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Three-Dimensional Plane (Frontal and Rotatory)

1. From sagittal analysis to three-dimensional analysis

The transition from analysis in the sagittal plane to analysis in the frontal and rotatory plane increases the complexity of the biomechanical approach.
In the sagittal plane, skeletal alterations are predictable: clear vector dominances exist for each vertebral segment.
In the frontal and rotatory plane, this predictability is reduced.
The greater complexity derives from the analysis of asymmetric shortening of bilateral muscles.
The issue is no longer one of intrinsically dominant muscles, but of situations in which anatomically identical muscles develop different tensions on the two sides of the body.
The aim of the analysis remains unchanged: to identify the shortened connective tissue components that determine skeletal adaptation.
The biomechanical principle governing the sagittal plane also applies to the rotatory plane, but its identification requires specific methodologies.

1.1 Examination methodology in the supine position

To identify the muscular shortenings responsible for vertebral rotations, the examination must be performed in the supine position.
In upright stance, the muscular system is constantly active in order to maintain equilibrium and align the G and R forces vertically.
What is observed in standing is the result of activation of the contractile components, not the state of the connective tissue components.
In the supine position, equilibrium is stable and no muscle needs to be activated in order to maintain position.
It thus becomes possible to observe the true structural shortenings, those present when the contractile components are deactivated.
It is not uncommon for skeletal elements to appear completely reversed compared with observation in upright stance: active compensations mask the underlying structural condition.
For assessment, the patient must be aligned in supine on the midline: centre of the malleoli, pubic symphysis, centre of the jugular notch of the manubrium sterni, and occipital centre.
This alignment eliminates compensations and makes structural asymmetries assessable.

1.2 Palpation methodologies for the rotatory plane

Palpation to identify vertebral rotations requires different techniques for each segment.
For the cervical vertebrae C1-C5, the spinous processes are not reliable because they are bifid.
Assessment is based on the transverse processes: the more anterior transverse process indicates the side of the convexity.
In the cervico-thoracic segment C6-T3, the spinous processes become reliable.
Their direction relative to the midline directly indicates vertebral convexity.
Thoracic vertebrae T4-T12, since they are not palpable in the supine position, are assessed through the lateral convexity of the thorax.
Thoracic translation relative to the midline reflects the underlying vertebral convexity, since the vertebrae are connected to the ribs.
For the lumbar vertebrae, the spinous processes are again used, and their direction relative to the midline indicates convexity.

1.3 Rotation and convexity: the biomechanical relationship

By anatomical convention, vertebral rotation is named according to the direction of the vertebral body.
When a vertebra rotates to the right, the vertebral body rotates to the right and the spinous process consequently shifts to the left.
Rotation of the vertebral bodies determines contralateral translation of the vertebrae relative to the midline.
On the concave side, the intervertebral discs undergo greater compression.
Rotation and convexity are aspects of the same biomechanical phenomenon: in this text, convexity will be indicated, with the understanding that vertebral body rotation is contralateral.
This rule changes only in certain types of scoliosis in which rotation and convexity become homolateral, a phenomenon that will be analysed in the section dedicated to scoliosis.

1.4 Choice of convexity as the reference

Vertebral rotations are clinically relevant not only in manifest scolioses.
Minor rotations may produce symptoms through radicular compression and represent a significant part of everyday clinical cases.
It is preferable to speak of convexity rather than rotation of the vertebral bodies because the muscles directly inserting onto the vertebrae produce, through active traction, homolateral convexity and contralateral rotation.
This terminological choice reflects the muscular logic of the phenomenon.
There are two mechanisms capable of producing vertebral concavity.
The first is direct muscular traction: the contralateral muscle pulls the vertebrae on which it inserts into convexity, thereby determining concavity on the opposite side.
The second is the mechanical resultant: elevation of the hemipelvis, for example, mechanically produces lumbar vertebral concavity not linked to muscles directly inserting onto the spine, but rather as a consequence of skeletal alteration.
Example: neurological symptoms in the right upper limb due to compression of the T2 root occur on the concave side, the right, but the cause lies in the muscles of the left side, which determine homolateral convexity of the vertebrae.
Treatment must therefore be directed toward the muscles on the left side, the cause, and not toward the right side where the symptom manifests, the effect.
Analysis of the frontal and rotatory plane therefore requires a specific methodology, with examination in the supine position, differentiated palpation techniques for each vertebral segment, biomechanical interpretation distinguishing muscular cause from skeletal effect, and a systemic approach that considers compensations between the different planes.

In the following paragraphs, these principles will be applied to the specific analysis of each vertebral segment, from the cranio-cervical region to the pelvis, identifying primary muscular causes and their secondary skeletal effects.

1.5 Distinction between contraction and shortening

Before proceeding with the detailed analysis, one fundamental distinction must be clarified.
Muscular contraction and muscular shortening produce the same immediate effects on the skeleton, but with a substantial difference in the duration of these effects.
Contraction moves the skeleton for the duration of the contraction itself.
When contraction ceases, the skeleton returns to the initial position determined by the length of the connective tissue components.
Shortening, which involves the connective tissue component of the muscle fibre, produces a stable modification of skeletal axes.
The vertebrae remain deviated, the discs compressed, and the nerve roots under pressure even when the contractile component is relaxed.
This text analyses the effects of stable shortening.
This is the cause of permanent skeletal alterations and chronic symptomatology.
Examination in the supine position, by eliminating the active contractions necessary for maintenance of equilibrium, makes it possible to identify precisely these structural shortenings that represent the core of biomechanical analysis.

2. The cranium and the priority of visual function

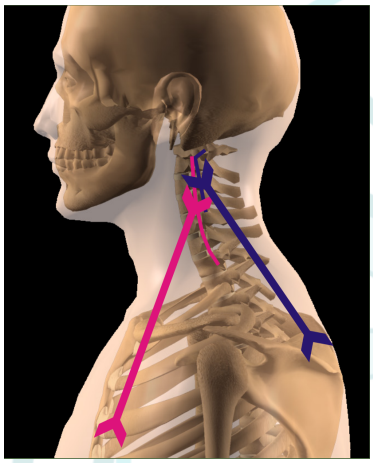
The position of the cranium in space is ensured by postural reflexes through the co-contraction of all the cranio-cervico-scapular muscles.
Since horizontal vision is a priority function, significant alterations due to rotation or inclination of the head are rarely observed, except in specific pathological conditions such as torticollis.
It is more common for the underlying skeletal structures to become misaligned in order to allow good head positioning.
In this process, the hyoid bone, through its multiple connections, plays the role of a mechanical relay, as seen in the previous chapter.
When rotation and inclination of the cranium appear as relevant elements, interference from disorders arising in other systems should be suspected.
The visual system may interfere through ocular suppression, latent strabismus, eso- or exophorias.
The otorhinolaryngological system may interfere through vestibular disorders and hearing alterations.
Other systems may also be involved through mechanisms not yet fully defined.
Hence the importance of performing specific tests in collaboration with specialists in order to exclude extra-muscular causes before proceeding with biomechanical analysis.

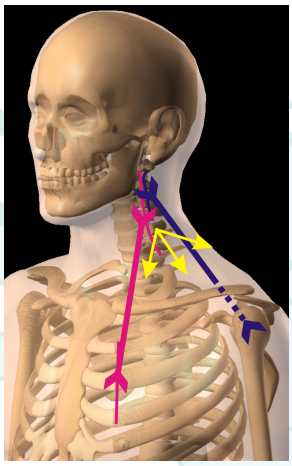
3. Cervical vertebrae (C1-C5)

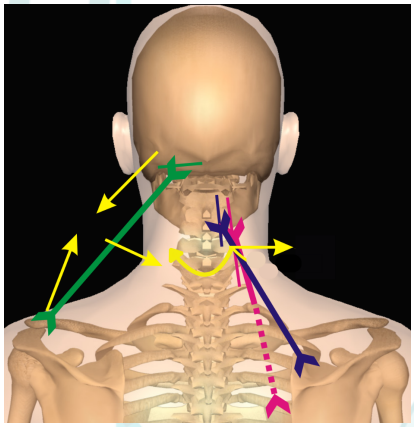
3.1 Direct muscular action

The levator scapulae and the scalenes are the principal muscles responsible for deviation of the cervical vertebrae.
When either develops asymmetric shortening, vertebral convexity is produced homolaterally.
The levator scapulae originates from the transverse processes of C1-C4 and inserts onto the superomedial angle of the scapula.

The scalenes originate from the cervical transverse processes and insert onto the first two ribs.
In clinical reality, these muscles shorten together; given their close anatomical and functional relationship, it is not possible for one to shorten without the other.
The distinction between the two groups has mainly didactic value in order to understand the vector components involved.
The final effect of their combined shortening is a roto-translation of the cervical vertebrae: lateral translation creating convexity and rotation of the vertebral bodies.
The upper trapezius fibres, since they do not insert directly onto the vertebrae, may produce convexity only through indirect mechanisms such as cranial inclination and shoulder elevation.
This event is quite rare and is seen in specific conditions such as torticollis.



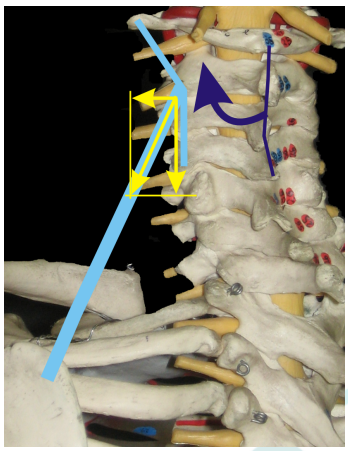


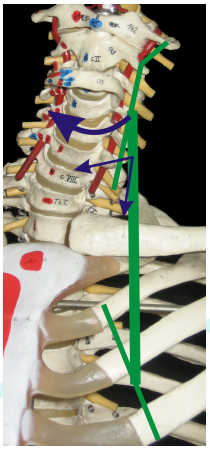


Figures 1, 2 and 3 - Scalenes: magenta; levator scapulae: blue; upper trapezius fibres: green; actions: yellow arrows. Cervical convexity is produced directly by the levator scapulae and the scalenes. The upper trapezius fibres may produce it indirectly through cranial inclination and shoulder elevation.

3.2 Vector analysis of the forces

Vector analysis shows how the force components act on different planes: on the horizontal plane they determine vertebral rotation; on the vertical plane, disc compression.
In greater technical detail, the levator scapulae, because of its posterior course, tends to produce homolateral rotation, whereas the scalenes, because of their anterior course, tend to produce contralateral rotation. Since they always act together, the resultant effect depends on their reciprocal balance.
The vertical components of both groups compress the intervertebral discs on the side of their action. This compression, added to the G and R forces analysed in Chapter 3, creates an asymmetric distribution of loads with concentration of the g and r components at specific points.





Figures 4 and 5 - Levator scapulae: light blue; scalenes: green. Vector analysis shows how the horizontal components produce opposite rotations, while the vertical components generate homolateral disc compression.

3.3 Mechanism of disc and radicular compression

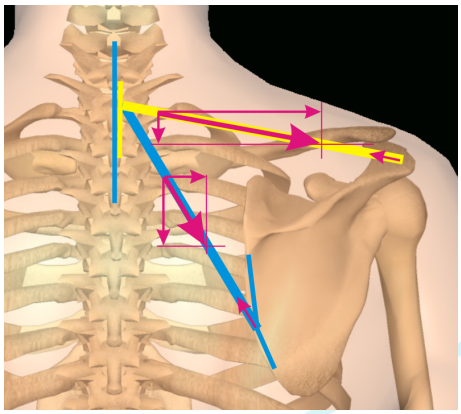
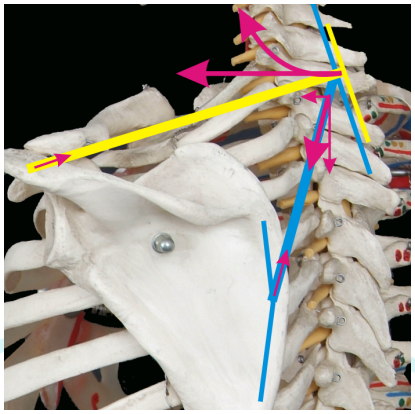
Disc compression occurs through different mechanisms on the two sides.
On the side of the convexity, it derives from the vertical components of the shortened muscles.
On the side of the concavity, it is the mechanical consequence of approximation of the vertebral bodies due to roto-translation.
The intervertebral foramen is reduced on the side opposite the convexity.
When the vertebral body rotates, the pedicle homolateral to the rotation approaches that of the underlying vertebra, reducing the space available for the nerve root.
This explains why neurological symptoms often appear on the side opposite the muscles responsible.

3.4 Clinical implications

Cervical pain and stiffness derive from the excess muscular tension required to maintain the vertebrae in their altered position.
The muscles with shortened connective tissue components show increased resistant force, while the contralateral muscles must increase their tone in an attempt to balance the system.
Muscle-tension headaches may originate from the cranial insertions of cervical muscles under permanent tension.
Neurological symptoms follow brachial plexus distribution: C5-C6 compression affects the musculocutaneous and radial territories; C8-T1 affects the ulnar territory.
Precise identification of the responsible muscles makes directed treatment possible, targeting the cause, muscular shortening, rather than the effect, symptomatology.

4. Cervico-thoracic vertebrae (C6-T4)

Directly acting on this spinal segment are the rhomboid minor and major and the middle fibres of the trapezius.
The rhomboids originate from the spinous processes C6-T4 and insert onto the medial border of the scapula.
Their shortening determines homolateral vertebral convexity.
The oblique arrangement of their force lines produces horizontal vector components that rotate the vertebral bodies contralaterally and vertical components that stiffen the vertebral segment.
The middle fibres of the trapezius, with a more horizontal arrangement from C7-T3 to the medial border of the scapula, produce similar effects: homolateral convexity with contralateral rotation of the vertebral bodies.

Figures 6 and 7 - Middle trapezius fibres: yellow; rhomboids: blue. Both muscular groups determine homolateral convexity with contralateral rotation of the vertebral bodies. The vertical vector components, greater in the rhomboids because of their obliquity, stiffen the C6-T4 segment.

Compression on the intervertebral discs follows the mechanism already described for the cervical segment:
on the side of the convexity it derives from the vertical muscular components, on the side of the concavity from mechanical approximation of the vertebral bodies.
Clinical manifestations range from cervico-brachial pain due to involvement of the lower cervical roots to referred symptoms mimicking epicondylitis.
In particular, compression at T2-T3 may produce elbow pain identical to epicondylitis but without a local cause.
Mistaking its origin may lead to treatments directed at the elbow when the real cause is vertebral.

5. Patterns of the latissimus dorsi

5.1 Complexity of the largest muscle in the body

The latissimus dorsi presents biomechanical complexity proportional to its size.
Its multiple force lines may be activated in different combinations, determining different clinical patterns.
To this complexity is added that of the muscles forming part of its functional unit.
The concept of functional unit, which will be explored further in the systemic section, identifies anatomically separate muscles that behave functionally as a single muscle.
The functional unit of the latissimus dorsi includes:

In the lower quadrant:

- quadratus lumborum
- transversus abdominis
- obliques

In the upper quadrant:

- subscapularis
- teres major

5.2 The five principal force lines

The latissimus dorsi presents five principal force lines:

1. from iliac crest to humerus
2. from iliac crest to lumbar vertebrae, through the quadratus lumborum
3. from iliac crest to vertebrae T7-T12
4. from vertebrae T7-T12 to humerus
5. from the last four ribs to humerus

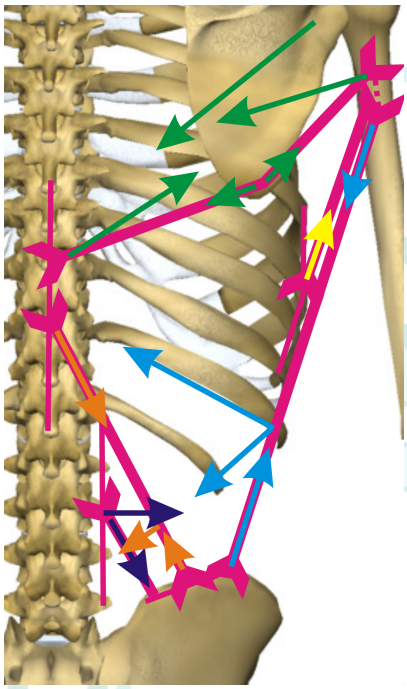


Figure 8 - In violet, the insertions of the latissimus dorsi and the direction of its force lines. The coloured arrows represent the vector resultants and the induced skeletal displacements. The complexity of the force lines enables the muscle to produce different biomechanical effects depending on which components are more shortened.

5.3 Principle of opposite resultants and classification into two patterns

Vector analysis of the force lines of the latissimus dorsi shows that many resultants act in opposite directions.
Depending on which force lines are more shortened, different skeletal patterns are produced.
This observation has led to identification of two principal patterns, termed pattern "A" and pattern "B."
The classification is not rigid: in clinical practice, the two patterns do not always present in pure form, and mixed forms are occasionally observed.
However, since the functional unit of the latissimus dorsi interconnects pelvis, spine, scapula, and humerus, the distinction between these two patterns greatly facilitates diagnostic assessment and therapeutic planning.

5.4 Pattern "A": the approximation pattern

In pattern "A," the fascicles of the latissimus dorsi connecting the iliac crest to the humerus are predominantly involved.
Their shortening approximates the hemipelvis to the homolateral shoulder.
The direct actions are:

- descent of the scapula
- elevation of the hemipelvis

The mechanical resultant is a homolateral lateral thoracic concavity, that is, vertebral concavity from T7 to T12.
Thoracic concavity does not derive from direct traction on the vertebrae, but is the mechanical consequence of approximation between scapula and hemipelvis.

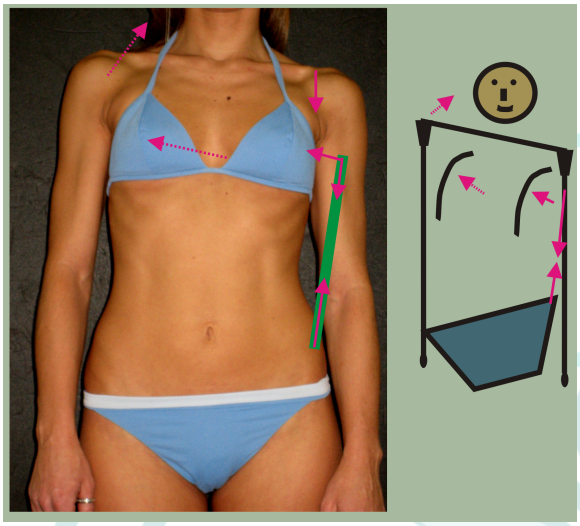


Figure 9 - Force line of the latissimus dorsi between iliac crest and humerus: green; direct actions: solid violet arrows; mechanical resultants: dashed violet arrows. Elevation of the hemipelvis and descent of the homolateral shoulder, with a descending clavicle, determine homolateral thoracic concavity by direct mechanical resultant and, indirectly, contralateral thoracic convexity with a contralateral high shoulder.

When the mechanical resultants prevail, the spine shows what appears to be a large-radius curve with contralateral convexity but which, diagnostically, must be interpreted as homolateral concavity.
Its reduction is not obtained by working on the muscles of the convex side, but by working on the latissimus dorsi of the concave side, which is directly responsible for the deviation through approximation of scapula and hemipelvis.

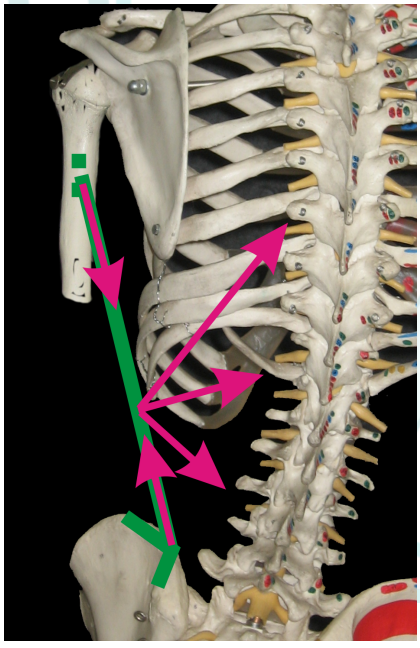


Figure 10 - Force line of the latissimus dorsi between iliac crest and humerus: green; mechanical resultants: violet arrows. With predominant involvement of the fascicles between humerus and iliac crest, the hemipelvis is elevated and the shoulder girdle depressed. The spine consequently shows a large-radius homolateral concavity.

5.5 Opposition of vertebral forces in pattern "A"

The latissimus dorsi inserts onto the spinous processes of T7-T12 and, through the thoracolumbar fascia, onto the costiform processes of the lumbar vertebrae.
The quadratus lumborum, in addition to the twelfth rib, inserts onto the costiform processes of the first three lumbar vertebrae.

These vertebral insertions create a particular mechanism: while the iliac-humeral fascicles of the latissimus dorsi determine elevation of the hemipelvis, which mechanically produces vertebral concavity, the quadratus lumborum, which is part of the functional unit of the latissimus dorsi, may directly pull the lumbar vertebrae homolaterally.
To this action, the homolateral diaphragm and psoas may also be added, both of which have direct vertebral insertions.
The quadratus lumborum, possibly together with the diaphragm and psoas, may therefore oppose the mechanical resultant of hemipelvic elevation, maintaining the spine vertical or creating homolateral lumbar convexity.
In this case, a double curve is produced in which:

- the quadratus lumborum, with possible participation of the diaphragm and psoas, is directly responsible for lumbar vertebral convexity through direct traction on the vertebrae;
- the latissimus dorsi determines upper thoracic vertebral concavity as a resultant of approximation between shoulder and hemipelvis.

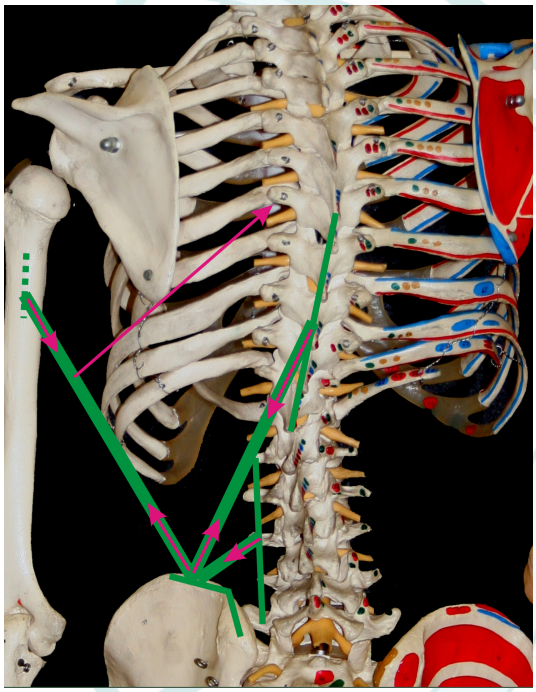


Fig. 11 - Involvement of the fibres of the latissimus dorsi from iliac crest to humerus, from iliac crest to thoracic vertebrae, and from iliac crest to lumbar vertebrae through the quadratus lumborum. In this case, the involvement of the fibres inserting onto the thoracic and lumbar vertebrae may oppose the mechanical resultant produced by elevation of the hemipelvis and determine vertebral convexity extending from the lumbar vertebrae to the lower thoracic vertebrae. Approximation of the shoulder girdle and the hemipelvis determines, by mechanical resultant, homolateral concavity of the thoracic vertebrae from T4 to T7. At vertebral level, a double curve is produced which, diagnostically, may be defined as lower convexity, because it is directly produced by muscles with vertebral insertion, and upper concavity, because it is a mechanical resultant.

5.6 Pattern “B”: the elevation pattern

Pattern “B” is characterized by the associated action of the upper fascicles of the latissimus dorsi and the muscles that elevate the shoulder girdle: upper trapezius fibres, levator scapulae, and rhomboids.
The global resultant of these muscles determines:

- elevation in adduction of the scapula
- elevation of the clavicle

The thoraco-humeral fascicles of the latissimus dorsi determine homolateral lateral thoracic convexity, that is, vertebral convexity from T4 to T12.
The inferior fascicles elevate the hemipelvis and rotate it posteriorly.

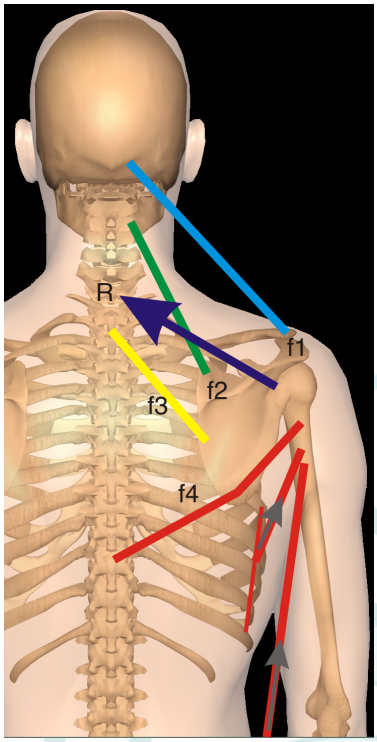


Fig. 12 - Latissimus dorsi: red; levator scapulae: green; rhomboids: yellow; upper trapezius fibres: light blue. In this pattern, the upper scapulo-humero-vertebral portion of the latissimus dorsi acts in association with the dominant muscles that elevate the shoulder girdle: upper trapezius fibres, levator scapulae, and rhomboids. Using the parallelogram rule, not shown in the figure, the global resultant between the muscles that elevate the scapula and those that depress it has been calculated. This gives rise to a global force line R determining elevation in adduction of the scapula. The costo-humeral fascicles of the latissimus dorsi determine increased homolateral thoracic lateral convexity, and the inferior fascicles determine elevation of the hemipelvis. The result is an associated pattern composed of: high shoulder, thoracic lateral convexity, vertebral convexity T4-T12, and elevated hemipelvis.

5.7 Mechanical consequences of scapular elevation in pattern "B"

Lateral thoracic convexity also derives from elevation of the shoulder girdle.
The rhomboids and middle trapezius fibres, by elevating and adducting the scapula, produce homolateral convexity of the thoracic vertebrae.
The serratus anterior increases its tension in an attempt to oppose scapular adduction and elevation.
Being subdominant relative to the adductors, the scapula becomes a fixed point for it.
Its traction therefore manifests on the ribs, the mobile point, which shift laterally and increase the thoracic deformity.

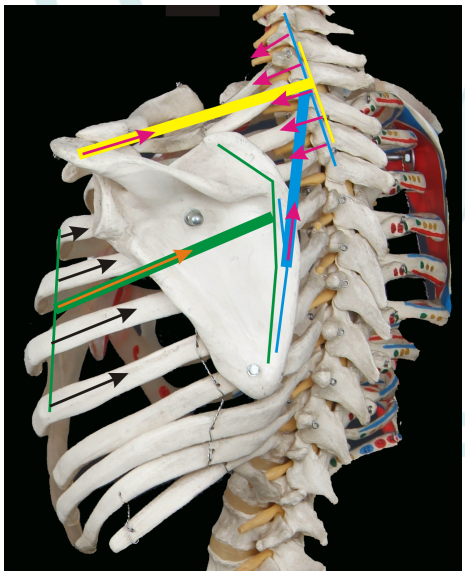


Fig. 13 - Middle trapezius fibres: yellow; rhomboids: blue; serratus anterior: green. The middle trapezius fibres and the rhomboids elevate the scapula in adduction and homolaterally translate the vertebrae from C6 to T4 in rotation. The vertebral convexity produced expands the upper ribs laterally on the same side. The increased tension of the serratus anterior, caused by its attempt to oppose scapular adduction, is translated into lateral expansion of the thorax. Thoracic lateral convexity above T7 is therefore the mechanical product of lateral spinal deviation and of serratus anterior action, for which the scapula becomes the fixed point and the ribs the mobile point.

5.8 Complete associated pattern of pattern "B"

Pattern "B" potentially presents, on the same hemibody:

- elevated and adducted scapula
- ascending clavicle
- upper thoracic lateral convexity, T4-T7
- lower thoracic lateral convexity, T7-T12
- elevation of the hemipelvis
- pelvic rotation

Not all of these elements are necessarily present at the same time.

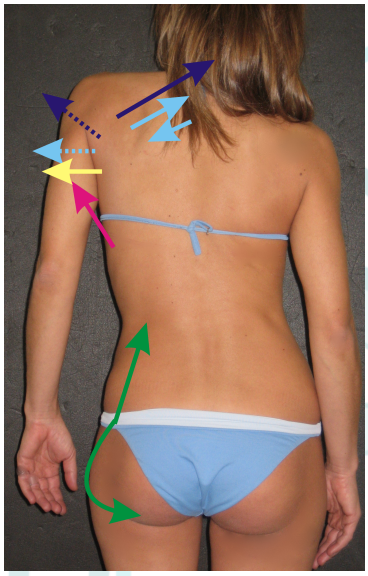


Fig. 14 - Blue arrows: global resultant of the action of the shoulder girdle elevators and the upper fascicles of the latissimus dorsi, the dashed arrow indicates the mechanical resultant induced by elevation in adduction of the shoulder; magenta arrow: action of the costo-humeral fascicles of the latissimus dorsi; green arrows: actions of the inferior fascicles of the latissimus dorsi; light blue arrows: actions of the middle trapezius fibres and rhomboids, the dashed arrow indicates the mechanical resultant induced by vertebral convexity; yellow arrow: action of the serratus anterior.

5.9 Variants of pattern "B": double curve and single curve

Variant with double curve
If, at lumbar level, the mechanical resultant determined by elevation of the hemipelvis prevails, a double vertebral curve is produced with lumbar concavity and thoracic convexity.
The inferior fascicles of the latissimus dorsi elevate the hemipelvis.
Elevation of the hemipelvis mechanically determines lumbar concavity as a resultant.
At the same time, the superior fascicles of the latissimus dorsi, associated with the rhomboids and the middle and lower trapezius fibres, directly determine thoracic vertebral convexity from T4 to T12 through direct traction on the vertebrae.

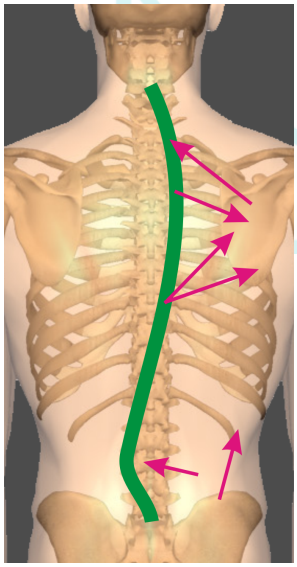
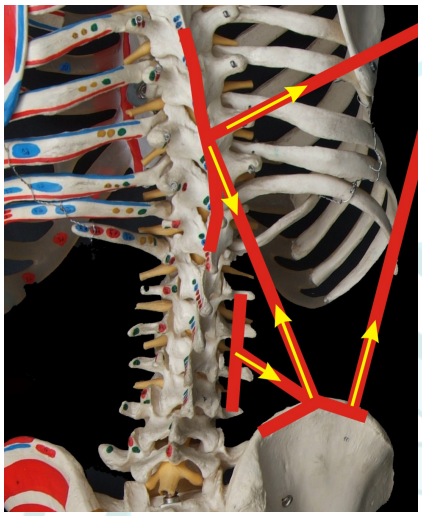
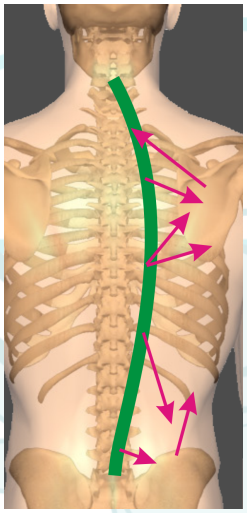


Figure 15 - In green, simulation of the vertebral course. If the mechanical resultant induced by elevation of the hemipelvis caused by the inferior fascicles of the latissimus dorsi prevails, the vertebral column will show lumbar concavity and thoracic convexity induced by the upper fascicles of the latissimus dorsi and by the scapular adductors.

Variant with single curve
When the fibres of the quadratus lumborum, which forms part of the functional unit of the latissimus dorsi, are shortened together with those of the latissimus dorsi connecting the pelvis to the thoracolumbar spine, they oppose the mechanical resultant determined by elevation of the hemipelvis.
The thoracolumbar spine then presents a vertical course or homolateral convexity even though the hemipelvis is elevated.





Figures 16 and 17 - Latissimus dorsi and quadratus lumborum: red; skeletal resultants: yellow arrows. Green line: simulation of the spinal course. In this case, even though the hemipelvis is elevated, the lumbar spine may appear straight or in homolateral convexity. The global vertebral course shows a large-radius convexity from T4 to L5.

A large-radius curve is thus produced, in which:

- thoracolumbar convexity is directly determined by traction on the lumbar vertebrae exerted by the quadratus lumborum and on the thoracic vertebrae by the latissimus dorsi;
- upper thoracic convexity is induced by the traction force exerted by the scapular adductors and by the mechanical resultant of shoulder elevation.

5.10 Diagnostic principles and clinical applications

Muscles with direct action on the vertebrae are dominant in determining vertebral deviations compared with deviations produced by mechanical resultants.
Diagnostically, deviations produced by direct muscular traction are defined as convexity, whereas those deriving from mechanical resultants due to displacement of other body segments are defined as concavity.
Apparently incongruent patterns are not uncommon, especially at lumbar level, where the vertebrae are often in homolateral convexity relative to the elevated pelvis.
If, with the hemipelvis elevated, the lumbar vertebrae appear aligned, this is only apparently a good sign.
Mechanically, the elevated hemipelvis should produce contralateral vertebral convexity.
If the vertebrae are aligned, this means that active forces, quadratus lumborum, diaphragmatic crus, and homolateral psoas, oppose the mechanical resultant.
This opposition stiffens the segment and produces disc compression through the vertical vector components.

5.11 Clinical frequency of the two patterns

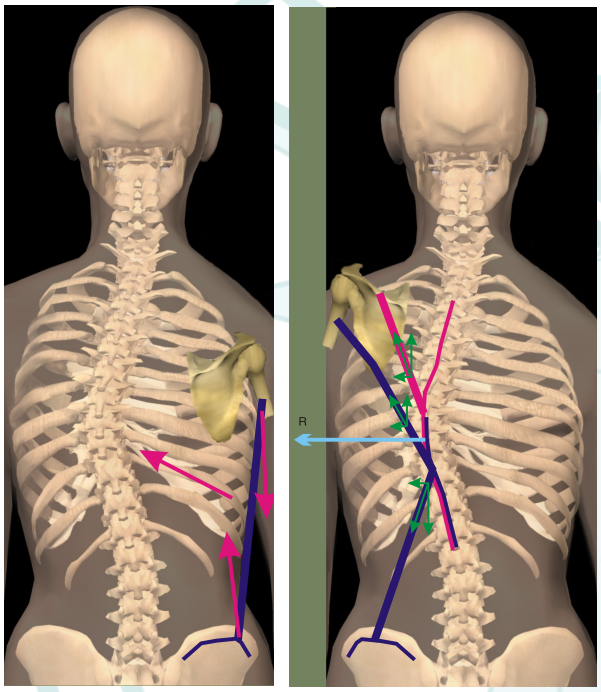
Pattern “A” of the latissimus dorsi is much rarer than pattern “B.”
Pattern “A” requires predominance of the iliac crest-to-humerus force line, a situation

biomechanically less frequent than pattern “B,” in which the vertebral and scapular insertion components prevail.

6. Vertebrae T4-T12

These are the vertebrae directly involved in the patterns of the latissimus dorsi.
Differential diagnostic criteria:

- **Vertebral concavity:** pattern “A” with dominant iliac crest-to-humerus force line
- **Vertebral convexity:** pattern “B” with prevalence of the force lines having vertebral insertion



Figures 18 and 19 - Vertebral lateral concavity in the left figure, pattern “A” of the latissimus dorsi; vertebral lateral convexity in the right figure, pattern “B” of the latissimus dorsi. In the left figure, the vertical force line of the latissimus dorsi, blue, by approximating scapula and pelvis, determines the mechanical resultant in vertebral concavity, magenta arrows. In the right figure, the vertebral force lines of the latissimus dorsi, blue, associated with those of the lower trapezius fibres, magenta, directly determine vertebral convexity, light blue arrow.

7. Lumbar vertebrae

The distinction between lumbar concavity and convexity follows specific criteria.
Lumbar concavity: when the deviation is proportional to elevation or rotation of the hemipelvis, and is therefore a mechanical consequence of pelvic displacement.
Lumbar convexity: when the course is not congruent with the deviation expected from pelvic elevation and rotation.
This incongruence, as already observed, may occur because of opposition to the mechanical resultant, and in this case the responsible traction force is homolateral to the side of the elevated pelvis.
It may also reveal disproportion due to excess: when the amount of pelvic elevation appears to produce an opposite vertebral convexity that is exaggerated in magnitude, this reveals direct traction by the contralateral muscles which, by taking advantage of the mechanical reaction, further amplify it.
The muscular vectors responsible for lumbar convexity are:

- quadratus lumborum
- diaphragm
- psoas

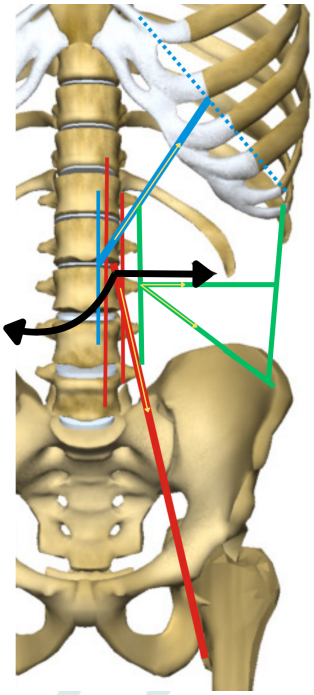


Figure 20 - Psoas: red; diaphragm: light blue; quadratus lumborum: green. The black arrows indicate the global resultant in homolateral convexity to the traction exerted by the three muscles and in contralateral rotation.

8. Pelvis

Elevation and posterior rotation are induced by the latissimus dorsi–quadratus lumborum pair. Two principal patterns can be distinguished:

1. elevation and homolateral rotation of the hemipelvis. This is the sign that the imbalance produced by asymmetric shortening of the muscles on the two sides is significant.
2. elevation of the hemipelvis on one side and contralateral rotation. This is the sign that muscular shortening on the two sides is less marked. In these cases, shortening of the latissimus dorsi–quadratus lumborum pair is usually greater on the side of the elevated hemipelvis.

9. Summary: the four independent curves

In the frontal and rotatory plane, the spinal column is composed of four muscularly independent curves:

1. cranio-cervical, C1-C5
2. cervico-thoracic, C6-T4
3. thoracic, T4-T12
4. lumbar, L1-L5

These curves may appear contralateral to one another or merge into broader radii. For treatment, they must be considered separately, with specific strategies for each segment.

Vertebral segment	Convexity	Concavity	Associated pattern
C1-C5	Levator scapulae; scalenes		Levator scapulae: elevated and adducted scapula; scalenes: convexity of the first ribs
C6-T3	Rhomboids; middle trapezius fibres		Elevation and adduction of the scapula
T4-T12	Pattern “B” of the latissimus dorsi		Elevated scapula and hemipelvis, lateral thoracic convexity
T4-T12		Pattern “A” of the latissimus dorsi	Descending clavicle, lateral thoracic concavity, elevated hemipelvis
L1-L5		Elevated and rotated hemipelvis, patterns “A” and “B” of the latissimus dorsi	
L1-L5	Quadratus lumborum, diaphragm, psoas		

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