

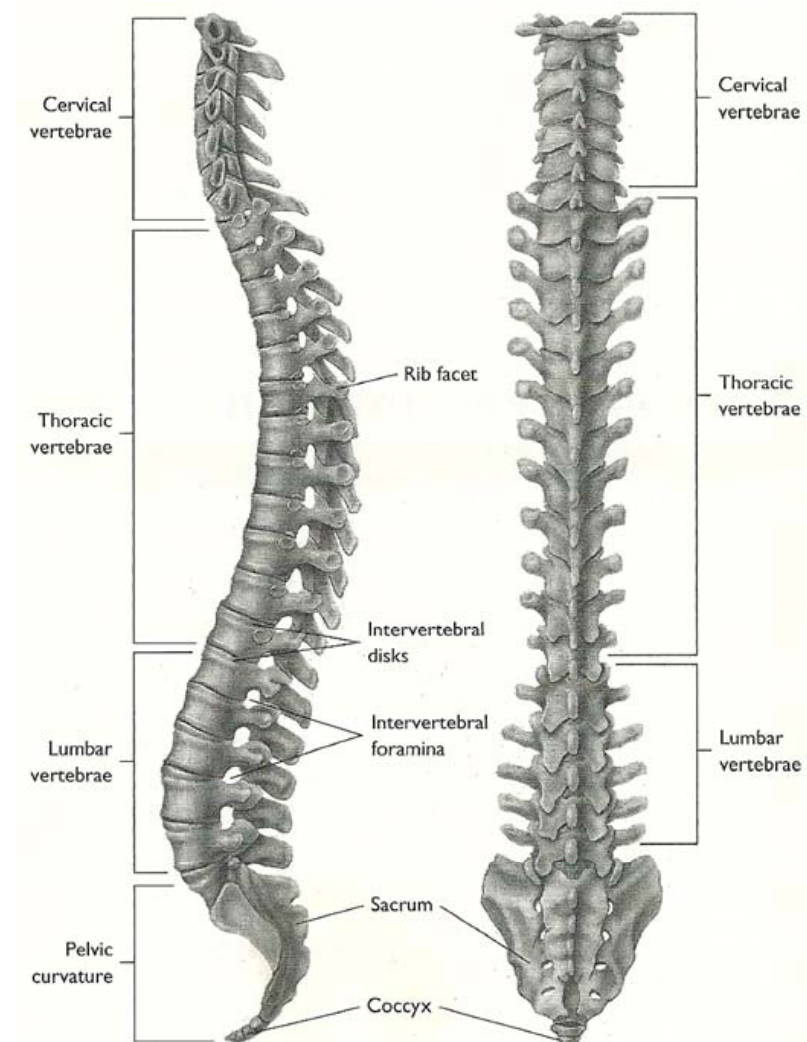
Chapter 9

The Biomechanics of the Human Spine

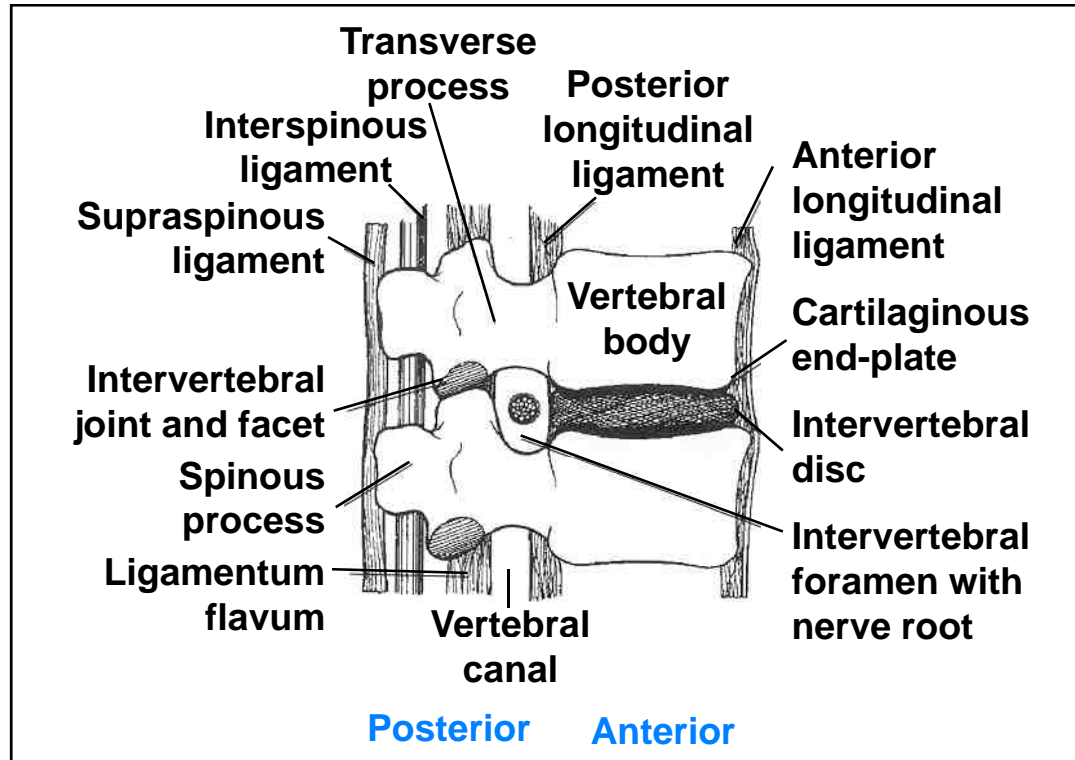
Basic Biomechanics, 6th edition
By Susan J. Hall, Ph.D.

Structure of the Spine

The spine is a curved stack of 33 vertebrae structurally divided into five regions:
cervical region - 7 vertebrae
thoracic region - 12 vertebrae
lumbar region - 5 vertebrae
sacrum - 5 fused vertebrae
coccyx - 4 fused vertebrae



Structure of the Spine



The **motion segment**, consisting of two adjacent vertebrae and the associated tissues, is considered to be the **functional unit** of the spine.

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Structure of the Spine

What types of joints connect adjacent vertebrae?

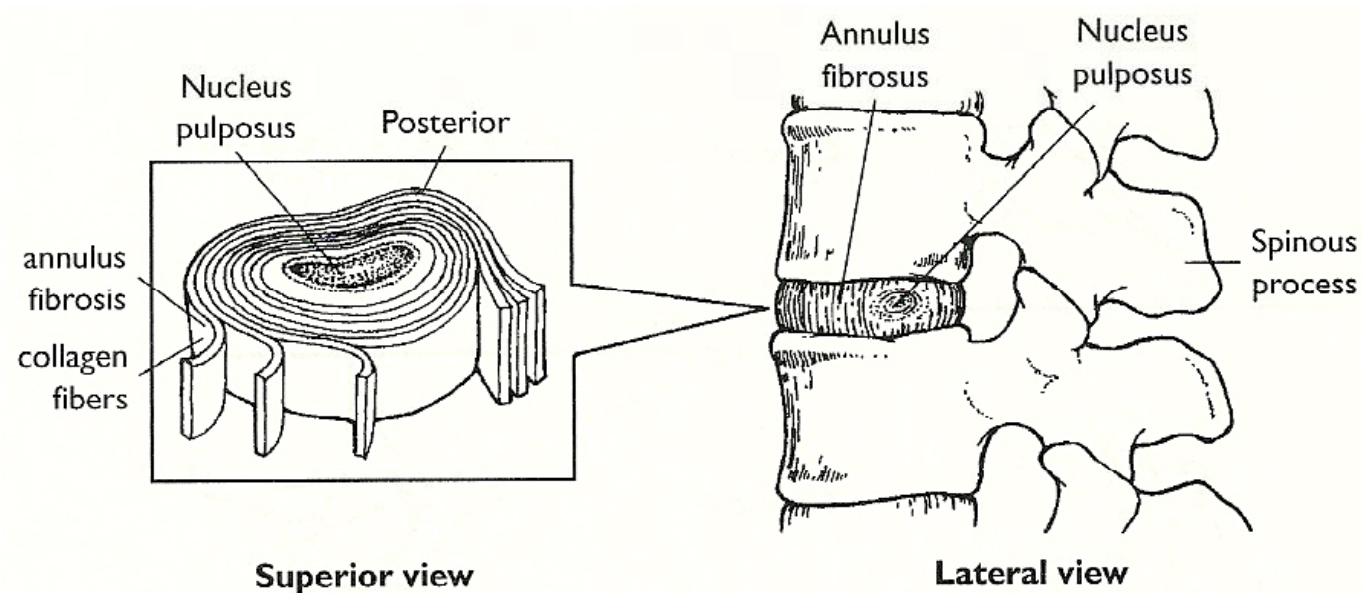
- intervertebral symphysis joints on the anterior side
- two gliding diarthrodial facet joints on the posterior side

Structure of the Spine

What is the function of the facet joints?

- to channel and limit the range of motion in the different regions of the spine
- to assist in load bearing, sustaining up to 30% of the compressive load on the spine, particularly when the spine is in hyperextension

Structure of the Spine



The **intervertebral discs** are fibrocartilaginous structures that cushion the anterior spinal symphysis joints. The center region is the **nucleus pulposus**, a colloidal gel with a high fluid content. This is surrounded by the **annulus fibrosus**, a thick, fibrocartilaginous ring that forms the disk exterior.

Structure of the Spine

What are the primary spinal curves?

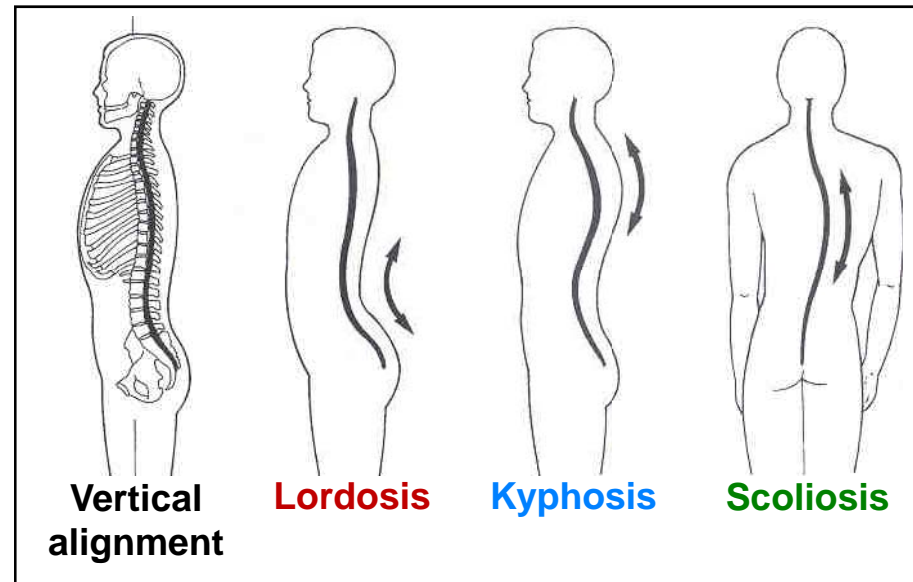
- the thoracic and sacral curves
- (concave anteriorly)
- are present at birth

Structure of the Spine

What are the secondary spinal curves?

- the lumbar and cervical curves
- (concave posteriorly)
- develop from supporting the body in an upright position after young children begin to sit and stand

Structure of the Spine



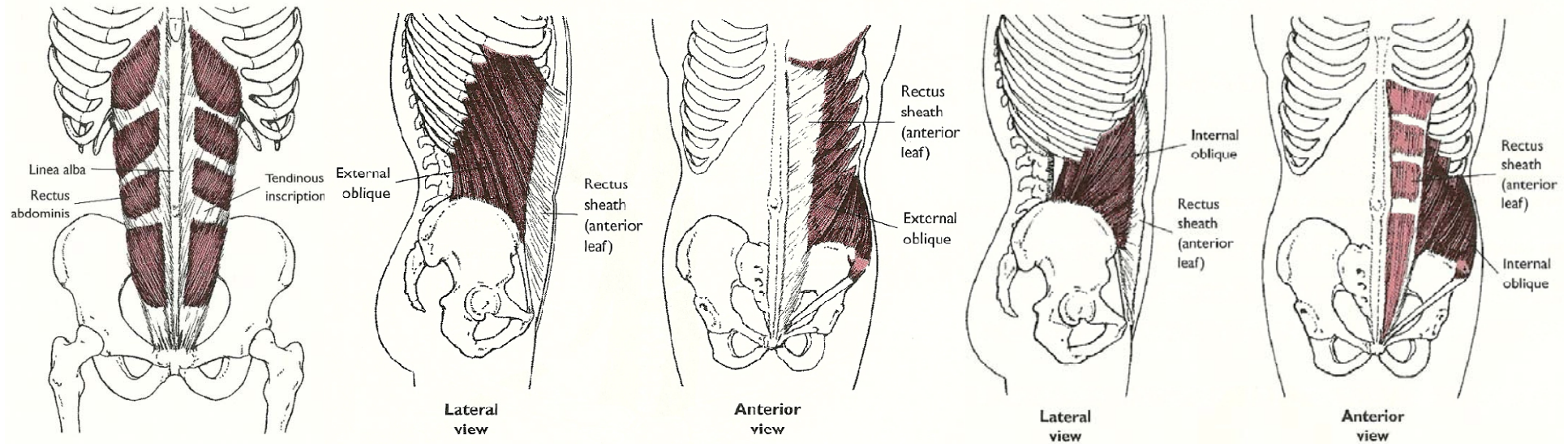
Lordosis - exaggerated lumbar curve
Kyphosis - exaggerated thoracic curve
Scoliosis - lateral spinal curvature

Movements of the Spine

What movements of the spine are allowed?

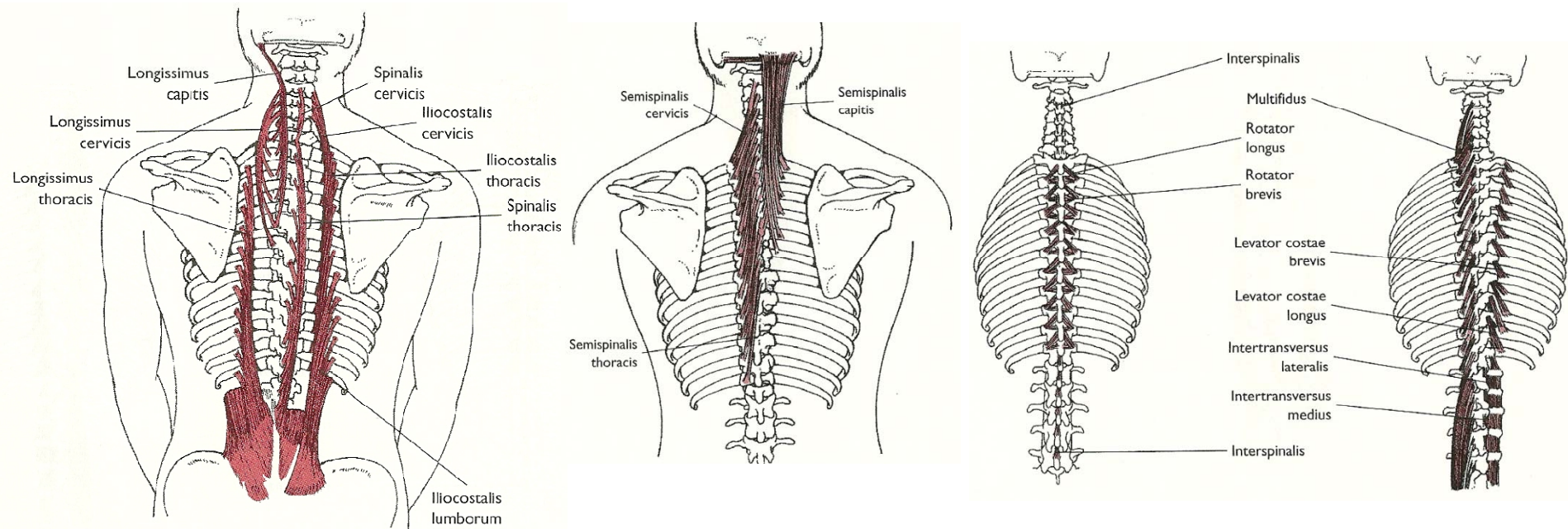
The movement capabilities of the spine are those of a ball and socket joint, including movement in all three planes, and circumduction.

Movements of the Spine



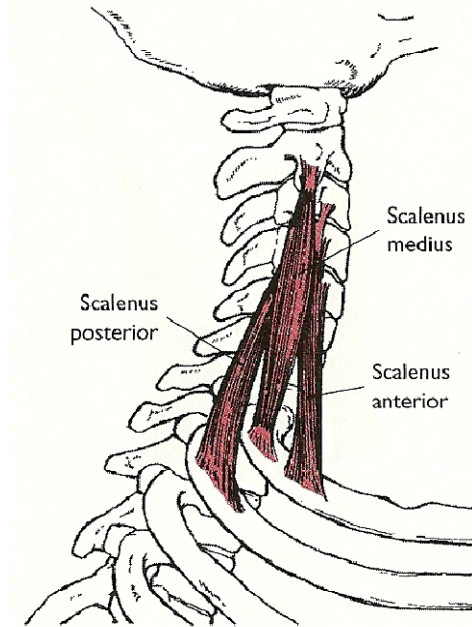
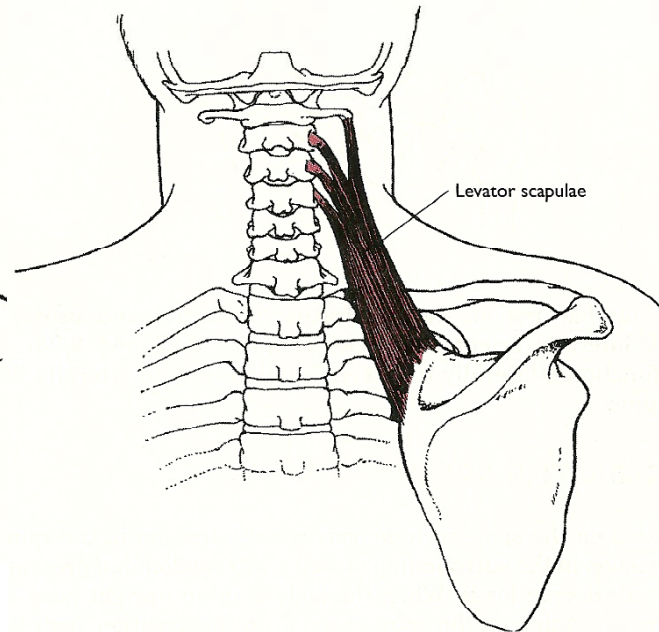
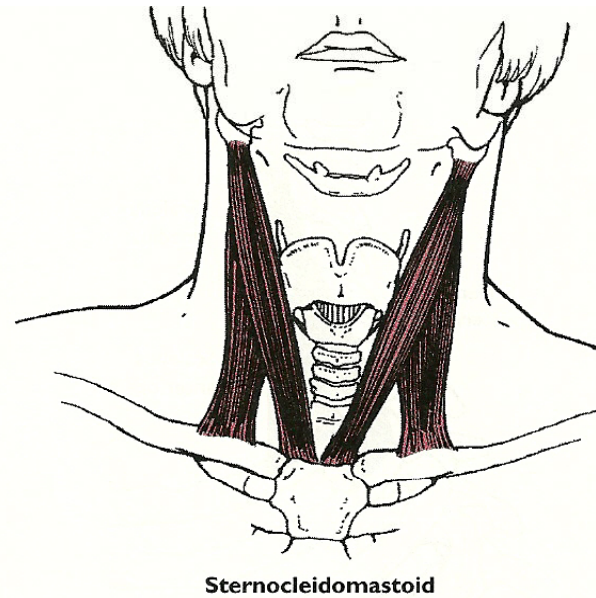
The abdominal spinal flexor muscles include rectus abdominis, the internal obliques, and the external obliques.

Movements of the Spine



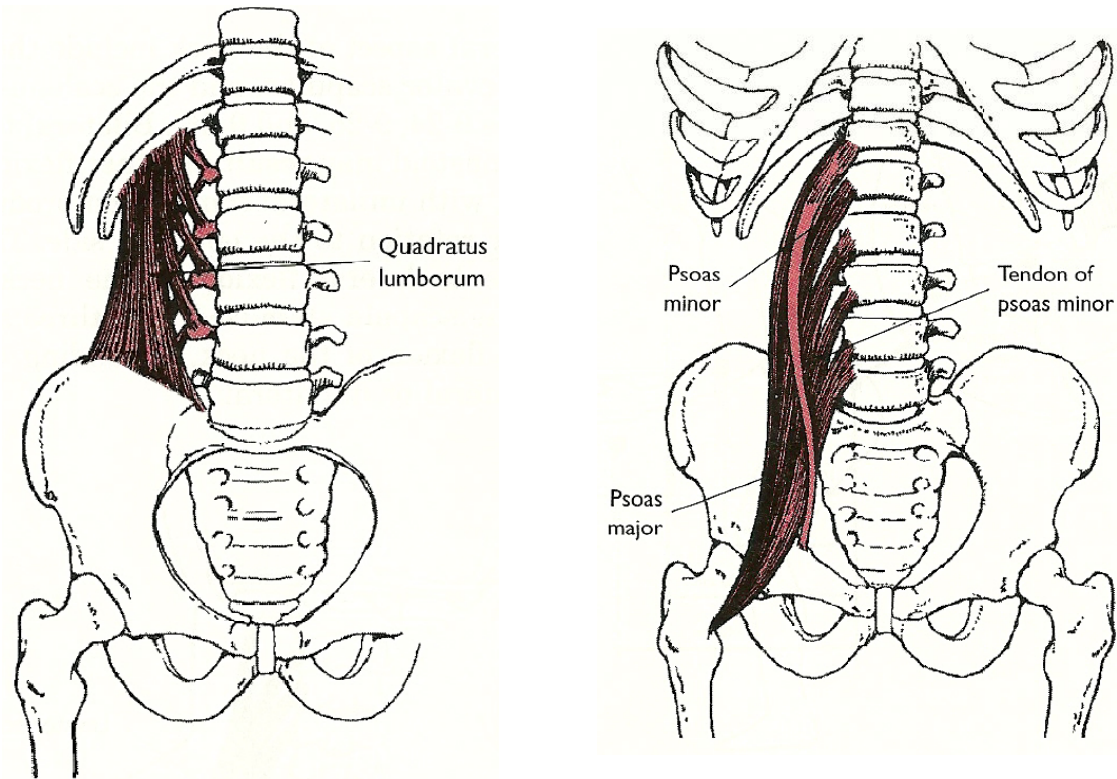
The thoracic and lumbar spinal extensors are erector spinae - (spinalis, longissimus, and iliocostalis), semispinalis - (capitis, cervicis, and thoracis), and the deep spinal muscles - (multifidi, rotatores, interspinales, intertransversarii, and levatores costarum).

Movements of the Spine



The cervical lateral flexor muscles include sternocleidomastoid, levator scapulae, and scalenus anterior, posterior, & medius. When developing tension unilaterally, the cervical flexors and extensors also contribute.

Movements of the Spine



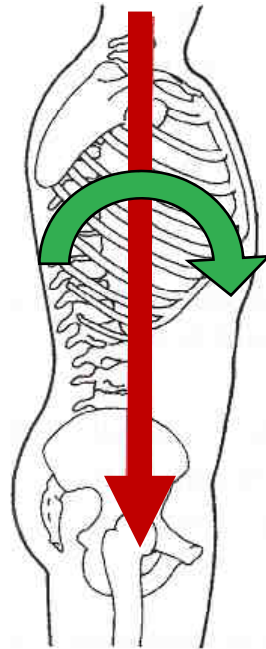
The lumbar lateral flexor muscles are the quadratus lumborum and psoas major. The lumbar flexors and extensors also contribute when developing tension unilaterally.

Loads on the Spine

What forces commonly act on the spine?

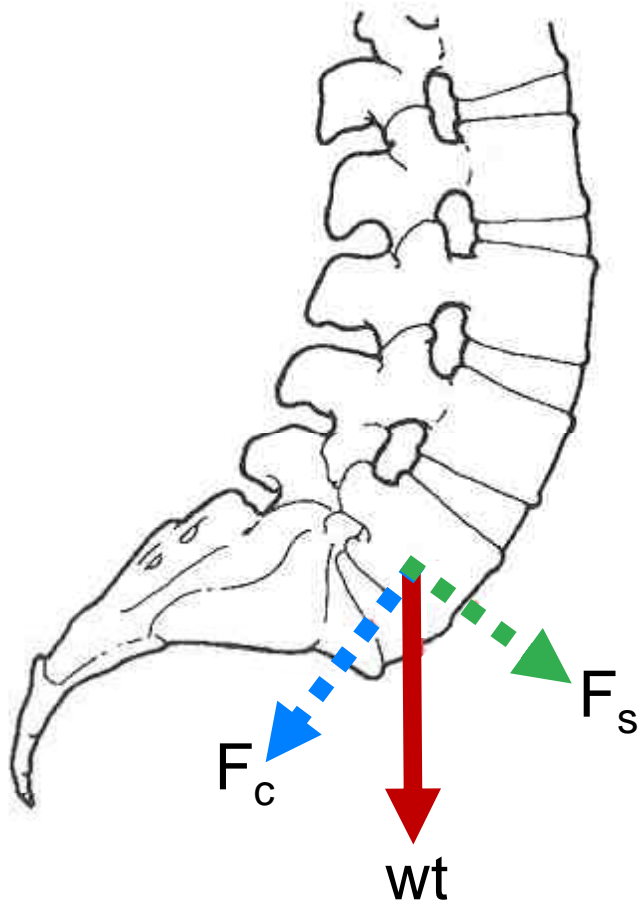
- body weight
- tension in the spinal ligaments
- tension in the spinal muscles
- any external loads carried in the hands

Loads on the Spine



In normal standing position, body **weight** acts anterior to the spine, creating a forward **bending load (moment)** on the spine.

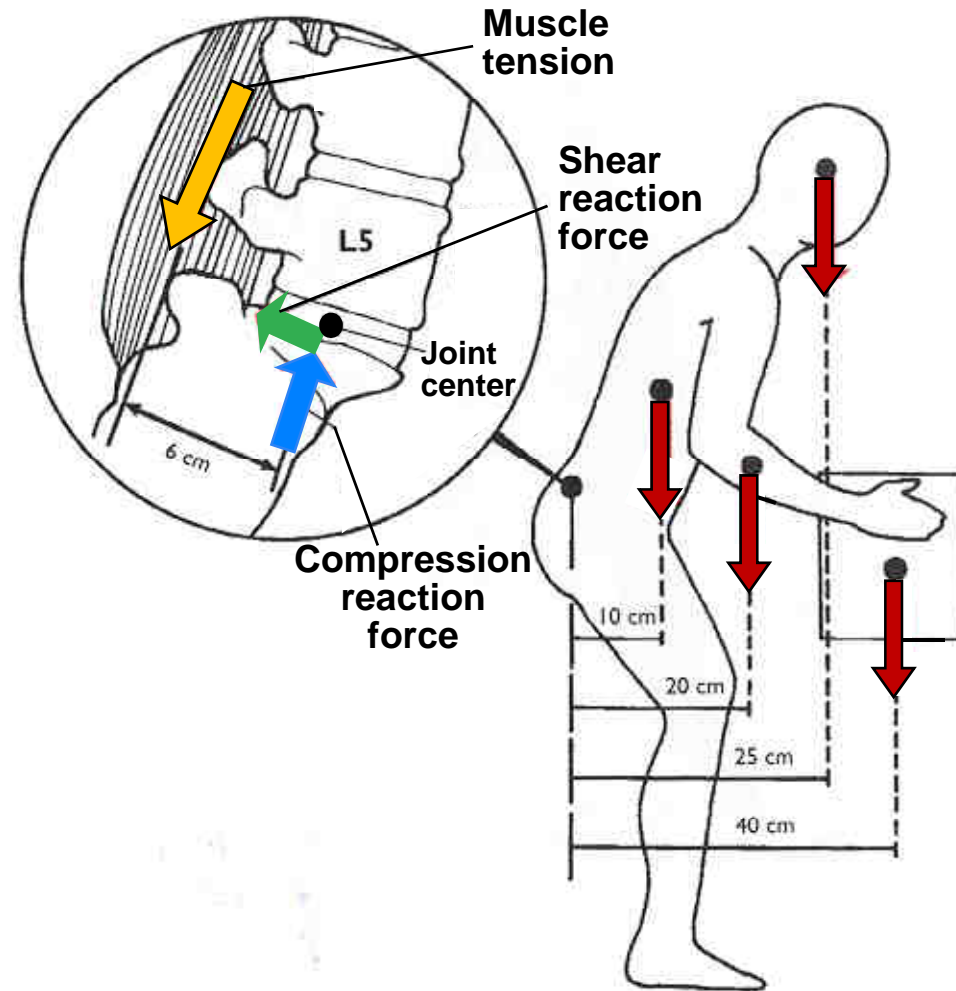
Loads on the Spine



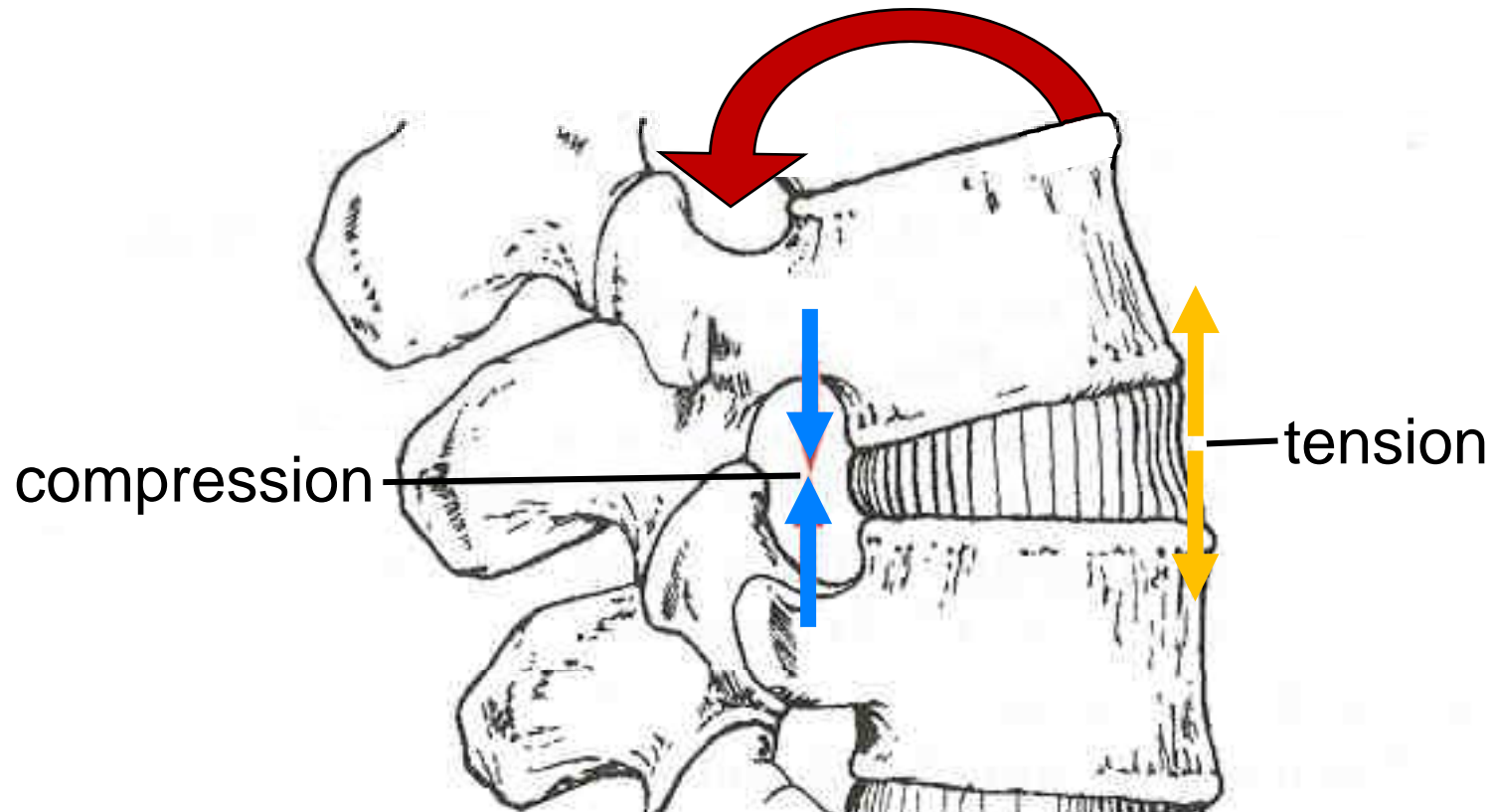
Because the spine is curved, body **weight**, acting vertically, has components of both **compression** (F_c) and **shear** (F_s) at most motion segments.

Loads on the Spine

During lifting, both **compression** and anterior **shear** act on the spine. Tension in the spinal ligaments and muscles contributes to compression.



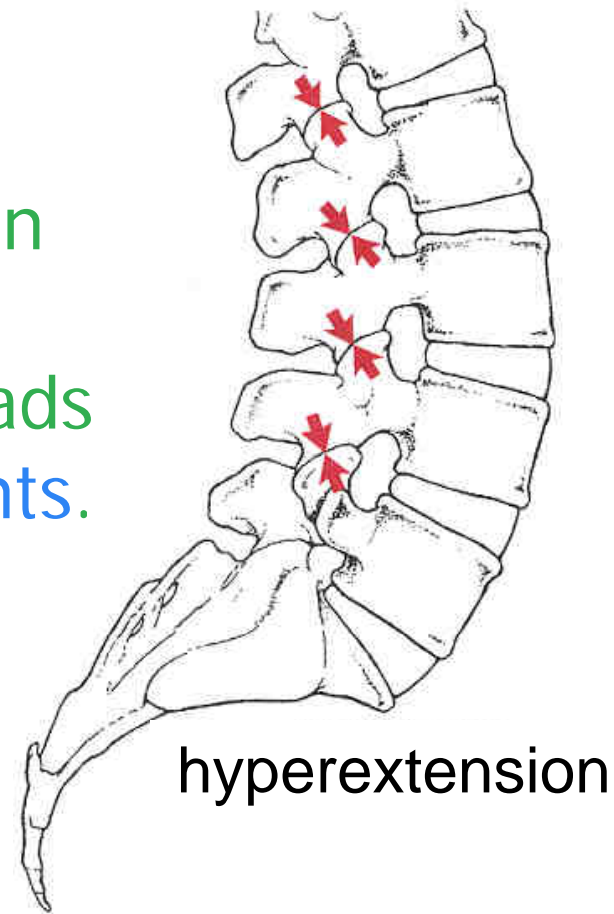
Loads on the Spine



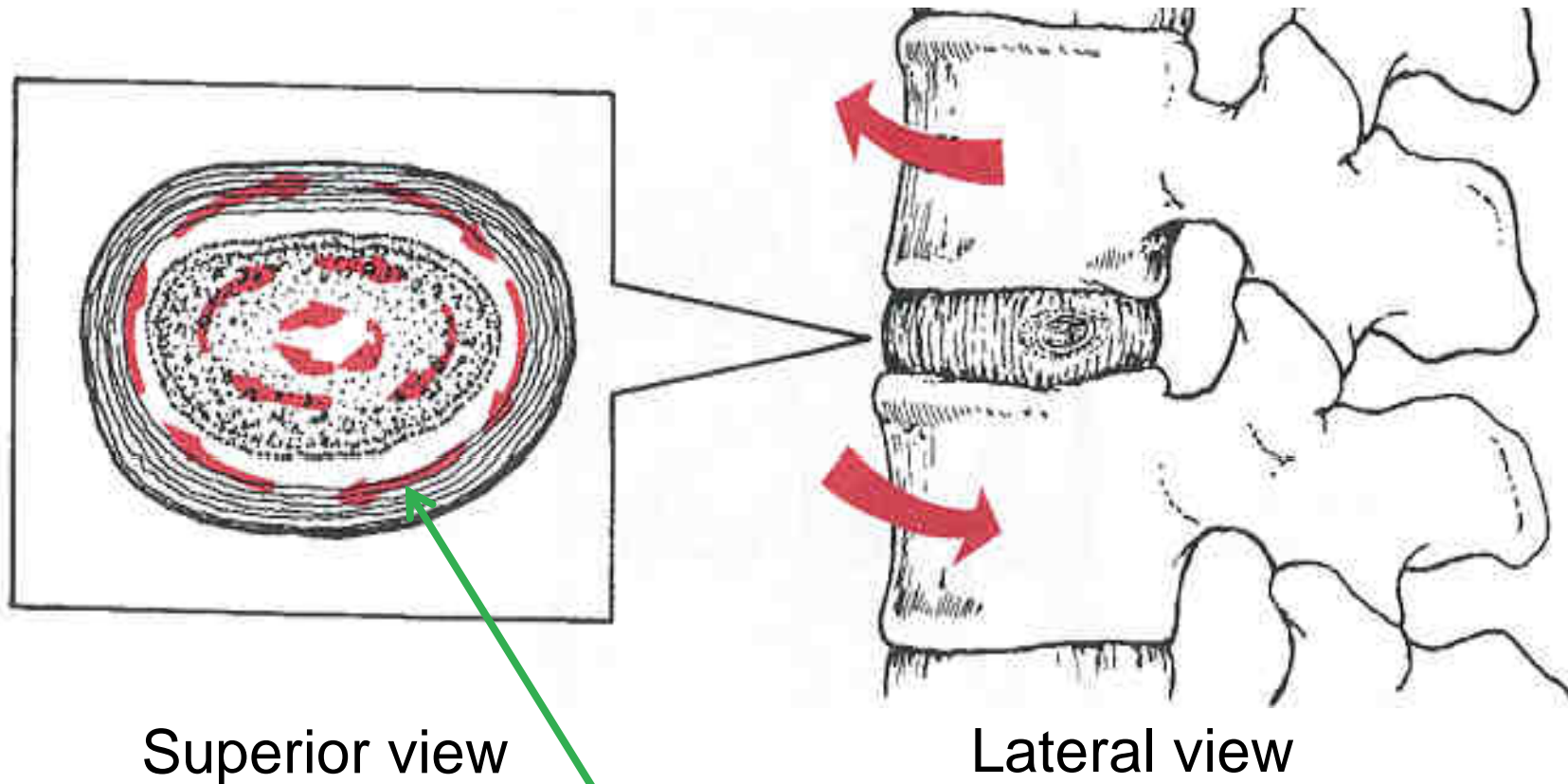
Lumbar hyperextension can create a **bending load (moment)** in the posterior direction.

Loads on the Spine

Lumbar
hyperextension
produces
compressive loads
at the facet joints.



Loads on the Spine



Spinal **rotation** generates **shear** stress in the intervertebral discs.