DRAFT

SYNOPTIC OUTLINE

VERTEBRAL COLUMN - STRUCTURE AND FUNCTION
INVERTED PENDULUM

Vertebral column provides both support and motion

I. Vertebral Column Structure : - is ...

1. Segmented - Motion unit - Two adjacent vertebrae and Intervertebral Disk
2. Composite - Composed of Hard (Bone) and Soft tissues (Intervertebral disks, ligaments and muscles)
3. Prestressed/ Loaded - Ligaments (3 continuous ligaments and several discontinuous ligaments)
4. Prismatic - shape of vertebrae - ultimately column (provides bending stiffness)
5. Curved - resists bending stresses

~~Column~~

II. Vertebral Column is divided into one anterior and two posterior columns:

1. Anterior Column (Support & Movement) formed by vertebral bodies and intervertebral disks
   A. Resists compressive stress (Disks resist both compressing and bending stress)
   B. Composite structure allows flexibility

2. Posterior Columns formed by articular facets forming the intervertebral joints. --
   Articular facets control both Direction and Magnitude of movement. Movements between regional vertebral form a continuum.
   [Thoracic vert. - spinous process limit extension; thin IV disks limit flexion; ribs limit side bending; articular facets make axial rotation easier: Lumbar vert. Articular facets limit axial rotation.]

III. Vertebrae:

A. Components: (In general are prismatic in shape)
1. Body: resists compression - by – supero-inferior surfaces curved - arches; trabeculae internal structure
2. Neural Arch (Lamina & Pedicles) : House and protect spinal cord
3. Pedicles : adjacent pedicles form intervertebral foramen
4. Articular processes - Inferior articular facet over laps subadjacent superior articular face forming synovial intervertebral (zygophyseal) joints. Morphology varies with region. Determine direction of motion. (?) & magnitude.
5. Processes (Spinous and Transverse) : Sites for muscle attachments; Lever arms.

B. Regional Differences [Typically 5 Cervical; 12 Thoracic; 5 Lumbar; 5 (fused) Sacral & variable # Coccygeal
Atlas C1 and C2 Axis - form Atlanto-Occipital joint (flexion - extension "YES") and atlanto-axial joint (rotation "NO") –Dens reduces flexion - extension _"Hangman's fracture - Whiplash Injury".
Middle thoracic vertebrae have a total of 10 articular facets - reflection of function.
Lumbar vertebrae - spinous processes - spinal / lumbar puncture.
CERVICAL V. - BIFID TRANSVERSE PROC.; FORAMEN TRANSVERSARIUM; SPINA PROMINENCE

IV. Intervertebral Disks (Form @ 25% of the length of Vertebral Column -Continuously under compressive load) Is an amphiarthroses and permits movement between adjacent vertebrae. WEDGE SHAPE; SIZE (HEIGHT) DIFF. GRADIENT

A. Annulus Fibrosus - Surrounds nucleus pulposus; attached to adjacent vertebrae with lamelliform (ply) layers.

B. Nucleus Pulposus; remnant of notochord.
1. Is non-compressible [Equalizes compressive load] and deformable. - a fluid ball bearing, permits both movement between adjacent vertebrae and the change in shape of the vertebral column (i.e. curves)
2. Has high water content - which is lost during the day - may reduce height @ 2 cm.

3. Dehydration (due to aging) - reduces height.

C. Herniation (of Nucleus Pulposus - "slipped disk") -. Extrusion of the nucleus pulposus through the annulus fibrosus.- Rarely into the adjacent vertebral bodies (Schmorl's Nodes)

1. Herniation is typically directed posterolaterally (because presence of anterior longitudinal and posterior longitudinal ligaments.)
2. .Posterolateral herniation will typically impinge on the "next lower spinal nerve" both in cervical and lumbar regions. Reasons .....

2a. There are 7 cervical vertebrae and 8 cervical nerves. Herniation of disk, e.g., between C5 & C6 could impinge the 6th Cervical nerve, which in the cervical region exits ABOVE the 6th cervical vertebrae.

2b.In the lumbar region, the pedicles are located high on the bodies of the vertebrae, and the nerves exits through the superior aspect of the intervertebral foramen close to the superior pedicle, therefore, herniation of e.g. L4 and L5 typically will spare L4 and impinge upon the L5 spinal nerve.

V. Ligaments

A. Continuous ligaments:
1. Anterior Longitudinal Ligament - Broad- attaches to margins of vertebral bodies
2. Posterior Longitudinal Ligament
3. Supraspinous Ligament

B. Discontinuous (segmented ligaments):
1.Intraspinous Ligament
2. Ligamentum Flavum
3, Intertransversarii ligaments

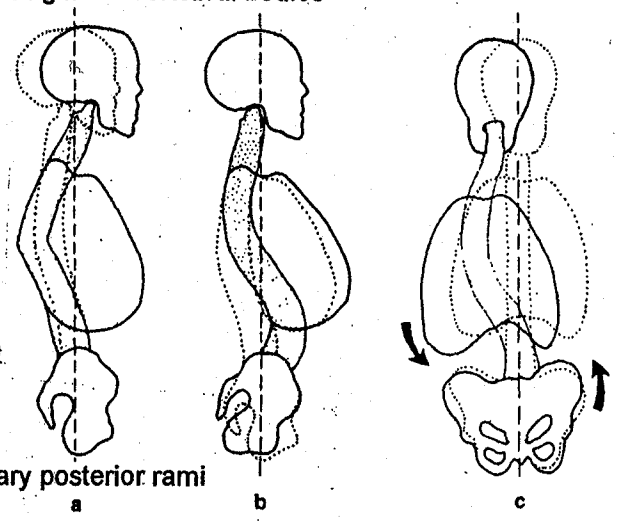


Figure 14.2. Abnormal curvature of the vertebral column. (a) Kyphosis. (b) Lordosis. (c) Scoliosis.

VI. Curves: Primary and Secondary (mechanically obligatory) Curves

A. Repositions the center of mass
B. Pelvo-vertebral connections -automatic balance adjustment
C. 3 Kinetic curves --- Cervical, Thoracic, Lumbar
D. Fixed curve - Sacral

VII. Intrinsic Muscles of the Back : - Defined by innervation - primary posterior rami

A. [Superficial Layer - Muscles of Upper Limb]

B. Intrinsic Muscles of the Back

1. Spino-transverse group:
Splenius capitis
Splenius cervicis
Unilaterally: Rotate head ipsilaterally
Bilaterally: extend head and neck

2. Erector Spinae: (Sacrospinalis)
3 Superficial Columns - Iliocostalis, longissimus and spinalis
Unilaterally: Lateral bending with lateral abdominal muscles ipsilateral axial rotation
Bilaterally: Extend the VC

3. Transverso - Spinalis
3 Deep layers - Semispinalis. Multifidi and rotators
Unilaterally: Axial rotation contralaterally
Bilaterally: Extend the VC

4. Segmental - Interspinalis Intertransversarii

C. Suboccipital Group:
Inferior & Superior Oblique Capitis muscles
Posterior Rectus Capitis Major & Minor
Innervation - Posterior rami C1

D. Anterior Vertebral Muscles:
Longus Colli; Lateral - and Anterior Rectus Capitis (Innervation - Anterior Rami)

E. Lateral Group:
Scalene (Levator Scapulae) -(Innervation - Anterior Rami)

VIII. Movements:

A. Axial Rotation
B. Flexion - Extension
C. Lateral Bending / Flexion

1. IPSILATERAL
SUP. + DEEP - (LATERAL BENDING)
2. CONTRALATRAL
SUP + DEEP - AXIAL ROTATION
MOVEMENTS TOWARDS SUP. SIDE
3. BILATERAL
SUP + DEEP - EXTENSION.

IX: Increased curvatures

A. Anterior - Posterior
Increased Anterior Curvature **Kyphosis** (CONCAVE ANTERIORLY)
Increased Posterior Curvature - **Lordosis** (CONCAVE POSTERIORLY)

B. Lateral Curvature - **Scoliosis**
PRIMARY + SECONDARY

X: Mechanics

Static - erect posture weight is distributed equally of each vertebrae.& disk

One method of the analysis of the force on the vertebral column -examples - old fashioned method ...

Lifting a weight - a 20 kg weight flexed to 90 degrees anterior and 20 cm from vertebral column will produce a flexor moment (torque) of 400 kg/cm on the vertebral column. To maintain erect posture - the intrinsic muscles of the back [e.g. muscles attaching to the spinous process] will exert a counter force of 200 kg through a lever arm of 2 cm The resulting Joint Reactive Force = 220 kgs..

Lifting or supporting a weight while *bending* over. - If a 20 kg weight is supported 50 cm from the 5th lumbar vertebrae. This will produce a flexing moment (torque) of 1000 kg/cm. To maintain the static posture, the back muscles will exert of force of 500 kg with a 2 cm lever arm to produce a counter torque of 1000 kg/cm. The joint reactive force equals 520 kg.

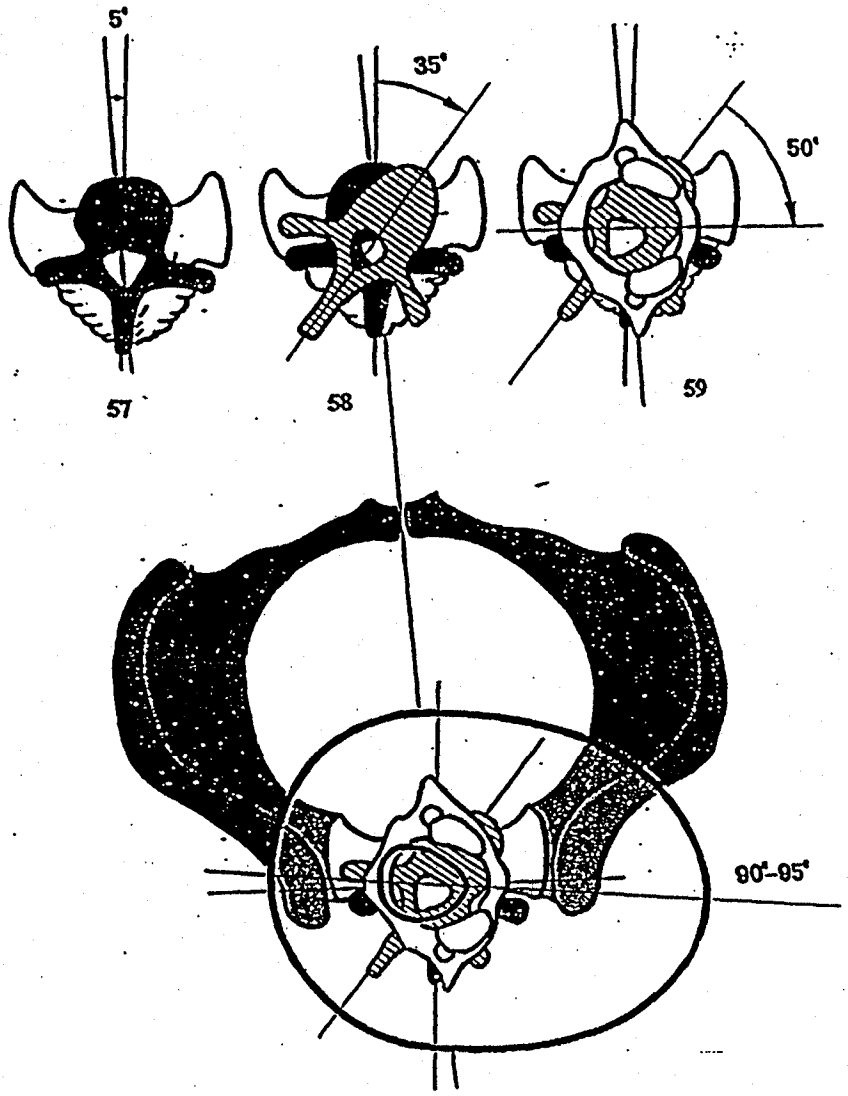
The actual values are less because the contraction of the antero-lateral abdominal muscles will compress the abdominal viscera - in effect supplying a counter force.

Dr. A. Solimene 9/2003

AXIAL ROTATION

LUMBAR REGION @ 5 DEGREES
THORACIC REGION @ 35 DEGREES
CERVICAL REGION @ 45 TO 50 DEGREES

VERTEBRAL COLUMN - LUMBO-SACRAL JUNCTION TO HEAD @ 90 DEGREES



Kapandji, I. A., 1974, The Physiology of the Joints, V. 3 (2nd Ed.), Churchill Livingstone, New York

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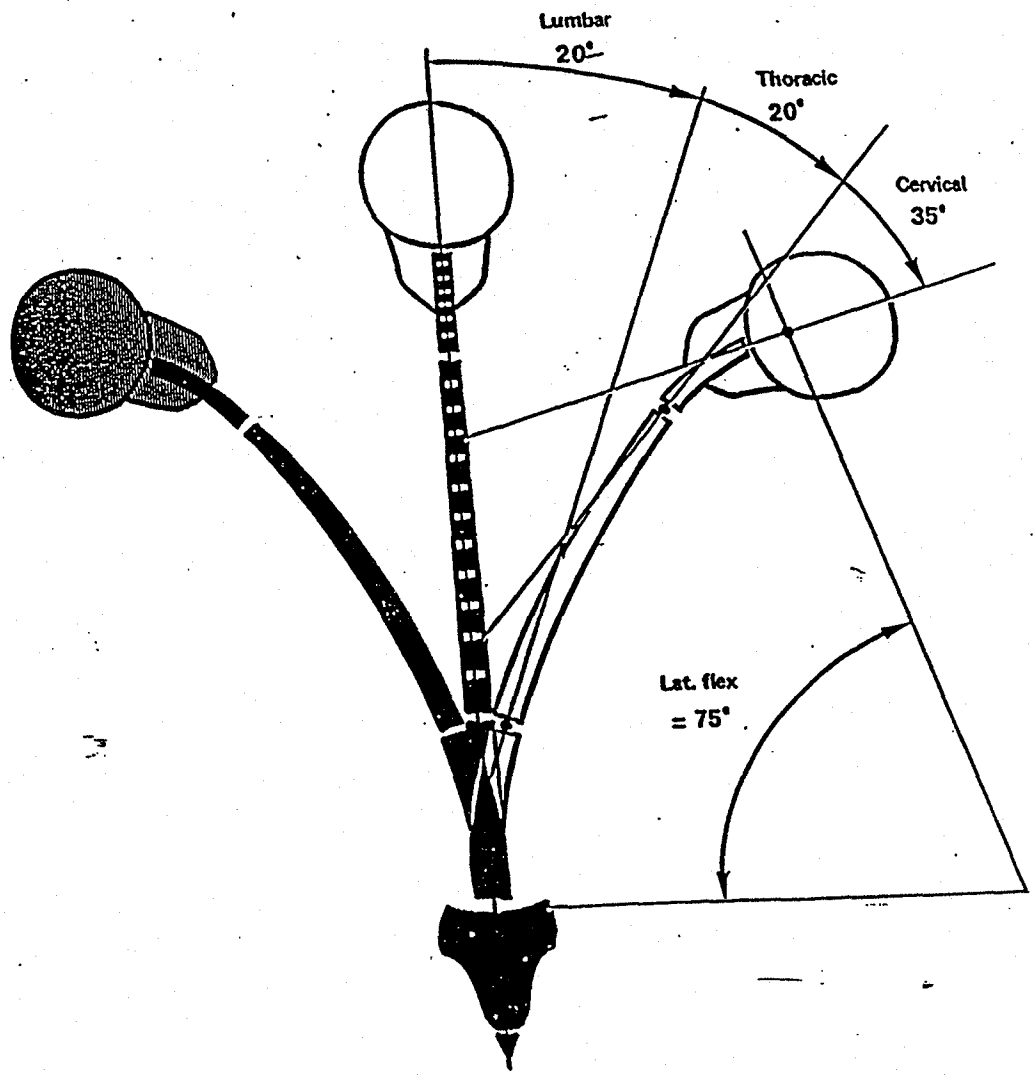
VERTEBRAL COLUMN - Range of Motion

LATERAL FLEXION [BENDING]

LUMBAR REGION @ 20 DEGREES
THORACIC REGION @ 20 DEGREES
CERVICAL REGION @ 35 TO 45 DEGREES

VERTEBRAL COLUMN - LUMBO-SACRAL JUNCTION TO HEAD @ 75 TO 85 DEGREES



Kapandji, I. A., 1974, The Physiology of the Joints, V. 3 (2nd Ed.), Churchill Livingstone, New York

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VERTEBRAL COLUMN - Range of Motion

FLEXION AND EXTENSION

LUMBAR REGION

FLEXION @ 60 DEGREES EXTENSION @ 35 DEGREES

THORACO-LUMBAR REGION

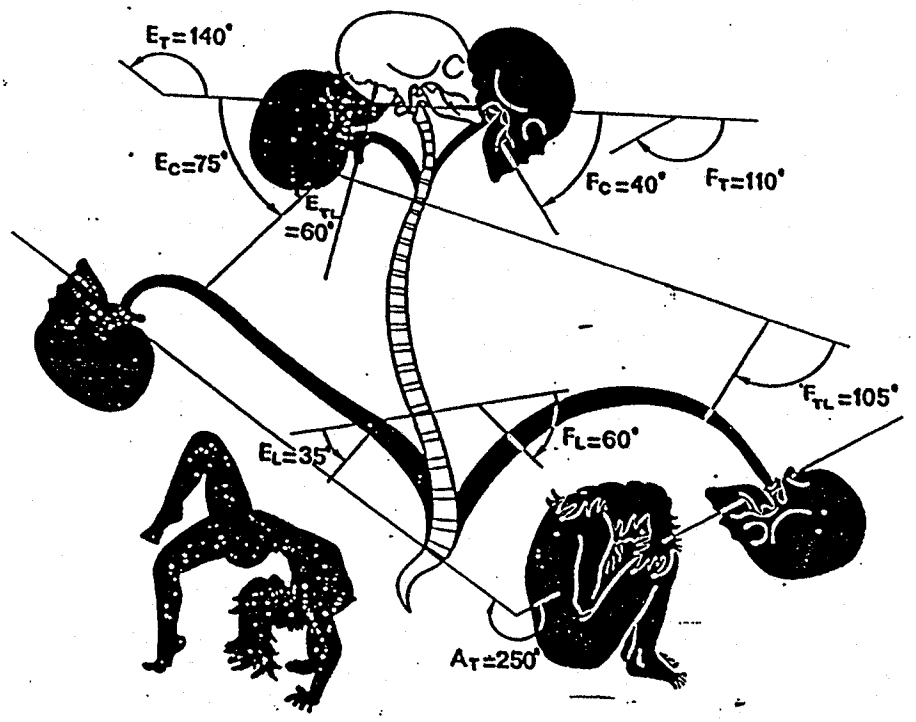
FLEXION @ 105 DEGREES EXTENSION @ 60 DEGREES

CERVICAL REGION

FLEXION @ 40 DEGREES EXTENSION @ 75 DEGREES

VERTEBRAL COLUMN - LUMBO-SACRAL JUNCTION TO HEAD

FLEXION @ 110 DEGREES EXTENSION @ 140 DEGREES



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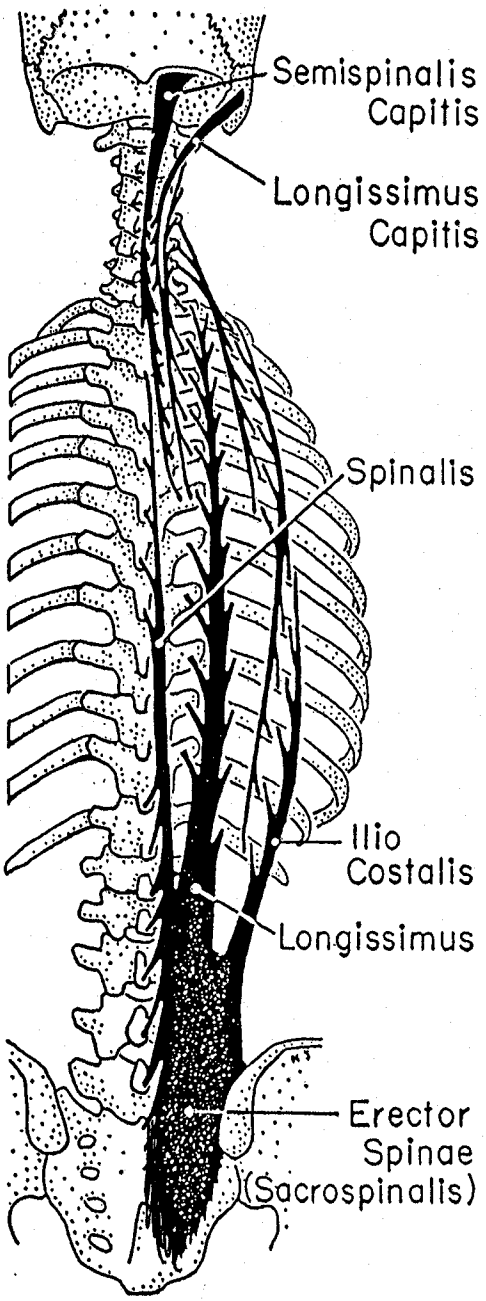


Fig 3 Plan of the erector spinae and semispinalis.

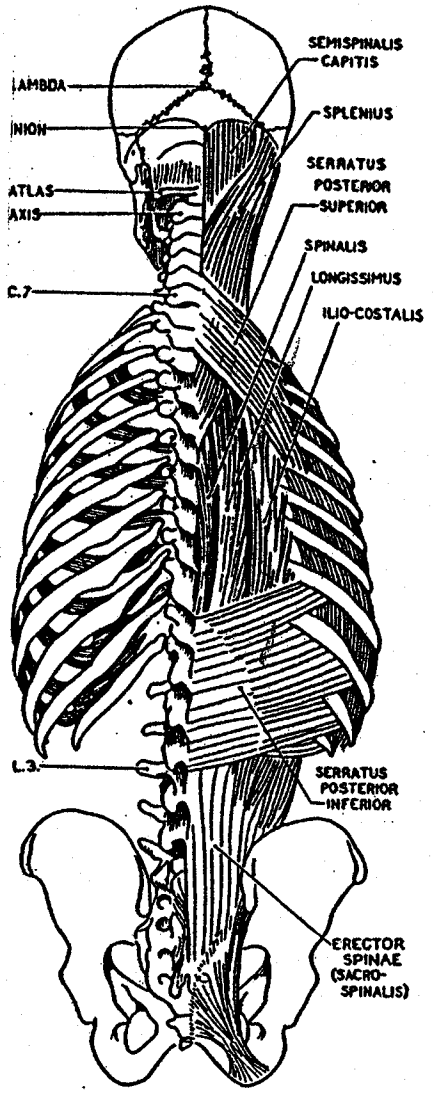


Figure 29.7. Intermediate muscles of the back.

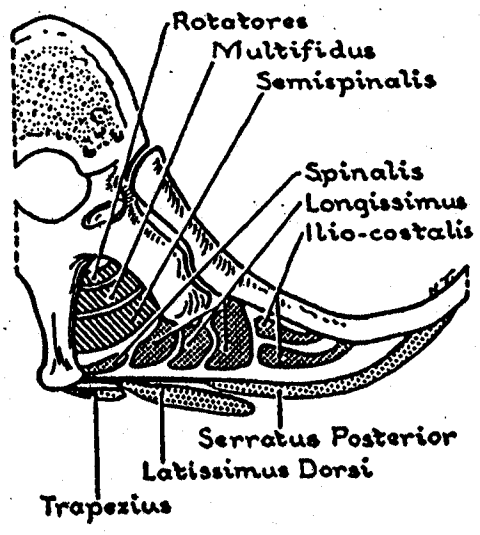
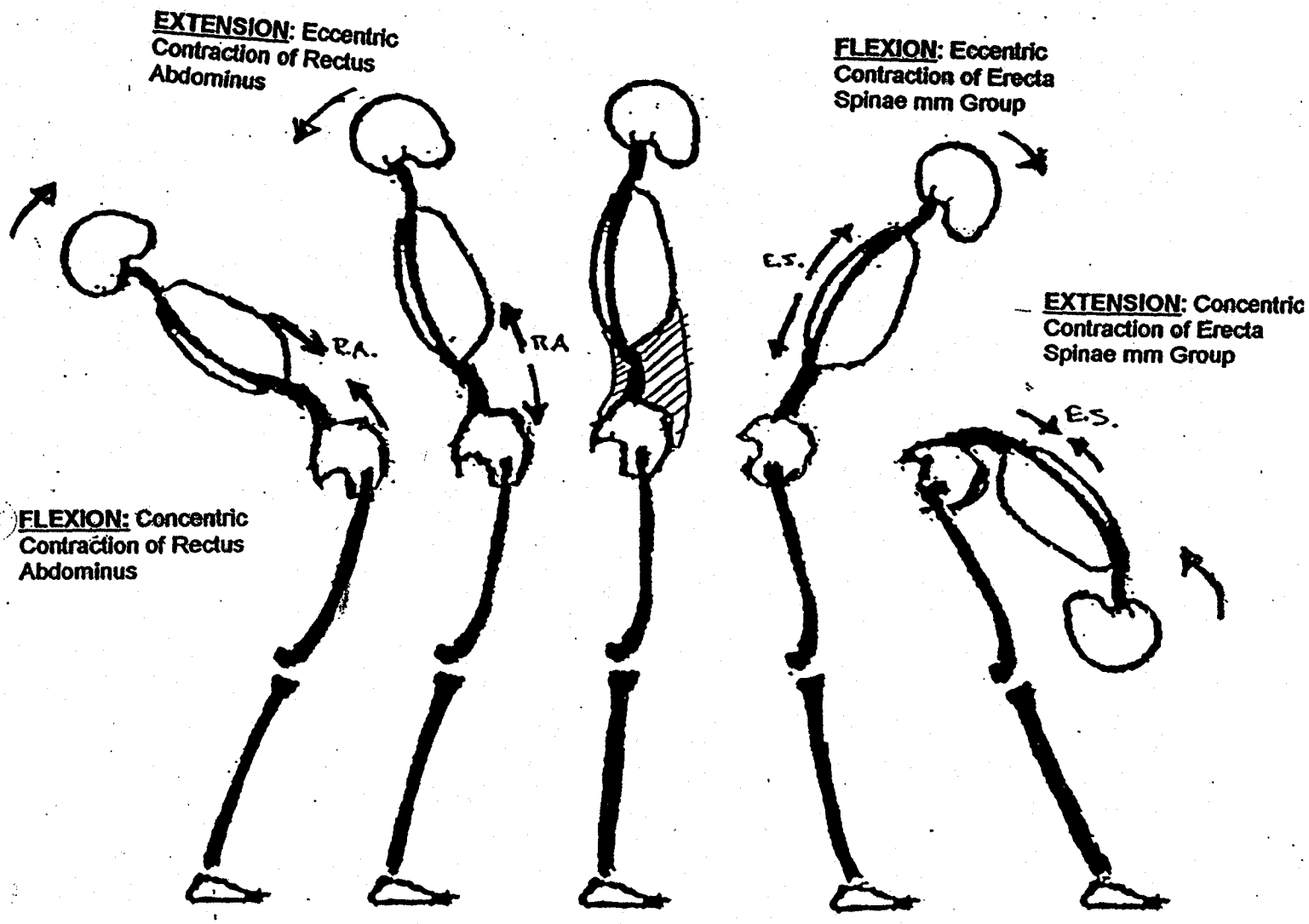


Figure 29.10. Muscles of back on cross-section.

FLEXION AND EXTENSION OF THE VERTEBRAL COLUMN

INTERACTION BETWEEN CONCENTRIC, ECCENTRIC CONTRACTION & GRAVITY



1. Flexion initiated by Rectus Abdominus and controlled by Erecta Spinae (Intrinsic mm of Back) .
   Prime Mover: After action is initiated is Gravity

2. Extension initiated by Erecta Spinae muscle group and controlled by Rectus Abdominus.
   Prime Mover: After action is initiated is Gravity

INTERVERTEBRAL DISCS

1. Comprises about 25% of the vertebral column length.

2. Under pressure continuously

3. Fibrocartilagenous composition
   A. ANNULUS FIBROSUS
      1. attached to adjacent vertebrae
      2. fibers run in cruciate bands - lamelliform
      3. supports nucleus pulposus

   B. NUCLEUS PULPOSUS
      1. remnant of embryological NOTOCORD
      2. surrounded by annulus fibrosus
      3. mucinous tissue with fiberous and mucopolysaccharide complexes
      4. has extremely high water content; accounts for the fat that a person may be as much as 2 cm. taller upon rising than at the end of the day.
      5. acts as a non-compressible, but deformable, pad
         a. essential for weight bearing
         b. allows considerable movement

4. Conforms to surfaces of apposed vertebral bodies: differences in thickness anteriorly and posteriorly cause the vertebral curvatures (thicker anteriorly in the lumbar and cervical regions).

5. Disc degeneration:
   A. associated with dehydration of the nucleus pulposus
   B. loss of water and mucopolysaccharide leads to a narrowing of intervertebral space and reduced the capacity of the disc to act as a cushion between vertebrae.

6. Disc herniation ("slipped disc")
   A. prolapse (extrusion) of the nucleus pulposus through the annulus fibrosus.
   B. herniation usually occurs between L4 and L5 or L5 and S1, but may also occur in the cervical region
   C. rarely prolapse may occur into the suprajacent or subjacent vertebral bodies (Schmorl's node).
   D. most commonly, herniation is directed posterolaterally due to the presence of the anterior longitudinal ligament and the posterior longitudinal ligament. Posterolateral prolapse will impinge on the next lowest spinal nerve. This is true <u>both</u> in the cervical and lumbar regions.
      1. in the cervical region, there are 8 cervical nerves, but 7 vertebrae; thus, herniation of the disc between C5 and C6 would impinge upon the 6th spinal nerve, which exits <u>above</u> vertebra 6.

      2. in the lumbar region, the pedicles of the vertebrae are located high on the body; thus, herniation of the disc between L4 and L5 will not harm the 4th nerve which exits superior to the disc, but the 5th as it descends across disc 4 to its intervertebral foramen, producing <u>sciatica</u>.

7. Summary: Function of the discs are to bind the vertebrae together (amphiarthroses), permit movement between adjacent vertebrae, and to distribute forces uniformly over the entire surface of the vertebra regardless of the degree of flexion/extension, rotation or lateral flexion because it operates as a fluid filled sac.