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Upper Limb

1. Introduction

The "shoulder" region represents one of the most complex areas of the entire musculoskeletal system.
This complexity derives from the multiplicity of joints and relationships that simultaneously contribute to the function and disorders of this district.
The shoulder complex involves six different articular relationships that operate in an integrated way:

- scapulo-hyoid relationship
- scapulo-vertebral relationship
- scapulo-costal articulation, muscular in nature
- scapulo-humeral joint
- sterno-clavicular joint
- scapulo-clavicular relationship

Any alteration in muscular equilibrium in one of these relationships may simultaneously involve the others, giving rise to complex clinical patterns.
Analysis of this district therefore requires assessment of which combination of articular relationships is involved in the specific pattern, identifying which muscular forces, through their selective shortenings, determine the skeletal configuration responsible for the symptom or the present conflict.

2. Scapulo-costo-vertebro-hyoid relationship

2.1 Physiological positioning and muscular dominance

The scapula rests on the rib cage and, under physiological conditions, is positioned at the side of the thorax, with its medial border aligned with the spinous process of T5.
In the cranio-caudal direction, it is maintained by the antagonistic action between the muscles that elevate it and those that depress it.
In the previous chapters, the position of the scapula relative to the thorax was analysed, identifying how, in the rare cases in which a pure latissimus dorsi pattern "A" is present, the scapula appears adducted and depressed.
The skeletal confirmation that this is a depressed scapula is provided by the clavicle, which, instead

of having a horizontal course, also appears descending, with the acromioclavicular joint below the sternoclavicular joint.
In all other cases, dominance is in adduction and elevation of the scapula.
The constant element always present is scapular adduction.
Outside of specific pathologies linked to congenital or acquired skeletal malformations, the scapulae are always adducted, with consequent reduction of the physiological kyphosis with apex at T5.

2.2 Vector analysis of scapular positioning

Analysis of the forces acting on the scapula reveals a clear asymmetry in muscular dominance.

Summary of the vertical positioning of the scapula

SCAPULA	
Adduction	Upper trapezius fibres; levator scapulae; rhomboids; middle trapezius fibres; lower trapezius fibres; vertebro-humeral portions of the latissimus dorsi
Abduction	The serratus anterior, the only scapular abductor when the upper limb is alongside the body, has a totally subdominant force line and cannot balance the combined action of the adductors
Elevation	Upper trapezius fibres; levator scapulae; rhomboids; vertebro-humeral portions of the latissimus dorsi which, when the scapula is elevated, help to keep it elevated and adducted, pattern “B” of the latissimus dorsi
Depression	Iliac crest-to-humerus force line of the latissimus dorsi, pattern “A”; lower trapezius fibres

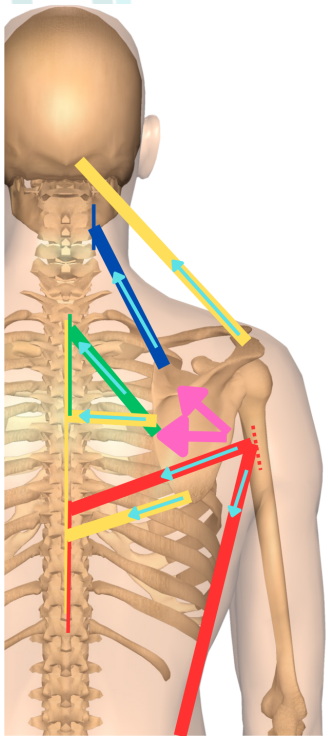


Figure 01: Vector analysis of scapular positioning
Yellow: trapezius, upper, middle, and lower fibres; blue: levator scapulae; green: rhomboids; red: latissimus dorsi; light blue arrows: force lines; violet arrows: global resultants

As shown in the figure, the global force line is directed toward scapular adduction and elevation. It may be directed toward adduction and depression of the scapula only in the presence of marked shortening of the fascicles of the latissimus dorsi running between the iliac crest and the humerus.

2.3 Anterior projection of the scapula

Terminological clarification
In this text, the term “anterior projection” or “anteriorization” is used instead of the traditional “forward shoulder posture.”
This terminological choice is not arbitrary but derives from the need for biomechanical clarity.
In common language, a misunderstanding has become established that associates forward shoulder position with scapular abduction.
Vector analysis shows instead that the scapula shifts anteriorly in association with adduction.
Using the term “anterior projection” clarifies that what is being described is an anterior displacement of the scapula that occurs while maintaining or increasing adduction.

Mechanisms of anterior projection
Parallel to adduction, the scapula can be anteriorized by the action of two specific muscles.

Action of the pectoralis minor
Involvement of the pectoralis minor determines anteriorization of the shoulder by approximation of the coracoid process of the scapula toward the ribs.
As a consequence, in upright stance, the inferior angle of the scapula becomes prominent.
Anteriorization caused by the pectoralis minor occurs in association with scapular adduction, not in substitution for it.

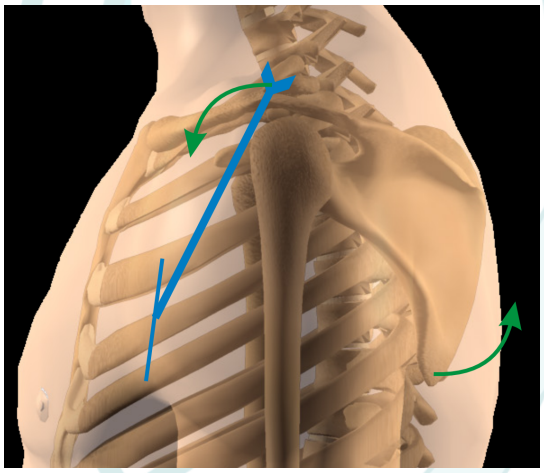


Figure 02: Involvement of the pectoralis minor, blue, determines anteriorization of the shoulder by approximation of the scapular coracoid toward the ribs. As a consequence, the inferior angle of the scapula becomes prominent, green arrows.

Action of the omohyoid
The omohyoid has a particular structure, as if it had a second connective tissue insertion interposed between the muscular fibres.
The portion of the omohyoid between the scapula and this connective tissue projects the scapula forward.
Anteriorization through the omohyoid is likewise associated with scapular adduction, producing a configuration in which the scapula is both approximated toward the vertebral column and displaced anteriorly.

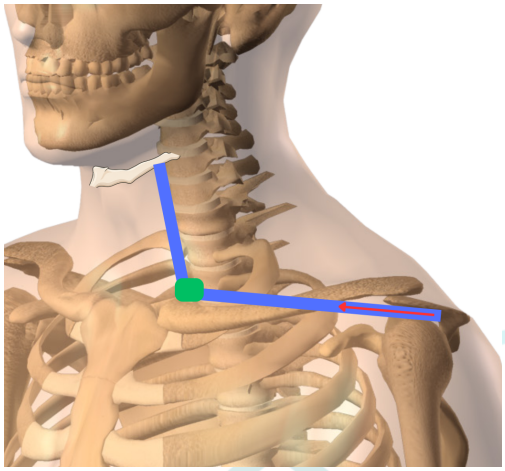


Figure 03: The omohyoid, blue, is as if it had a second connective tissue insertion, green, interposed between the fibres. The portion of the omohyoid between the scapula and the connective tissue carries the scapula forward.

3. Scapulo-humeral relationship

3.1 Muscular control of humeral positioning

The position of the humerus within the glenoid cavity and its movements are controlled by the scapulo-humeral muscles, the brachio-scapular muscles, the costo-brachial muscles, and the latissimus dorsi.
These muscles are asymmetrically distributed and have different vector potential, giving rise to dominant patterns.

3.2 Internal and external humeral rotation – anterior projection

Analysis of the rotational forces acting on the humerus reveals a clear asymmetry.

ACTION	ACTING MUSCLES	VECTOR DOMINANCE
Internal humeral rotation	Latissimus dorsi; pectoralis major; subscapularis; teres major; clavicular portion of the deltoid	Internal humeral rotation
External humeral rotation	Supraspinatus; infraspinatus; teres minor; spinal portion of the deltoid	

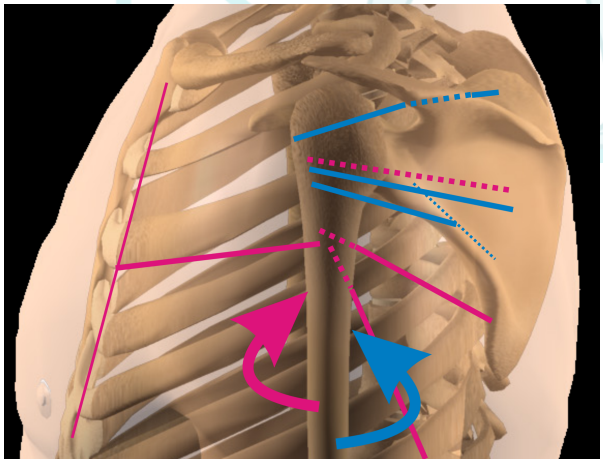


Figure 04: Rotational dominance Magenta: humeral internal rotators, latissimus dorsi, pectoralis major, subscapularis, teres major; blue: external rotators, supraspinatus, infraspinatus, teres minor. Vector dominance is entirely in favour of the internal rotators.

3.3 Mechanism of scapulo-humeral conflict

If, in addition to the humeral internal rotators, which rotate and carry the humeral head forward, the brachial biceps is also taken into account, an overall dominance is obtained in internal rotation and anterior projection of the humeral head within the glenoid.
This mechanism of approximation of the humeral head toward the anterior limit of the glenoid is accelerated by concomitant scapular adduction, paving the way for possible scapulo-humeral conflict.

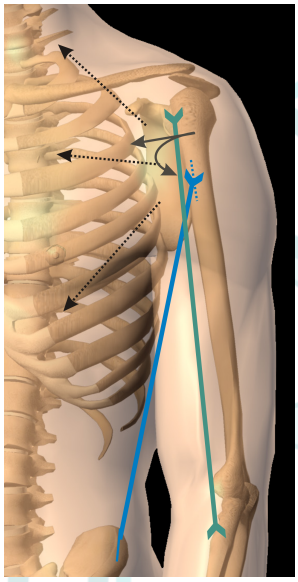


Figure 05: Mechanism of anterior conflict
For graphic simplicity, a single force line of the latissimus dorsi is used to represent all the humeral internal rotators, blue, together with the biceps. Overall, the humeral head rotates internally and is projected anteriorly within the glenoid cavity, black arrows. At the same time, the scapular adductors, dashed black arrows, draw the scapula toward the vertebral column.

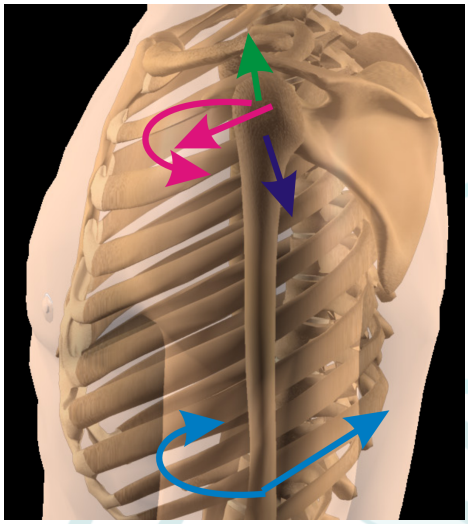
A movement in opposite directions is thus produced, the scapula backward and the humeral head forward, which accelerates the potential anterior conflict between scapula and humerus.

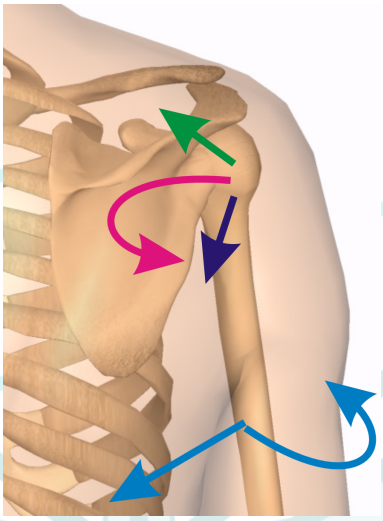
3.4 Superior and inferior projection of the humeral head

In addition to moving forward and into internal rotation relative to the glenoid, the humeral head may also move toward superior or inferior conflict.
Clinical experience and radiographs indicate which pattern is more frequent.

ACTION of the humeral head relative to the glenoid	ACTING MUSCLES	VECTOR DOMINANCE
Superior projection	Biceps; vertebro-humeral fascicles of latissimus dorsi pattern “B”. In pattern “B,” the shoulder girdle is elevated by the cranio-cervico-scapular muscles together with the more horizontal fibres of the latissimus dorsi. Since the latissimus dorsi inserts on the humerus and contributes to elevation of the shoulder girdle, it elevates the humeral head toward the superior portion of the glenoid. Deltoid	Much more frequent

Inferior projection	Iliac crest-to-humerus force line of the latissimus dorsi, pattern “A”	Rare





Figures 06 and 07: Global resultants of the muscles acting on the humerus, actions on the elbow not considered.
Proximal portion: anterior projection and internal rotation of the humeral head relative to the glenoid cavity, magenta arrows; elevation of the humeral head relative to the glenoid cavity, green arrow; depression of the humeral head relative to the glenoid cavity, dark blue arrow.
Distal portion: internal rotation, posterior flexion, adduction, blue arrows.

3.5 Understanding shoulder problems

Analysis of the acting forces clarifies the difficulties encountered in framing “shoulder” problems, especially those not attributable to traumatic events.

3.6 Summary of concomitant patterns

Skeletal alteration	Shortening of connective tissue portions of	Potentially associated skeletal pattern
Scapula adducted and elevated	Upper trapezius fibres; levator scapulae; middle trapezius fibres; rhomboids; lower trapezius fibres, adducts but does not elevate; latissimus dorsi pattern “B”	Ascending clavicle; convexity of vertebrae C1-C4; compression and convexity of vertebrae C6-T4; convexity of vertebrae T4-T12; convexity of vertebrae T7-T12, elevation of the hemipelvis
Scapula anteriorized, in adduction. The scapula is adducted but “dived” forward	Omohyoid; pectoralis minor; biceps, long head	Various problems linked to the relay function of the hyoid bone; convexity of the first ribs, in supine, and prominence of the inferior angle of the scapula, in upright stance

Humeral head within the glenoid cavity internally rotated, anteriorized, and elevated	Latissimus dorsi; subscapularis and teres major; biceps; deltoid, supportive and stabilizing but never the primary cause	Latissimus dorsi pattern “B”
Humeral head within the glenoid cavity internally rotated, anteriorized, and depressed, rare case	Iliac crest-to-humerus portion of the latissimus dorsi, pattern “A”	Elevated hemipelvis, concavity of vertebrae T7-T12

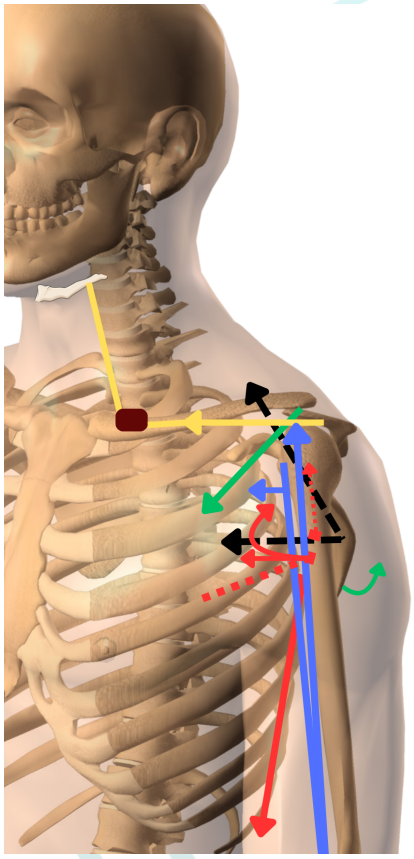


Fig. 08: Complexity of the forces acting on the shoulder:
Dashed black arrows: force lines of the muscles that elevate and adduct the scapula; omohyoid: yellow; pectoralis minor: green; biceps: blue; latissimus dorsi: red.

4. Subluxations

4.1 Additional problems of the shoulder complex

Further difficulties may be induced by the possible presence of subluxation of the sternoclavicular joint and of the humeral head.
Subluxations may themselves be the cause of shoulder symptoms, and not merely an associated finding.

4.2 Subluxation of the humeral head

Subluxation of the humeral head is determined by selective shortening of the subscapularis and teres major.
Their shortening may also be a cause of sternoclavicular joint subluxation, with a cascade effect.

In this case, sternoclavicular subluxation is determined, as a final effector, by the "unravelling" of the horizontal fascia passing through the manubrium sterni. This "unravelling" may be sustained precisely by the problem involving the subscapularis and teres major.

4.3 Subluxation of the sternoclavicular joint

Subluxation of the sternoclavicular joint may also be induced by shortening of the sternocleidomastoid.

4.4 Assessment tests

Test for humeral subluxation
Subluxation of the humerus is detected by bringing the upper limb into abduction so as to place the two muscles under tension.

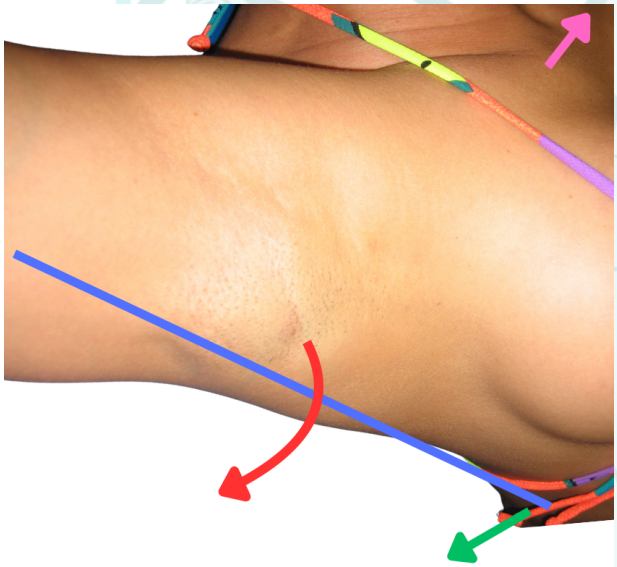


Figure 09: Subluxation test
Subscapularis and teres major, blue. By abducting the upper limb, the effect of shortening of the two muscles on the skeleton is made evident: humeral head subluxation, red arrow; scapular subluxation, green arrow; sternoclavicular subluxation, pink arrow

Test methodology
The test is carried out through manual repositioning of one individual element:

- correcting the position of the humeral head aggravates the subluxations of the scapula and sternoclavicular joint, the same applies to each selective correction
- containing two subluxations would markedly worsen the third

This shows that correction must occur simultaneously on all three correlated elements.
Even when only one of the subluxations is clinically present, treatment must nevertheless include containment of all three potential subluxations, in order to avoid de-latentization of problems not yet manifested.

Test for sternoclavicular joint subluxation
To assess the presence of sternoclavicular subluxation, the test is performed by applying pressure to the joint.
Physiological joint play should be only a few millimetres.
Sternoclavicular subluxation may also be independent of subscapularis and teres major problems and be determined instead by shortening of the sternocleidomastoid.

For evaluation, it is sufficient to rotate or incline the cranium, thereby placing the sternocleidomastoid in passive lengthening: if shortened, the subluxation will worsen.

4.5 Implications

Assessment of subluxations is an important element.
If present, the extrapyramidal system, through mechanisms that will be described in the macro-section on systemic assessment, activates itself for their protection, even at the cost of unbalancing skeletal regions far from the primary site, where symptoms may then appear. The sternoclavicular joint is also clinically relevant because instability can produce pain, mechanical symptoms, and secondary compensatory strategies.

5. The elbow

5.1 Elbow flexion

Given the total dominance of the sum of the flexors over the triceps brachii, this is the most common pattern.
One may think of the difficulties encountered after cast immobilization for fracture, where the resistant force of the flexors is such as to oppose elbow extension both actively and passively.

Note on inversion of action: elbow flexors behave as flexors only when the hand is the mobile point.
If the hand is the fixed point, as in a gymnastic floor exercise, the flexors invert their action and become extensors.
The triceps brachii participates in the action, although it is not the primary motor.

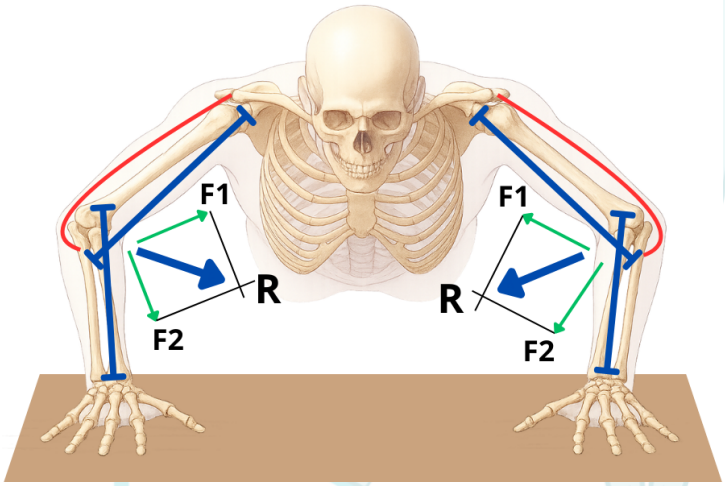


Figure 10: Inversion of action of the flexors
Upper-limb elbow flexors: blue; triceps brachii: red. With the hand as the fixed point, the elbow flexors inserting on the arm move the radius and ulna, green arrow F1, toward the shoulder. The elbow flexors inserting on the forearm, green arrow F2, move the humerus medially. The resultant R of the two actions is elbow extension, to which the triceps contributes secondarily.

5.2 Elbow hyperextension

Unless linked to ligamentous laxity, that is, to a severe systemic collagen disorder involving all joints, hyperextension is due to the chain relationship between scapular adductors and anterior upper-limb muscles, the elbow flexors.
For differential assessment, it is sufficient, in the supine position, to passively bring the upper limb into elevation.
This produces mechanical abduction of the scapula and the consequent “lengthening” of the adductors.
If the elbow flexes, this is the sign that lengthening of the scapular adductors is translated into shortening of the flexors.

5.3 Elbow deviations

Valgus: determined by shortening of the brachioradial muscles, supinators of the forearm.
Varus: determined by the muscles opposed to the valgizing ones, namely the pronators.
Since it is very rare to observe pronators dominating over supinators, the most frequent picture is the tendency toward valgus, with the forearm in semi-pronation.

6. The wrist

6.1 Ulnar deviation of the wrist

This is the product of shortening of the dorsal and palmar flexors of the hand, which share dominant ulnar deviation over radial deviation.

7. The hand

With regard to the hand, vector dominance is in flexion.

8. Conclusions of the chapter

Biomechanical analysis of the upper limb reveals a hierarchically organized system in which complexity progressively decreases from the centre toward the periphery.
The shoulder complex, with its six interconnected articular relationships, represents a clear example of how multiple muscular forces can determine specific skeletal configurations.
Vector analysis shows that muscular dominances, scapular adduction, humeral internal rotation, flexion of distal joints, are not random, but derive from precise anatomical asymmetries in force lines.
The mechanism of scapulo-humeral conflict is likewise not a random event: it expresses the predictable mechanical consequence of opposite forces, scapula in posterior adduction and humerus in anterior projection, converging according to measurable physical principles. The clinical relevance of scapulohumeral coordination and altered mechanics during arm elevation is well documented in the literature.
Subluxations, when present, constitute further mechanical alterations that the system must compensate for, often at a distance from the primary site.
Inversion of action of the elbow flexors when the hand becomes the fixed point shows how vector principles remain valid regardless of the point of application of forces, confirming that they respond to universal physical laws rather than arbitrary interpretative models.
The therapeutic approach must ultimately be based on understanding of these mechanisms. One begins with analysis of vector dominance within the shoulder complex, and then analyses how

tensions propagate through muscular chains toward the distal joints, where simpler and more predictable patterns facilitate identification of the primary causes of dysfunction.

9. Chapter summary

Complexity of the shoulder system: six articular relationships
Scapulo-hyoid, scapulo-vertebral, scapulo-costal, scapulo-humeral, sterno-clavicular, and scapulo-clavicular. Every alteration in one relationship simultaneously involves the others.

Scapular adduction as a constant condition
The adductors, trapezius, levator scapulae, rhomboids, latissimus dorsi, dominate over the serratus anterior, the only abductor. The scapula therefore remains adducted, with reduction of the physiological kyphosis at T5.

Scapular anteriorization: an additional mechanism
The pectoralis minor and omohyoid may project the scapula anteriorly. This anteriorization adds to adduction without replacing it, making the inferior angle of the scapula prominent in upright stance.

Dominance of the humeral internal rotators
Latissimus dorsi, pectoralis major, subscapularis, and teres major dominate over infraspinatus and teres minor. The result is internal rotation and anterior projection of the humeral head.

Mechanism of scapulo-humeral conflict
Simultaneous opposite movement: the scapula in posterior adduction, the humeral head in anterior projection. This accelerates the potential anterior conflict between scapula and humerus.

Imbalance of articular relationships as the cause of symptoms
Shoulder problems derive from imbalance in one or more of the six articular relationships, to which subluxations may be added as a further complication.

Superior projection of the humeral head is more frequent
Determined by the biceps, the horizontal fascicles of latissimus dorsi pattern “B,” and the deltoid. Inferior projection, latissimus dorsi pattern “A,” is rare.

Distal dominances progressively become simpler
Elbow: flexor dominance over triceps. Wrist: dominant ulnar deviation. Hand: dominant flexion. Complexity decreases from the shoulder toward the periphery.

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