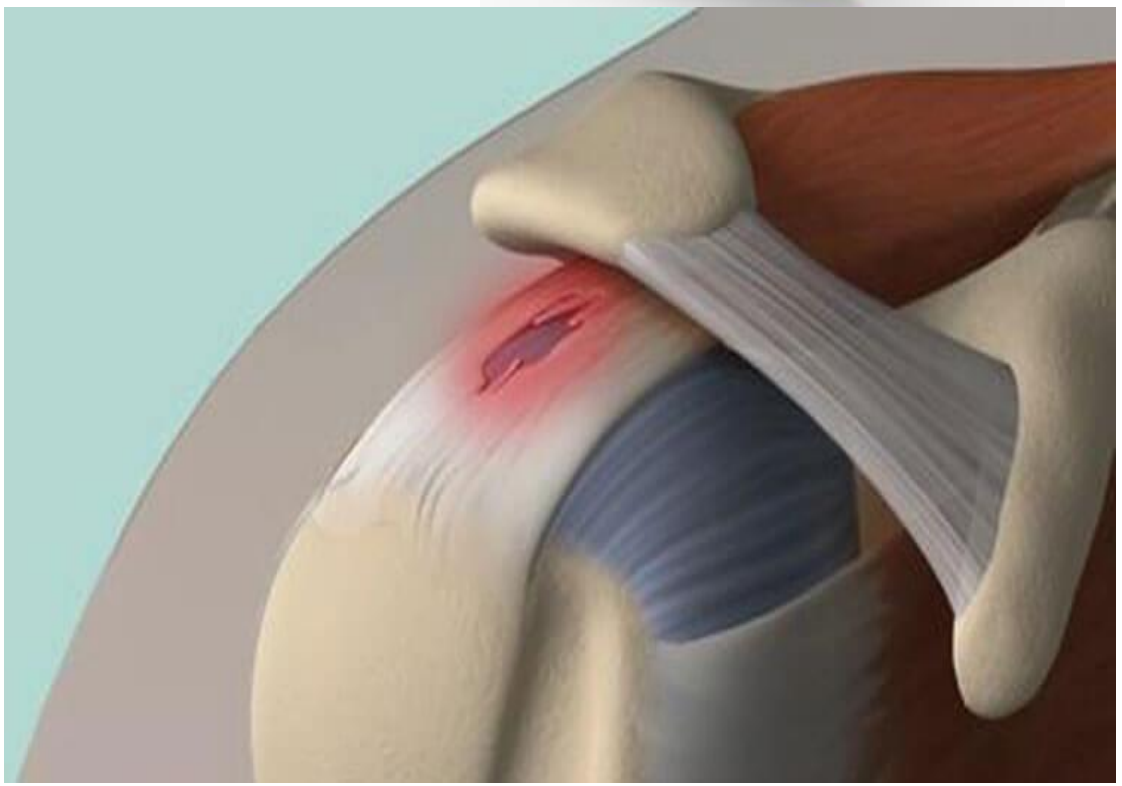
Serratus Anterior Muscle Weakness

- The pathomechanics of the right scapula after paralysis of the right serratus anterior caused by an injury of the long thoracic nerve.
- the contracting middle deltoid and supraspinatus dominate the scapular kinetics, producing a paradoxic (and ineffective) *downward* rotation of the scapula (exaggerated by applying resistance against the shoulder abduction).
- The combined active motions of downward rotation of the scapula and partial elevation of the arm cause the deltoid and supraspinatus to over-shorten rapidly (active insufficiency) reduces their maximal force potential



Vulnerability of the Supraspinatus to Excessive Wear

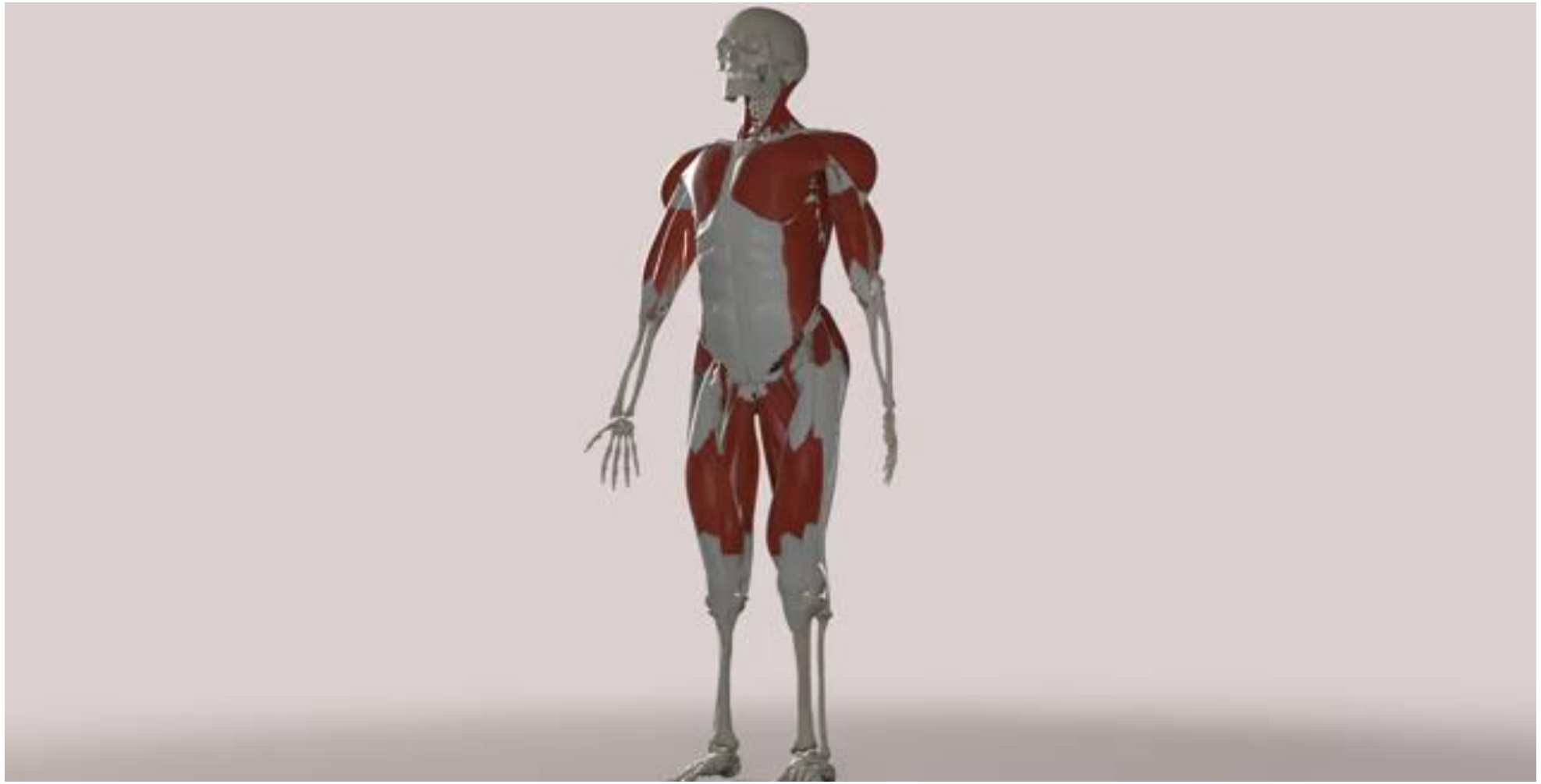
- biomechanically the supraspinatus must produce large internal forces, even during routine activities.
- The muscle has an internal moment arm for shoulder abduction of about 2.5 cm (about 1 inch).
- Supporting a load in the hand 50 cm (about 20 inches) distal to the GH joint creates a mechanical advantage of 1 : 20 (i.e., the ratio of internal moment arm of the muscle to the external moment arm of the load). A 1 : 20 mechanical advantage implies that the supraspinatus must generate a force 20 times greater than the weight of the load



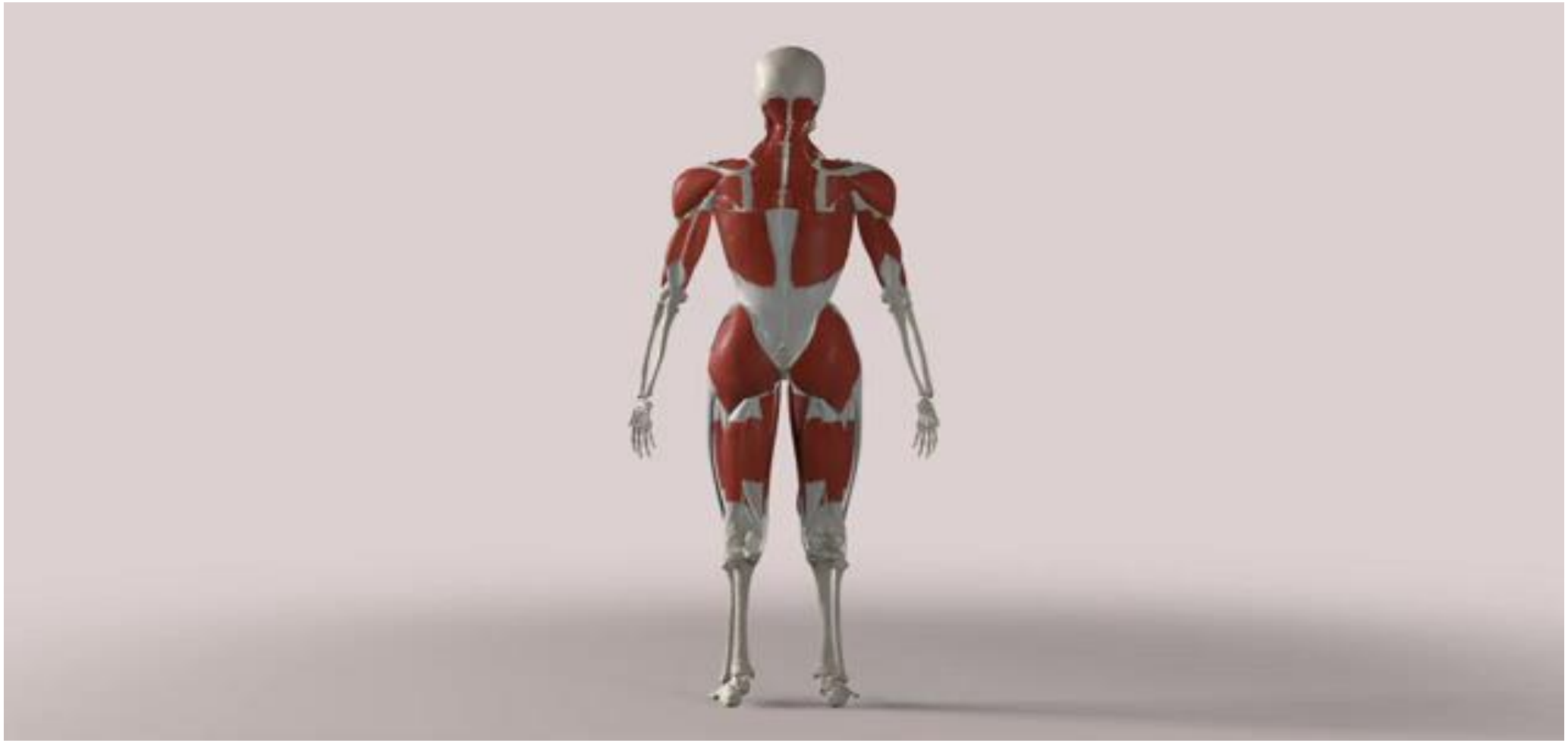
Muscles That Adduct and Extend the Shoulder

- the posterior deltoid
- latissimus dorsi
- teres major
- long head of the triceps brachii
- sternocostal head of the pectoralis major

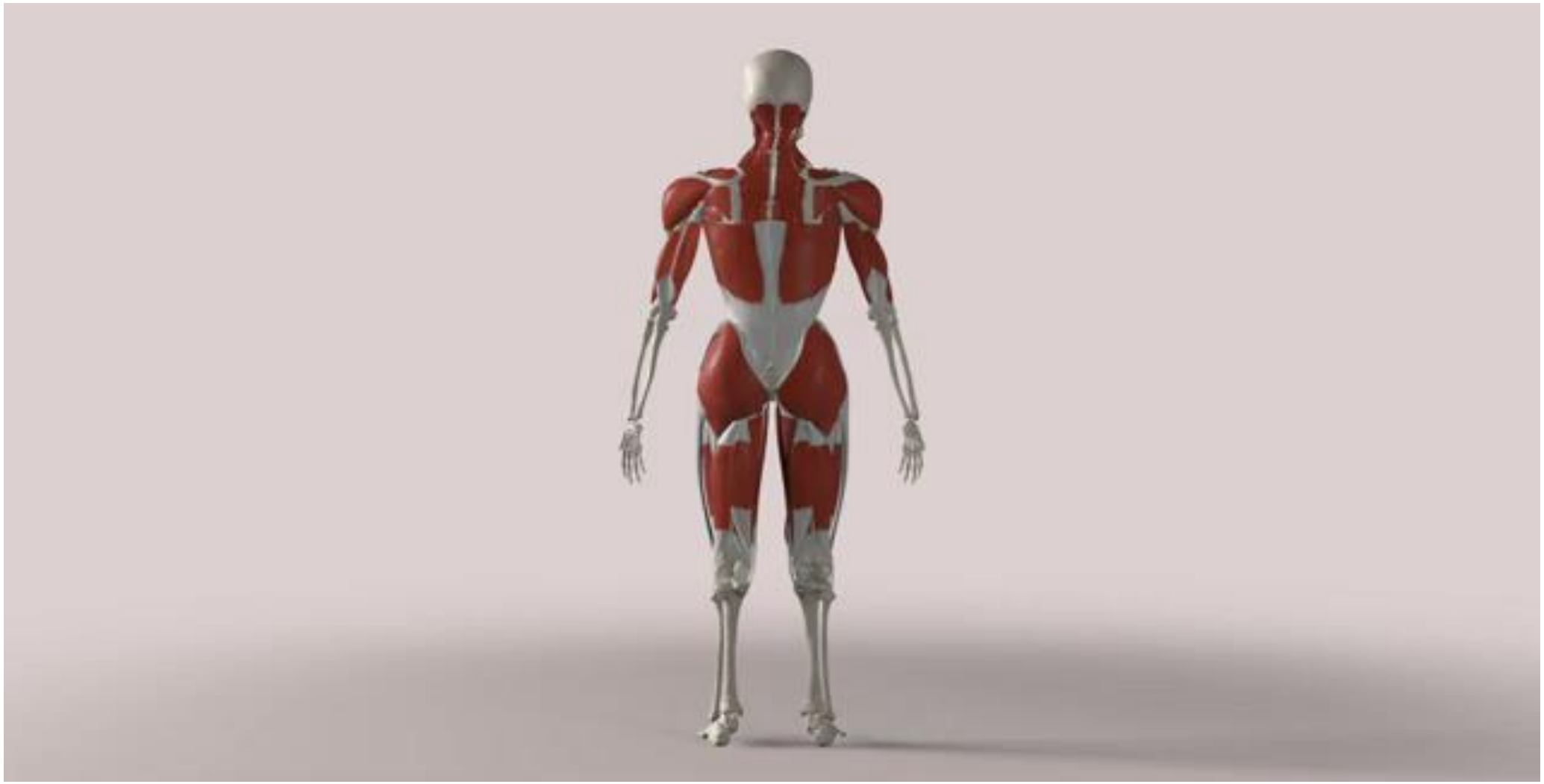
latissimus dorsi



Latissimus Dorsi Functions : Adduction



Latissimus Dorsi Functions: Internal Rotation



Latissimus Dorsi Functions: Retroversion Arm

Pectoralis major

Pectoralis Major Functions: Shoulder Adduction

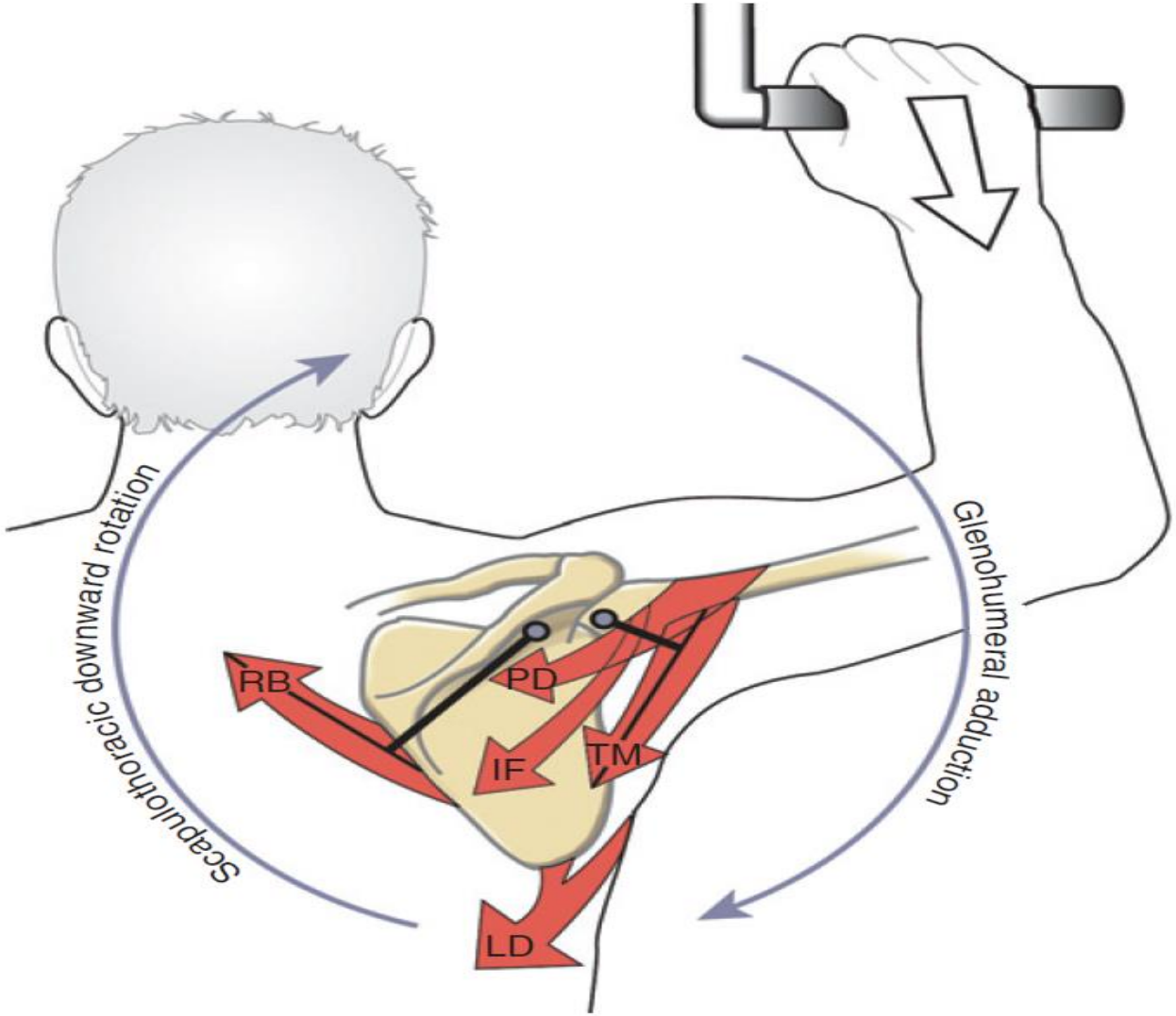
Pectoralis Major Functions: Internal Rotation Arm

Pectoralis Major Functions: horizontal adduction

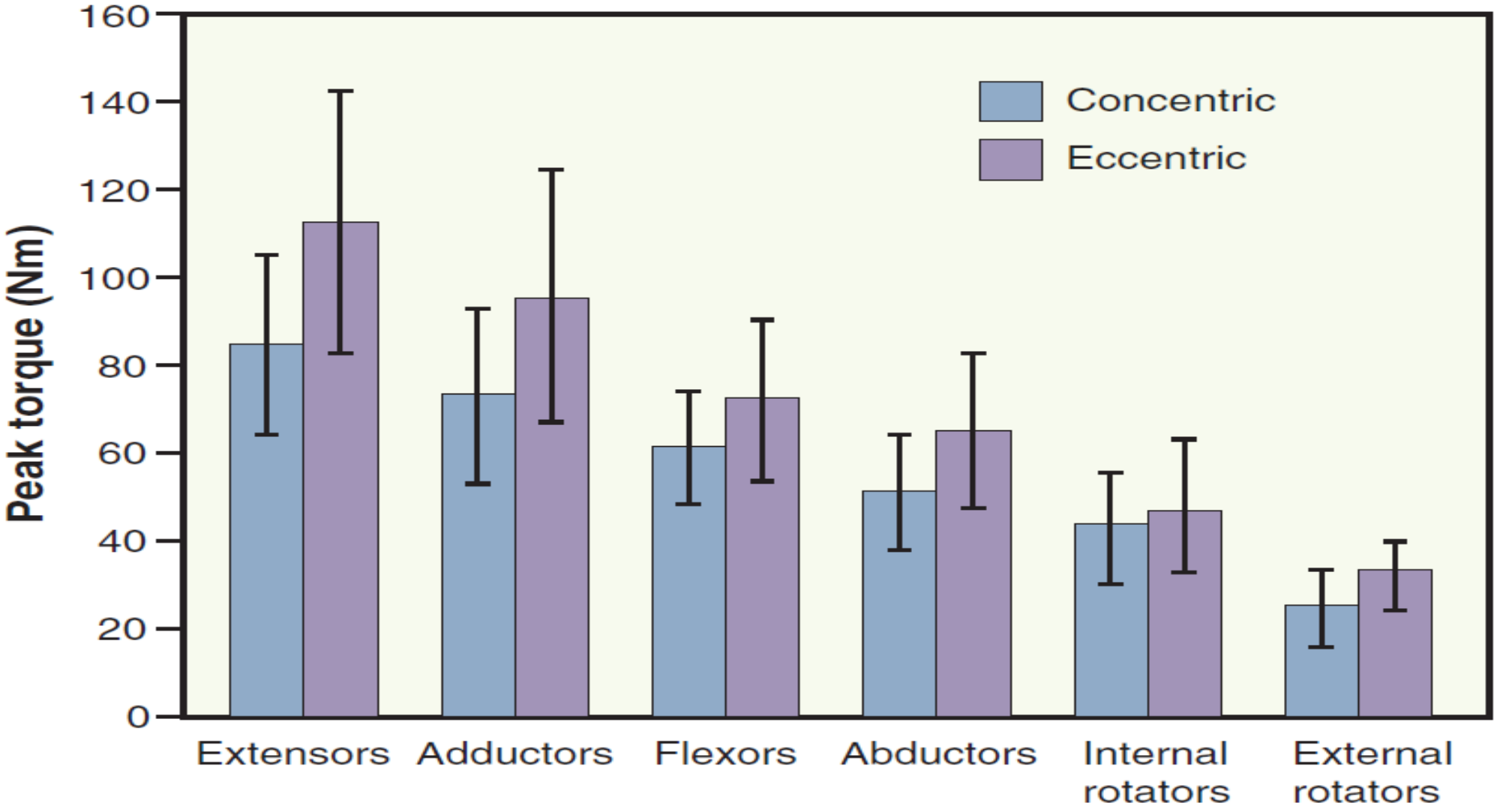
Pectoralis Major (clavicular head) Functions: shoulder flexion

Pectoralis Major Functions: shoulder depression

the muscular interaction between the scapulothoracic downward rotators and the glenohumeral adductors (and extensors) during a strongly resisted adduction effort such as a propulsive swimming stroke or climbing up a rope



peak torque data produced by the six shoulder muscle groups



strong synergistic action between the right lower trapezius *(LT)* and right posterior deltoid *(PD).* The lower trapezius must anchor the scapula to the spine and provide a fixed proximal attachment for the strongly activated posterior deltoid.