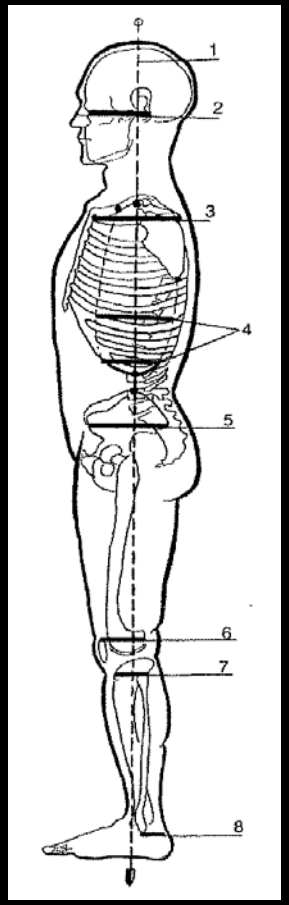
Posture analysis

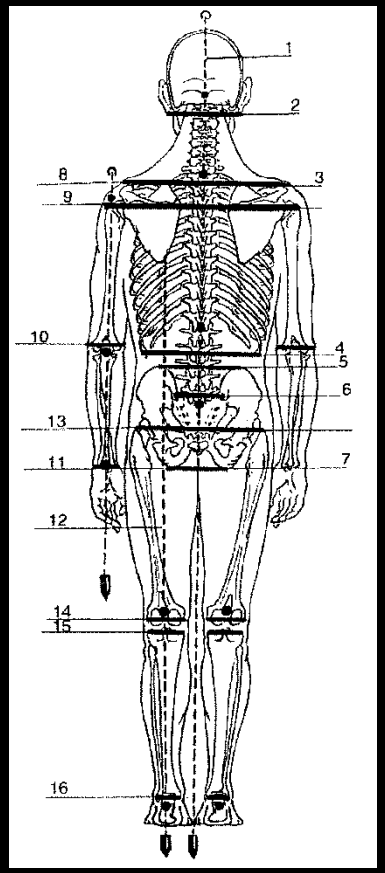
- A quick evaluation of structure and function
- Doctor views patient from behind (P-A) and from the side (lateral)
- References points of patient's anatomy relative to plumb (a position of balance)

Posture analysis

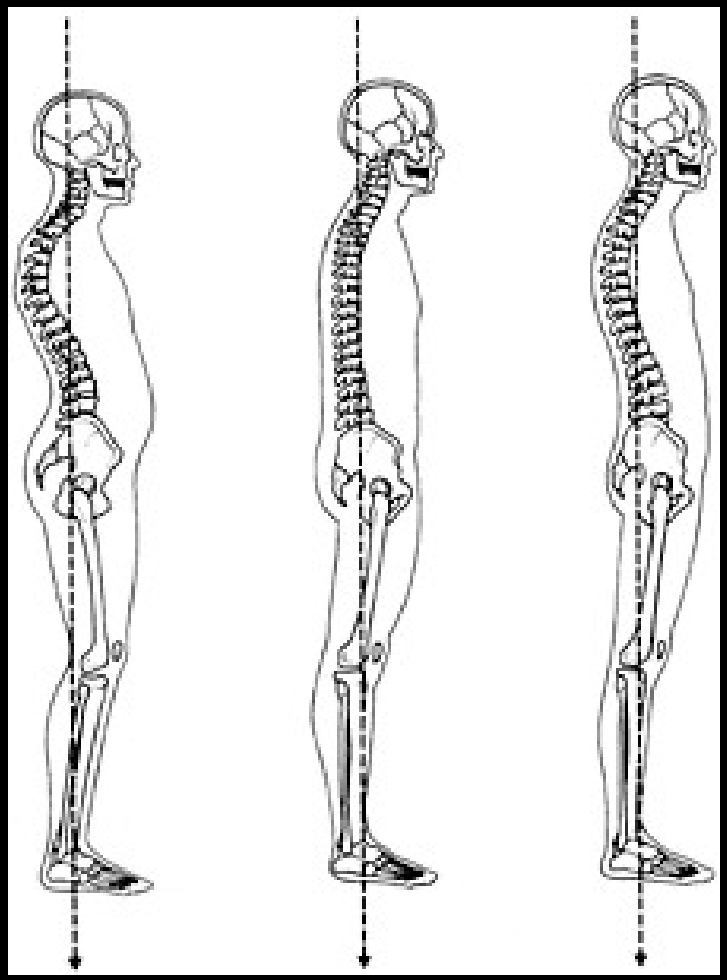


- Lateral View
  - Knees (anterior, posterior, plumb, genu recurvatum)
  - Trochanter (anterior, posterior, plumb)
  - Pelvis (anterior, posterior, neutral pelvic tilt)
  - Lumbar lordosis (hypo-, hyper-, normal)
  - Mid-axillary line (anterior, posterior, plumb)
  - Thoracic kyphosis (hyp-, hyper- normal)
  - Acromion (anterior, posterior, plumb)
  - Scapulae (protracted, retracted, normal)
  - Cervical lordosis (hypo-, hyper-, normal)
  - External auditory meatus (anterior, posterior, plumb)
  - Occiput (extended, neutral, flexed)

Posture analysis



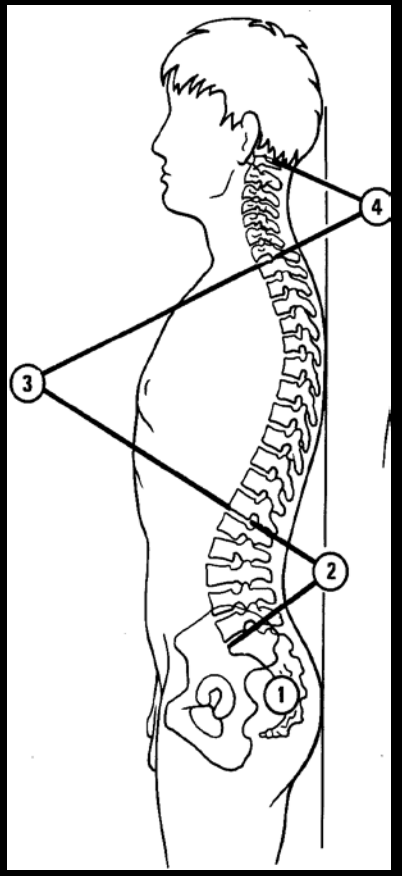
- Posterior – Anterior View
  - Feet (pronation, supination, normal)
  - Achilles tendon (bowed in/out, normal)
  - Knees (genu valga/vera, normal - internal/external rotation)
  - Popliteal crease heights (low, high, level)
  - Trochanter heights (low, high, level)
  - Iliac crest heights (low on the right/left, normal)
  - Lumbar scoliosis (right/left, or no signs of)
  - Thoracic scoliosis (right/left, or no signs of)
  - Shoulder level (low on the right/left, or normal)
  - Cervical scoliosis (right/left, or no signs of)
  - Cervical position (rotation, tilt, neutral)
  - Mastoid (low on the right/left, or normal)



…..poor postures

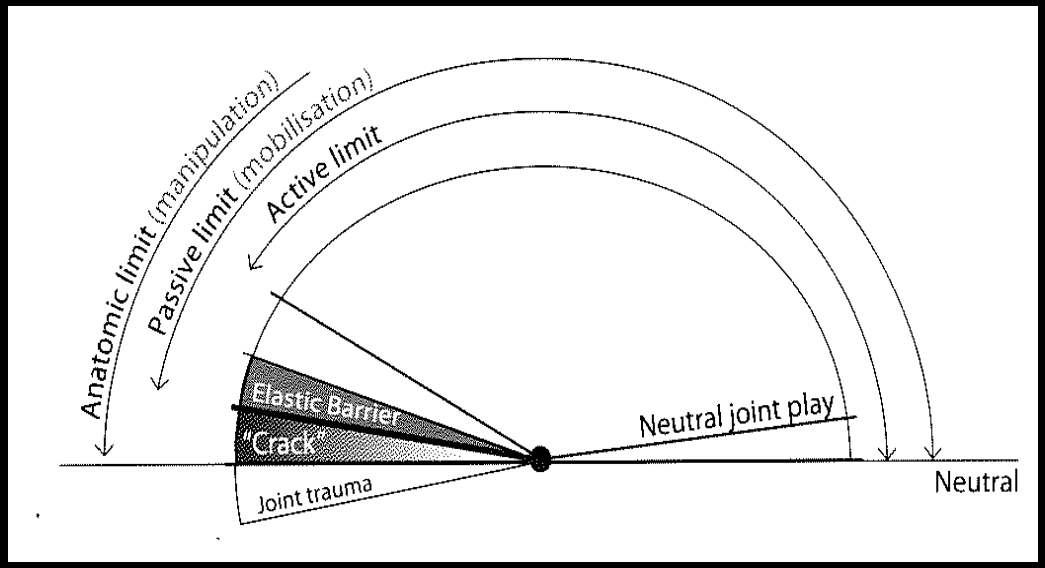
Functional Anatomy of the Spine

- The vertebral curvatures
  - Cervical Curve
    - Anterior convex curve (lordosis) develop in infancy
      - Infant begins to lift head
  - Thoracic Curve
    - Posterior convex curve (kyphosis) present at birth
  - Lumbar Curve
    - Anterior convex curve (lordosis) develops in response to weight bearing
      - Influenced by pelvis and lower extremity positioning
  - Sacrococcygeal Curve
    - Posterior convex curve formed from the fused sacral and coccygeal segments



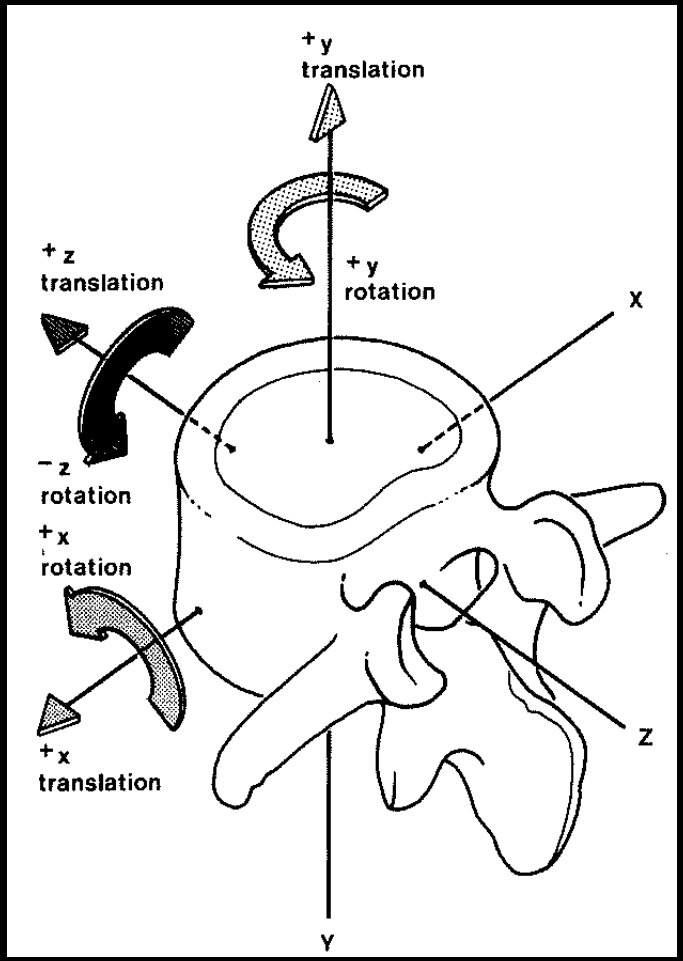
Joint Play

- The qualitative resilience of the joint capsule and peri-articular soft tissues that is found within a joint's passive range of motion between the end of preliminary tension and its elastic barrier of resistance



Basic Biomechanics

- **Planes of Movement**
  - Are defined in relation to three imaginary axis (X, Y and Z) drawn through a given structure

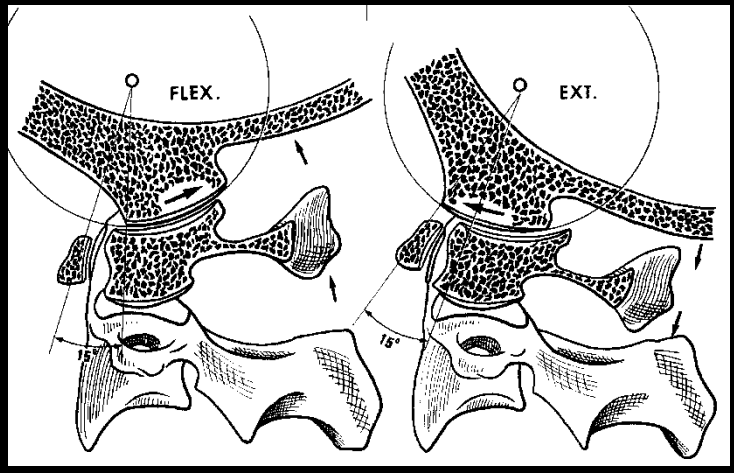


Basic Biomechanics

- **Planes of Movement**

The Cervical Spine

- Functional Anatomy of the Upper Cervical Spine
  - Atlanto-occipital joint
    - Mobile condyloid joint
      - Flexion/extension – 10-15°
      - Lateral bending – 5-8° (coupled with slight contralateral rotation* and horizontal translation)
      - Rotation - 0° (controversial)*

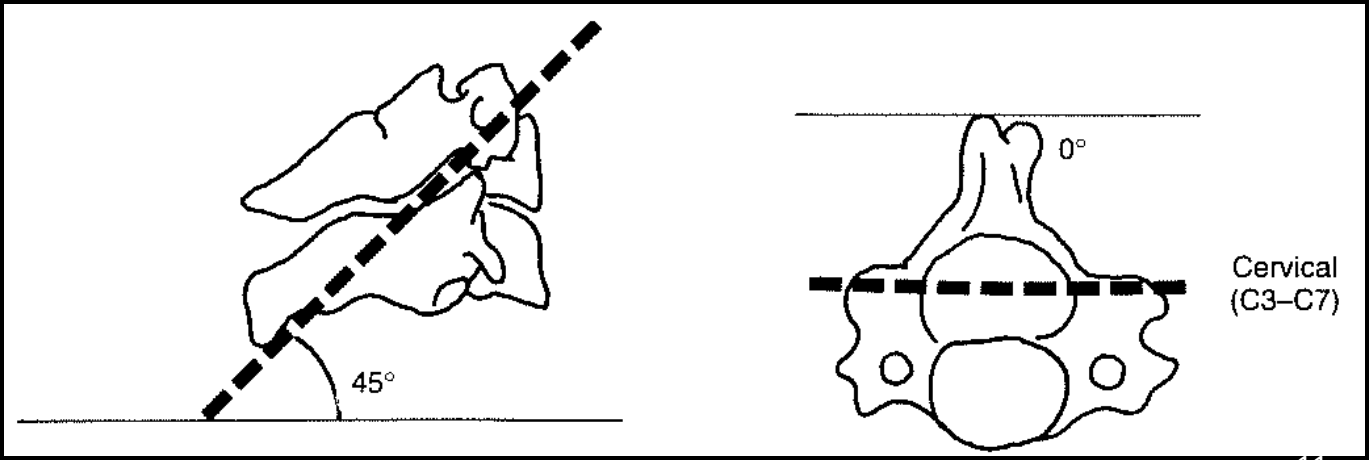


Upper cervical spine C0-C2

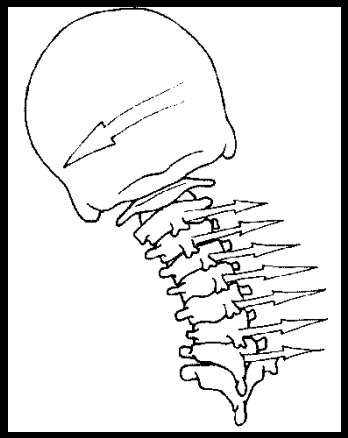
- C1/2 consists of two articulations:
  - Atlanto-odontoid
    - Trochoid artculation in the coronal plane
  - Altanto-axial
    - Arthroidial articulation oriented primarily in the transverse plane with a slight downward slant laterally
- The principle movement is that of axial rotation and secondarily that of flexion and extension
- Lateral bending at C1/2 is negligible

Lower cervical spine C3-C7

- C3-C7 are arthroidial articulations oriented approximately 45 degrees between the coronal and transverse planes
- The principle movement of the lower cervical spine is that of flexion and extension and secondarily lateral bending

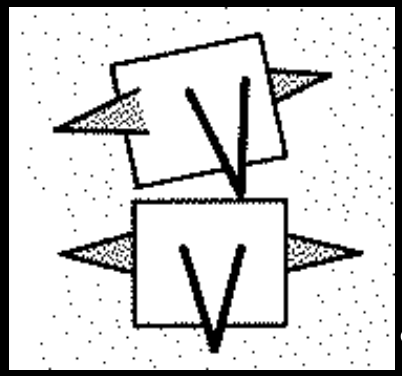


Lower cervical spine C3-C7



- Lateral bending is coupled with axial rotation
- In the lower cervical spine ipsilateral lateral bending is coupled with ipsilateral rotation
  - left lateral bending is coupled with left axial rotation (-θZ / +θY)
  - in the cervical spine, the spinous processes deviate to the side of convexity
- The amount of lateral bending and axial rotation as well as coupling progressively decreases from C2-C7

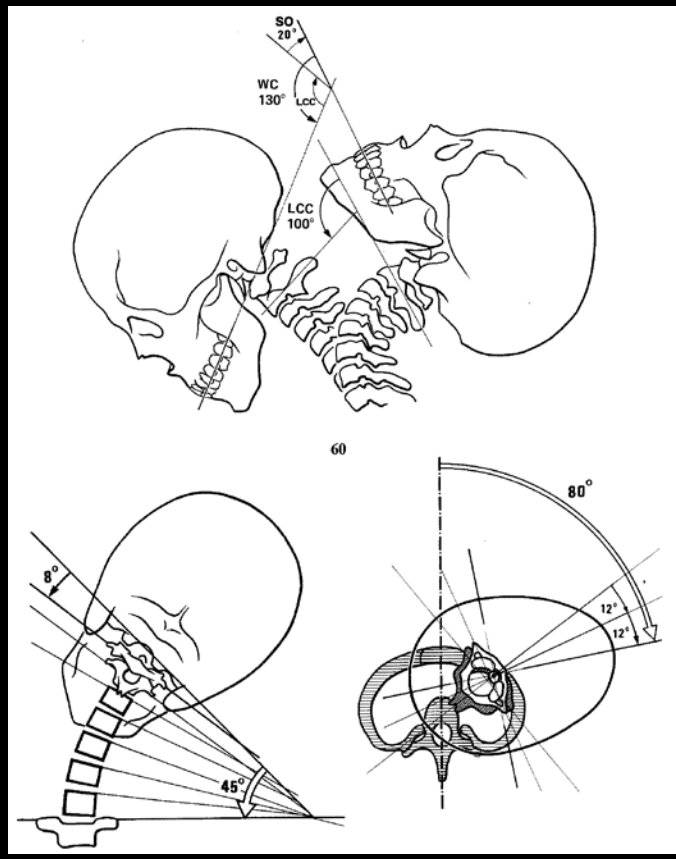
Lower cervical spine C3-C7



- During lateral bending the joints and discs on the concave side approximate as the convex side separates
  - The side that separates is known in static listings as the side of the open wedge (disc)
- In normal motion, during left lateral bending the joints on the left approximate and the right separates
  - Thus in left lateral bending the right side is considered to be the side of the open wedge

The Cervical Spine

- Functional Anatomy of the Lower Cervical Spine (C3-7)
  - Range and Pattern of Motion of the Lower Cervical Spine
    - Cervical region has greatest ROM of spine
    - Flexion - 40°
    - Extension - 24°
    - Lateral bending - 47° (to each side)
    - Rotation - 45° (to each side)

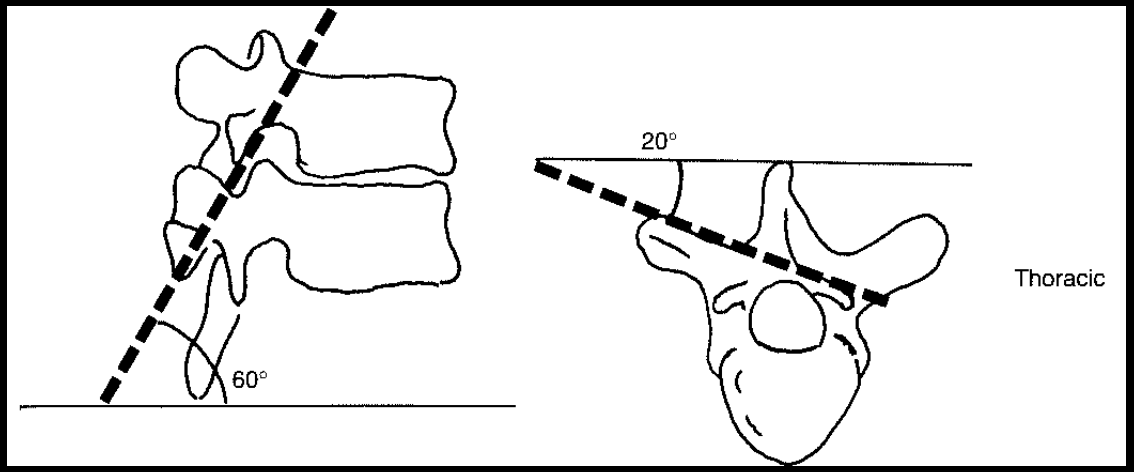


The Thoracic Spine

- **Functional Anatomy of the Thoracic Spine and Rib Cage**
  - Part of the ventilatory structures of the pleuropulmonary system
  - Primarily functions to protect the viscera
  - Least mobile part of the spine due to its articulations with the rib cage and thinness of its discs
  - Its neurological relationship with the autonomic nervous system and internal regulatory system has profound effects on their function

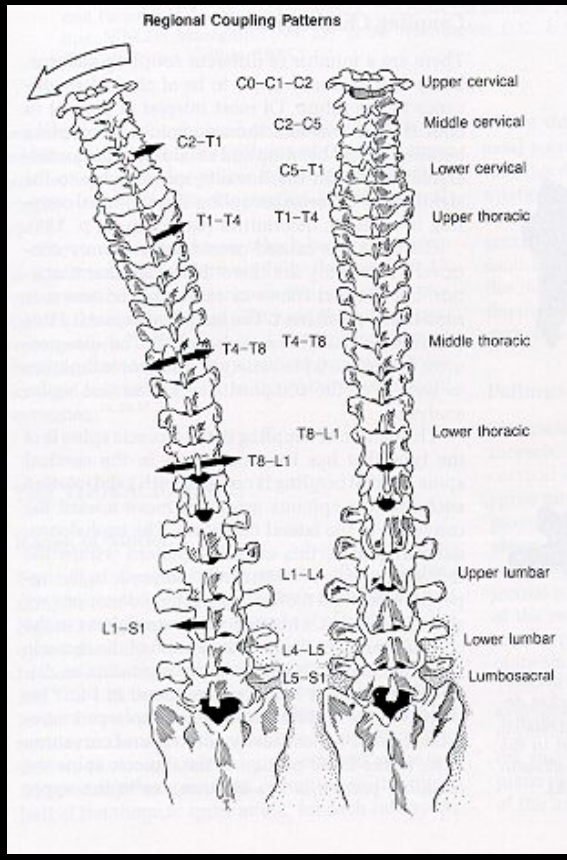
The Thoracic Spine

- The facets are angled at approximately 60° to the transverse and 20° to the coronal planes
- The principle movement is lateral bending
- Rotation is greatest in the upper thoracic spine and progressively decreases inferiorly
- Flexion and extension is least in the upper thoracic spine and progressively increases inferiorly



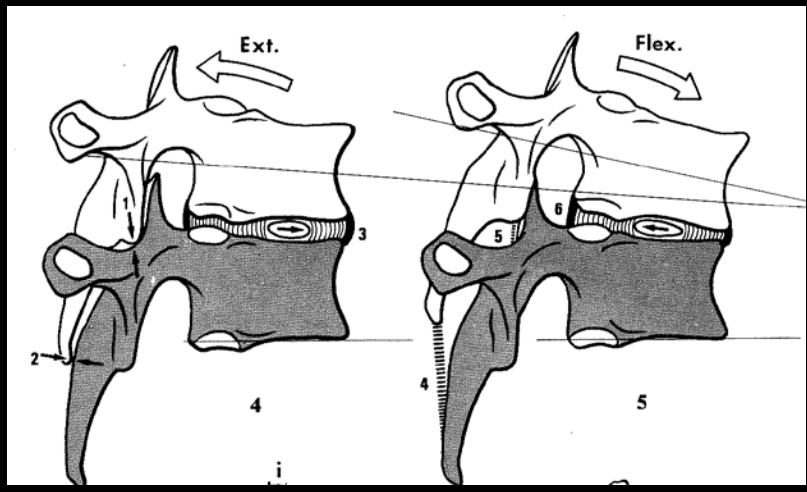
The Thoracic Spine

- Movements of the Spine
  - Lateral Bending
    - Is coupled with axial rotation of the vertebral bodies
      - Cervical and upper thoracic spine: Lateral bending is coupled with ipsilateral rotation (spinous process deviate towards the convexity)
      - Lumbar and lower thoracic spine: lateral bending is coupled with contralateral rotation (spinous process deviate towards the concavity)
      - Mid-thoracic spine: Is controversial



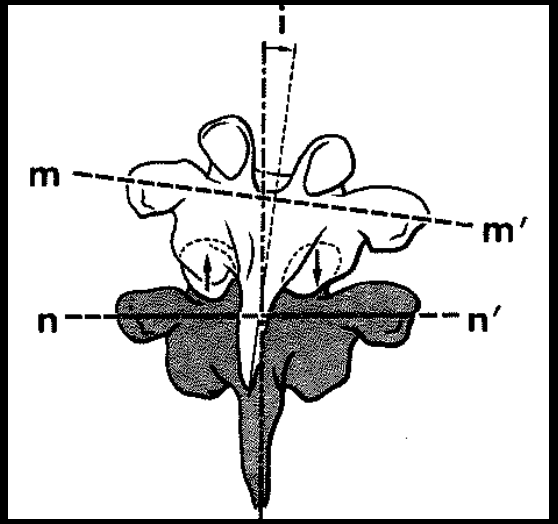
The Thoracic Spine

- Range and Patterns of Motion
  - Flexion and extension
    - Average per segment is 6°
      - Progressively more increases from upper region to lower region (upper avg 4° - middle avg 6° - lower avg 12°)
    - Extension limited due to impaction of articular and spinous processes
    - Movement involves coupled +/-θX and +/-Z



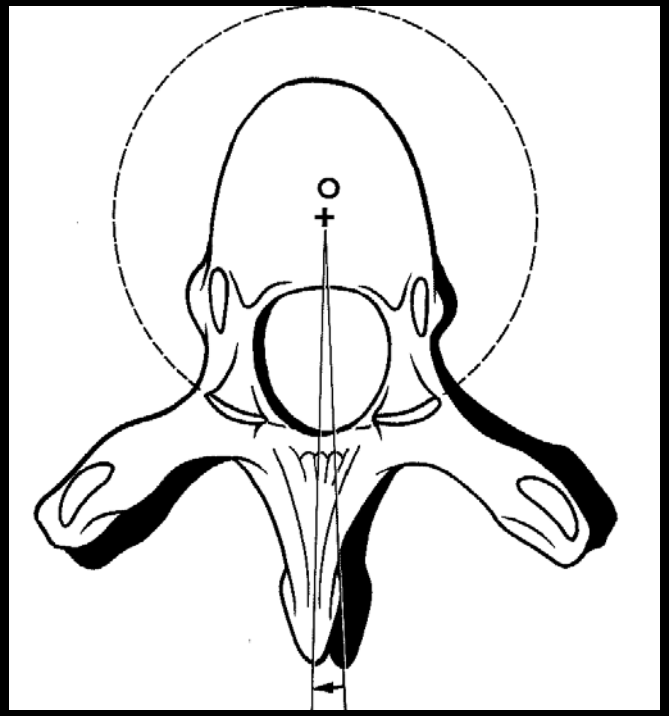
The Thoracic Spine

- Range and Patterns of Motion
  - Lateral Flexion
    - Avg 6° to each side
      - T11-12 avg 7-9 °
    - Lateral bending is coupled with axial rotation
      - Upper thoracic
        - » Lateral bending coupled with ipsilateral rotation
      - Middle thoracic controversial
      - Lower thoracic
        - » Lateral bending is coupled with contralateral rotation



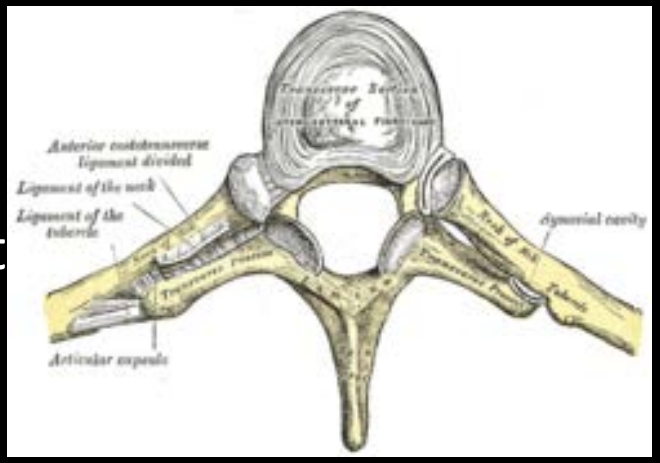
The Thoracic Spine

- Range and Patterns of Motion
  - Rotation
    - Axial rotation avg 8-9° in upper thoracic
      - Progressively decreases inferiorly
    - Axis of rotation is in posterocentral body and corresponds with convexity of facets
    - Coupled with lateral bending
      - As discussed previously



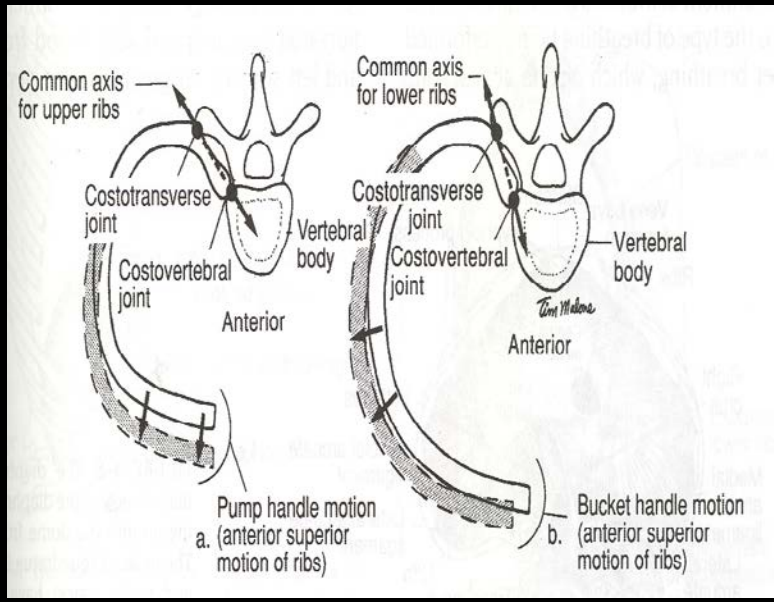
The Ribs

- Functional Anatomy and Biomechanics of the Rib Cage
  - Costo-transverse and –vertebral joint
    - Subject to joint dysfunction
    - To be considered in the normal activity of the thoracic functional unit on examination



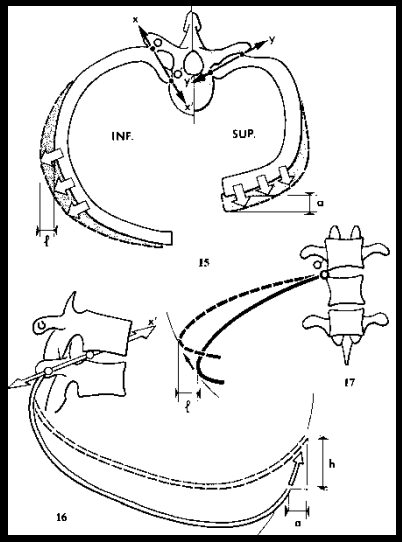
The Ribs

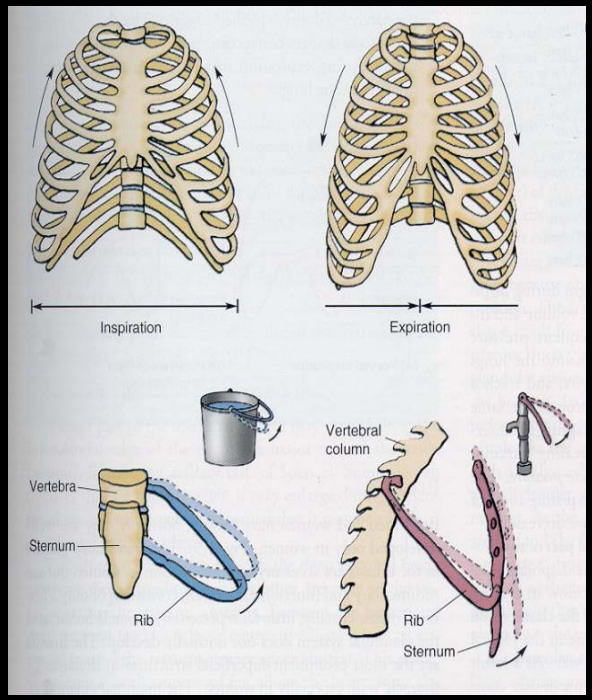
- Functional Anatomy and Biomechanics of the Rib Cage
  - Costo-transverse and –vertebral joints
    - Form a joint couple
      - Axis passes through center of each joint
      - Axis forms a swivel for the rib



The Ribs

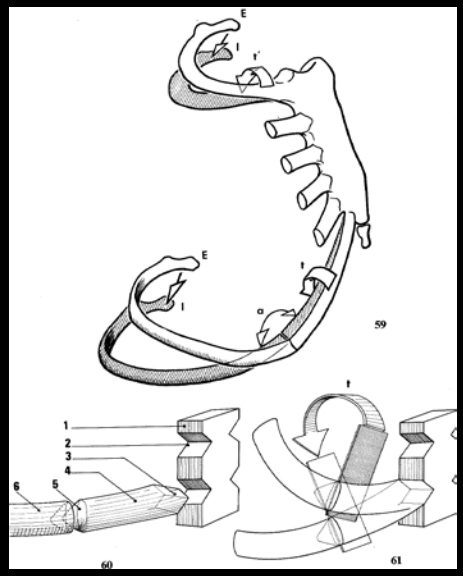
- Functional Anatomy and Biomechanics of the Rib Cage
  - Costo-transverse and –vertebral joints
    - Upper ribs
      - Axis lies closer to the frontal plane
      - During inspiration causes increase in A-P diameter (“pump handle motion”)
    - Lower ribs
      - Axis lies closer to the sagittal plane
      - During inspiration causes an increase in the transverse diameter of rib cage (“bucket handle motion”)

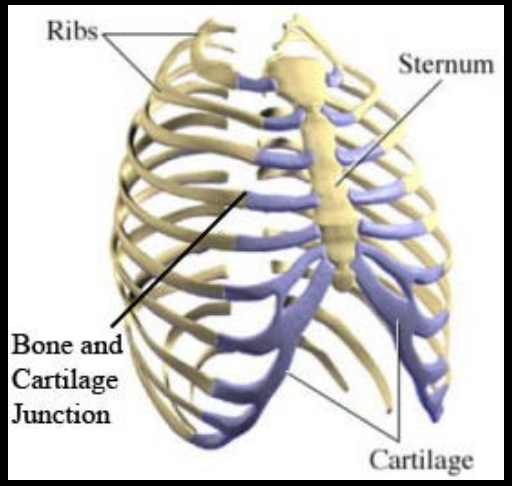




The Ribs

- Functional Anatomy and Biomechanics of the Rib Cage
  - Costochondral joint
    - Synarthrodial
    - Acts as a torsion bar during respiration
      - Torsion that occurs with inspiration responsible for return of thorax back to original position during expiration
      - Flexible in youth and ossify with age affecting respiratory efficiency



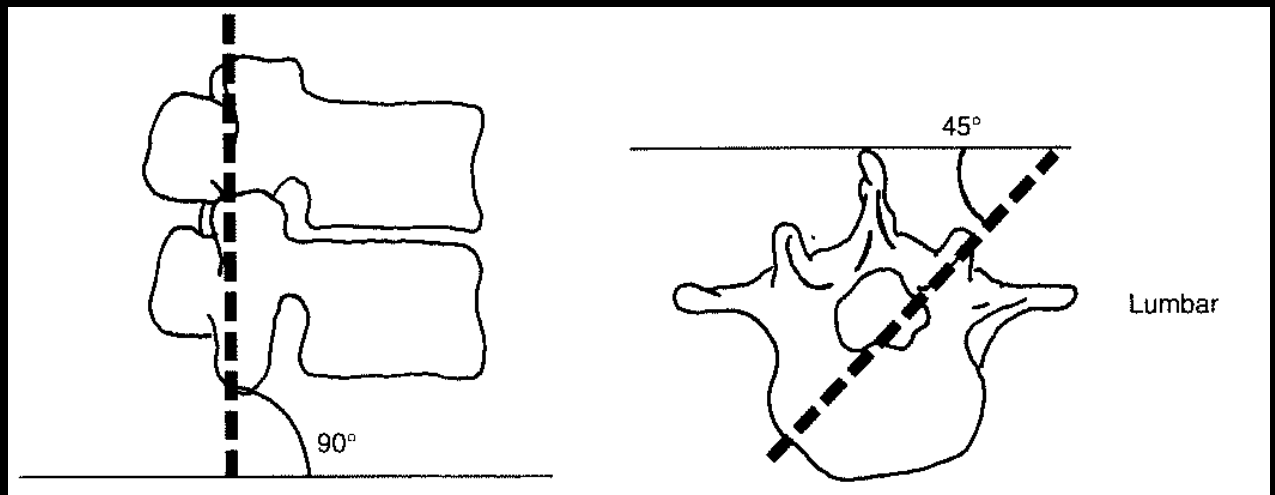


The Lumbar Spine

- **Functional Anatomy of the Lumbar Spine**
  - **The lumbar spine is responsible for the majority of the movement of the trunk**
  - **The articulations of the lumbar vertebrae consist of arthrodia (gliding) joints**
  - **The facets are oriented primarily in the sagittal plane becoming more coronal at the lumbosacral junction**
  - **The principle movement of the lumbar spine is flexion and extension**
    - **accounts for more than 75% of the total movement of the trunk**
    - **the orientation of the facets limits the amount of lateral bending (approximately 6° per segment unilaterally) and rotation (approximately 2° per segment unilaterally)**

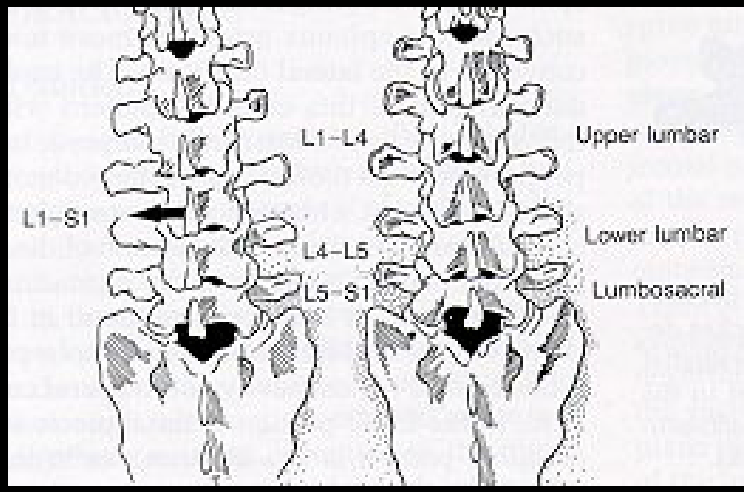
The Lumbar Spine

- Posterior elements
  - Intervertebral joints (zygapophyseal)
    - Lumbar facets are oriented at 90° to the transverse plane and 45° to the frontal plane
      - Movements include flexion, extension, lateral bending but little rotation
      - The lumbosacral joints differ in that their oblique orientation allow considerable rotation



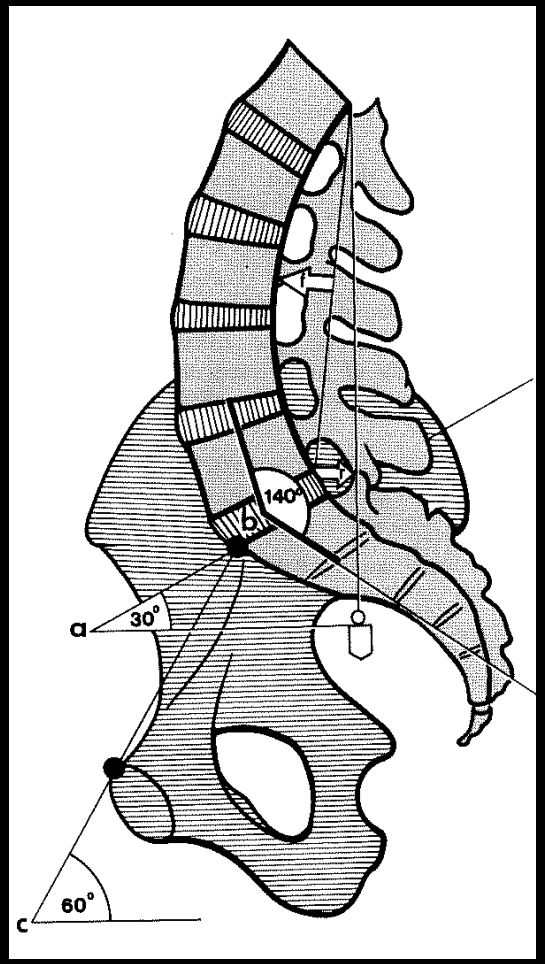
The Lumbar Vertebral Column

- Movements of the lumbar spine
  - Lateral bending
    - Lateral flexion is coupled with contralateral body rotation (spinous process deviate to side of concavity) (+/-θY and -/+θZ)
    - Segmental Lateral bending averages 6° per segment
      - Lumbosacral lateral bending is 50% less



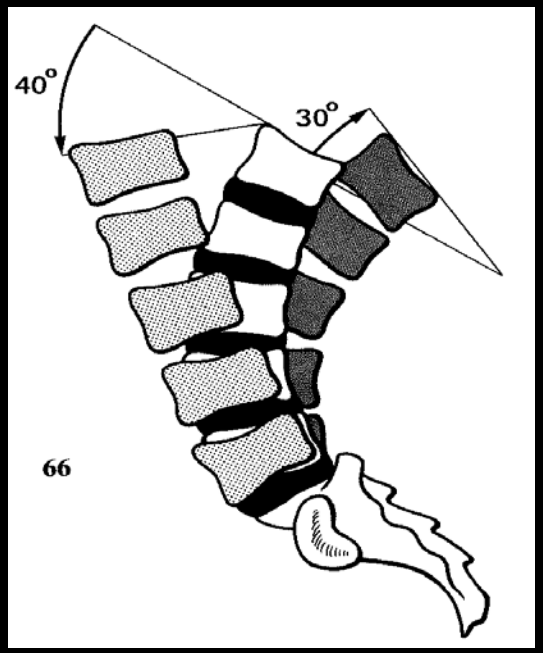
The Lumbar Spine

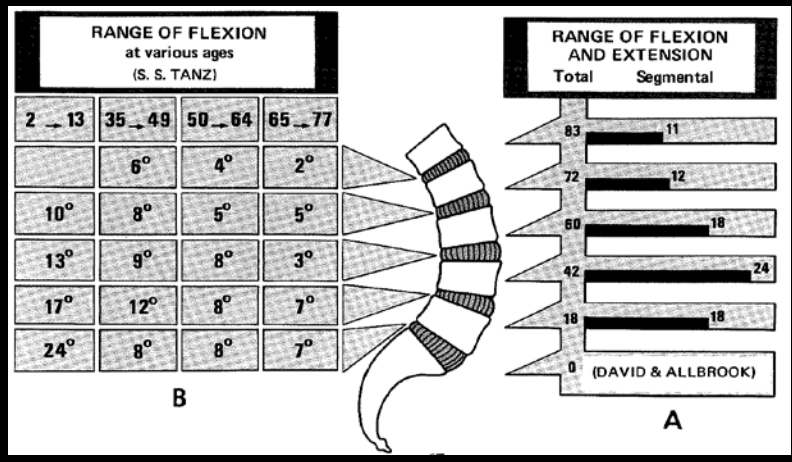
- Lateral View
  - Angle of the sacrum ~30°
  - Lumbosacral angle ~140°
  - Angle of pelvic tilt ~60°
  - Index of lumbar lordosis (max at L3)
    - ≥ = increase lordosis
    - ≤ = decrease lordosis



The Lumbar Spine

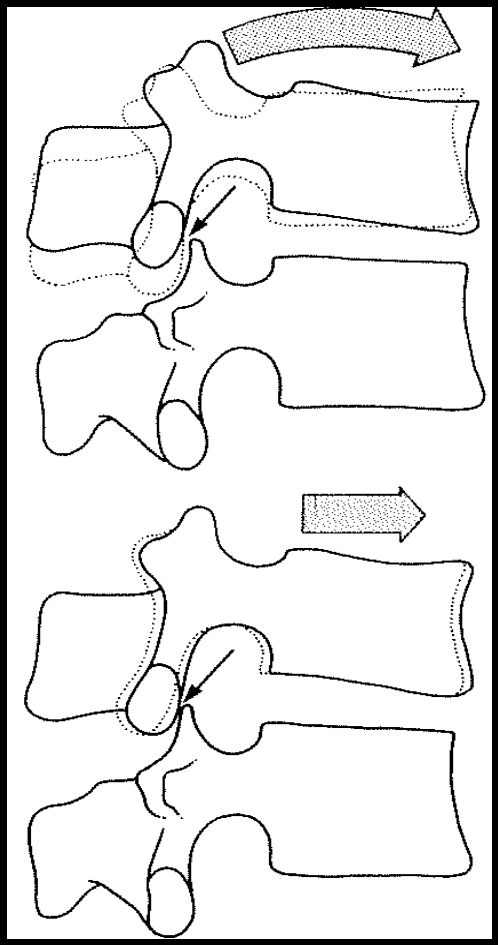
- Movements of the lumbar spine
  - Flexion - ~40°
    - Primarily due to the flattening of the lumbar lordosis
    - Motion is due to anterior sagittal rotation and forward translation (+θX / +Z)
      - Panjabi has proposed 4.5 mm of segmental translation considered the upper limit for radiographic evidence of clinical joint instability
    - Segmentally increases inferiorly





The Lumbar Spine

- Movements of the lumbar spine
  - Flexion
    - Zygapophyseal joints play a significant role in stabilizing the lumbar spine in flexion
      - Anterior translation is resisted by bony impaction
      - Flexion is resisted by the tension of the joint capsule (39%) and posterior ligaments of the vertebrae (anulus (29%), ligamentum flavum (13%), inter and supraspinous (19%)
        - » The posterior ligaments role is to protect the disc

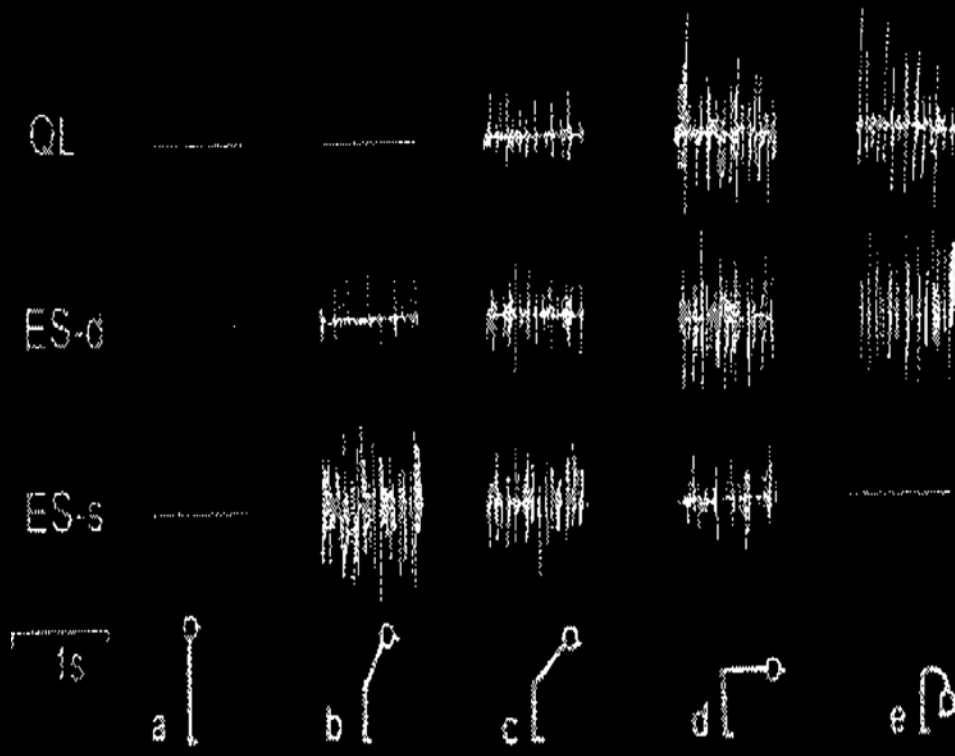


The Lumbar Vertebral Column

- Lumbar muscles and their fascia
  - Functions
    - Major active movements
      - Activity continues until the “critical point” is achieved
        - » Point where muscular activity ceases and the vertebral column is braced by zygapophyseal joint locking and tension within the posterior elements
        - » Marks the transition of spinal load-bearing from muscles to the ligamentous system

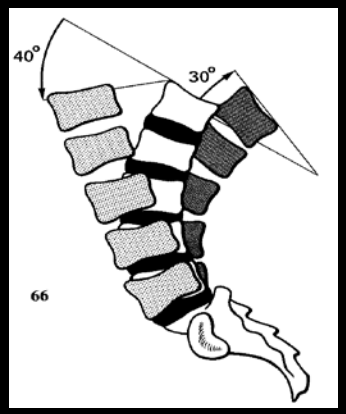
Functional Anatomy of the Trunk

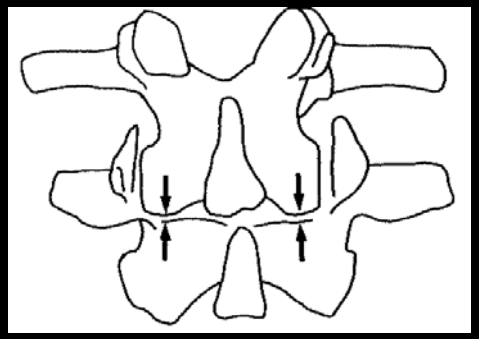
- Flexion-relaxation phenomena
  - At full flexion the electrical activity of the erector spinae ceases (flexion-relaxation phenomena) – deep paraspinals and QL's become electrically active

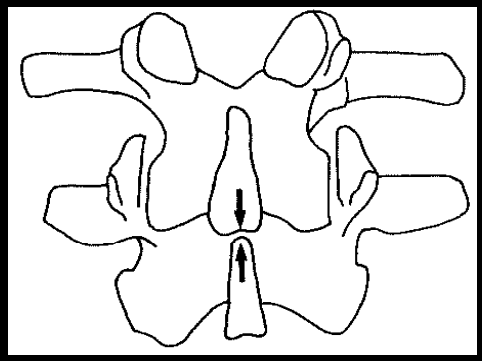


The Lumbar Spine

- Movements of the lumbar spine
  - Extension - ~30°
    - Movement involves posterior sagittal rotation and translation (-θX/-Z)
    - Motion is limited by
      - bony impaction of the spinous processes and inferior articular processes
      - resistance of the anterior anulus, anterior longitudinal ligament (ALL) and anterior joint capsule

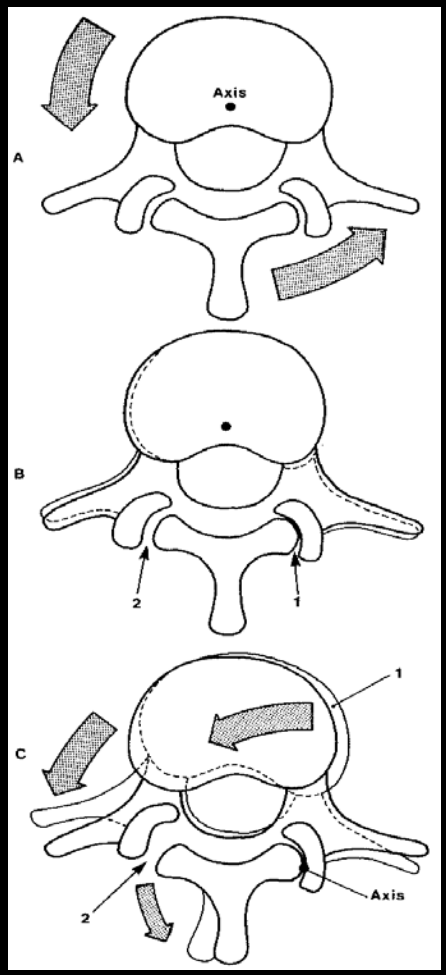






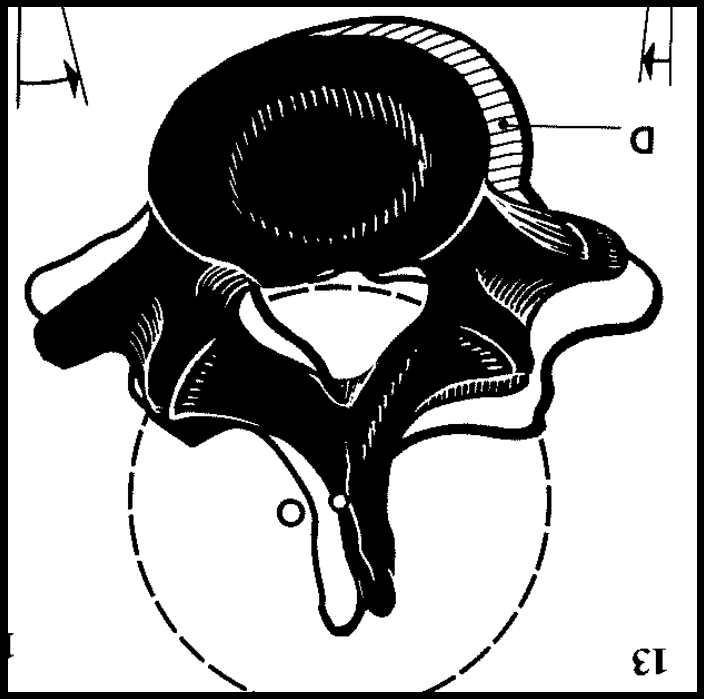
The Lumbar Spine

- Movements of the lumbar spine
  - Axial rotation – 10-15° (1-2° per segment)
    - Involves torsion of the intervertebral disc and impaction of the zygapophyseal joints
    - Movement is resisted by
      - All of the fibers of the anulus that are inclined toward the direction of rotation
      - The posterior ligaments (ipsilateral joint capsule, inter- and supraspinous ligaments
      - Bony impaction of the contralateral zygapophyseal joint (new IAR)



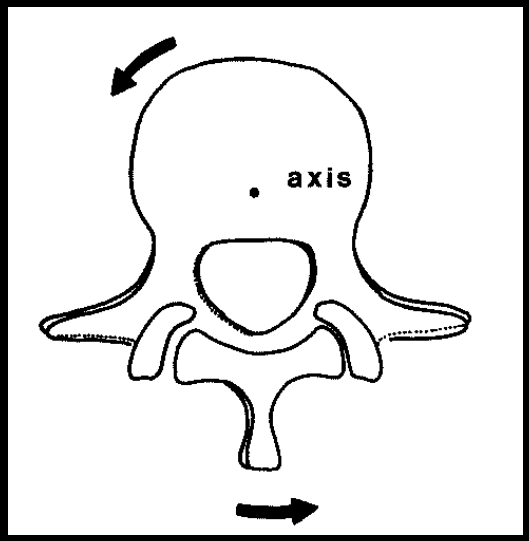
The Lumbar Vertebral Column

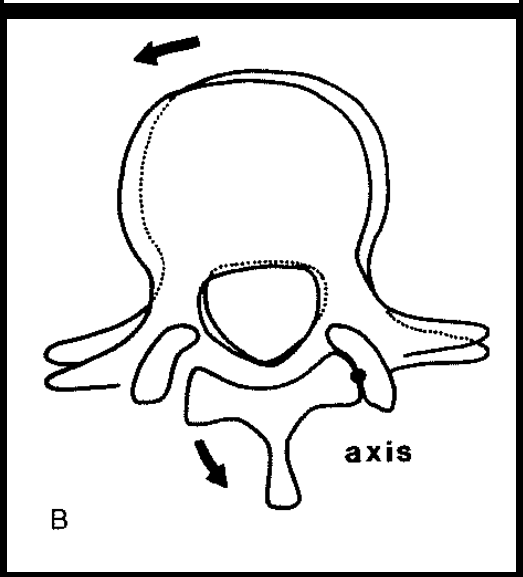
- Movements of the lumbar spine
  - Axial rotation
    - Maximal rotation per segment without annular injury is ~3°
    - Onset of torsional injury to the disc occurs at ~4° and macro-failure occurs at ~12° of rotation



The Lumbar Spine

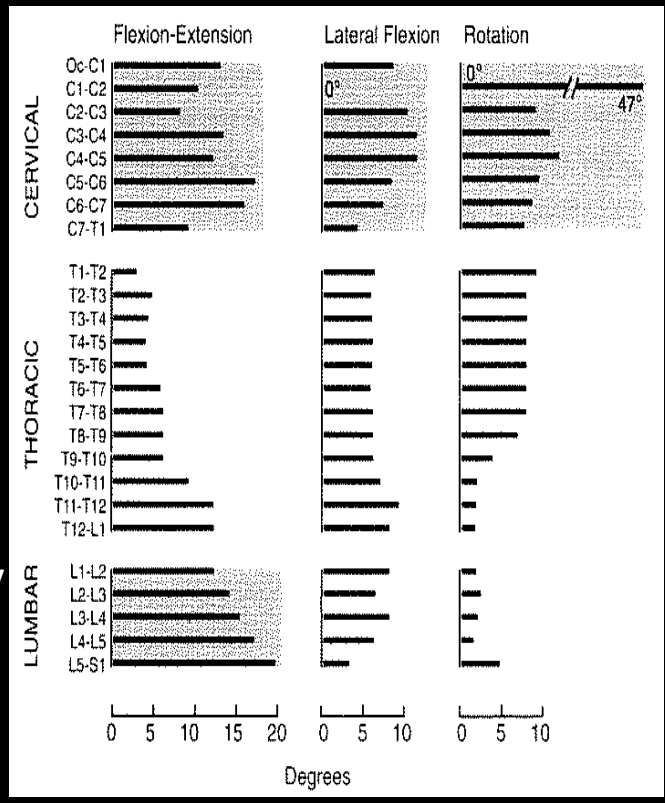
- Movements of the lumbar spine
  - Axial rotation
    - The axis of rotation in a lumbar vertebrae passes through the posterior central aspect of the body
    - As the vertebrae rotate:
      - The contralateral zygapophyseal joint impacts and compresses
        - » axis of rotation shifts to the impacting joint
        - » axial rotational forces converted to lateral shear forces on the disc
        - » Increased tensional forces on the ipsilateral joint capsule





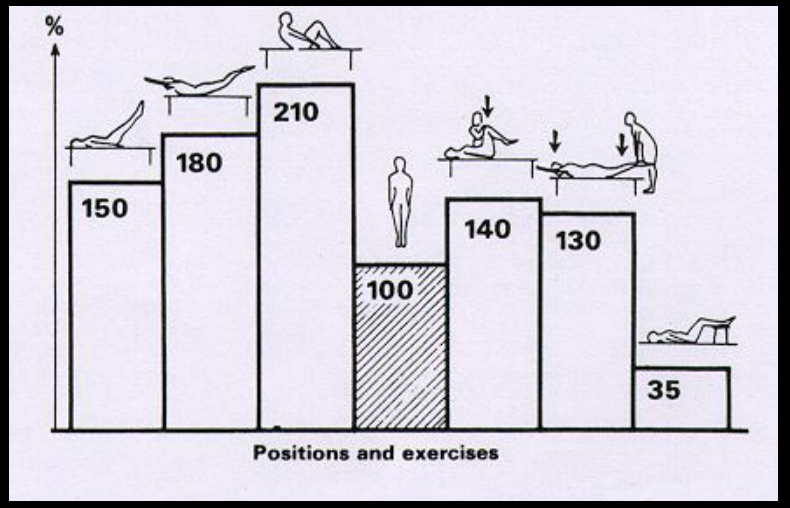
Functional Anatomy of the Trunk

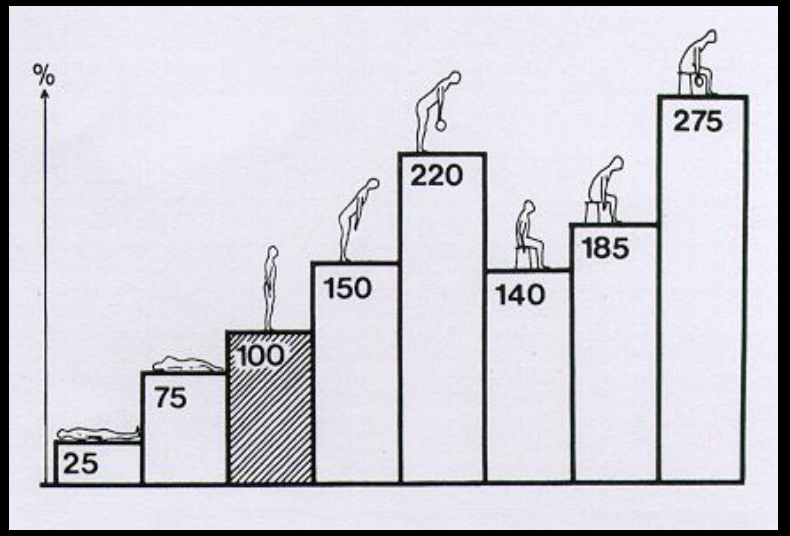
- Segmental Motion of the Spine
  - Range of Motion
    - Flexion/Extension – Greatest at L5-S1, followed by C5-7 and OC-C1
      - Most limited from T1-6, progressively increasing inferiorly
    - Lateral Flexion – Greatest range is C2-5, T11-L1 and L3/4
      - Most limited at C1-2 and C7-T1
    - Rotation – Greatest at C1/2
      - Progressively decreases inferiorly – very limited between T10-L5 and least at OC-C1



Functional Anatomy of the Trunk

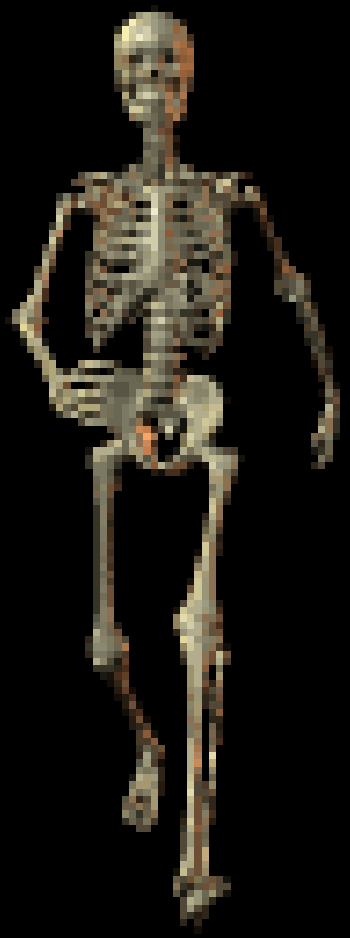
- Anterior elements
  - Intervertebral disc
    - The loads on the disc are created by activities such as sitting, coughing, and laughing which are greater than those of standing, walking or twisting
    - During normal weight bearing (ADL) the water content of the disc is reduced (creep) decreasing disc height by 20%





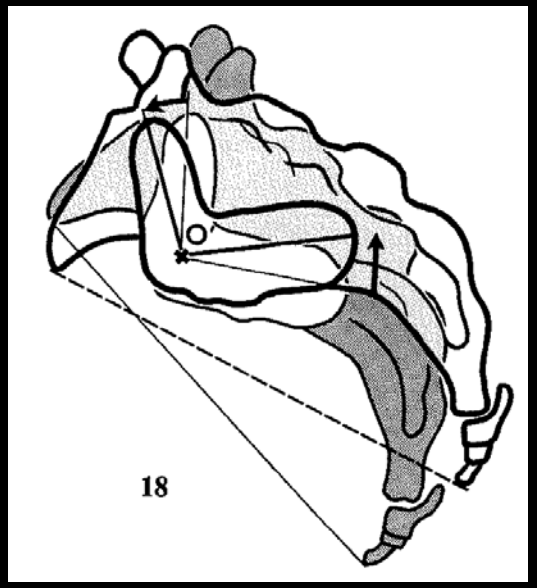
The Bony Pelvis and SI Joints

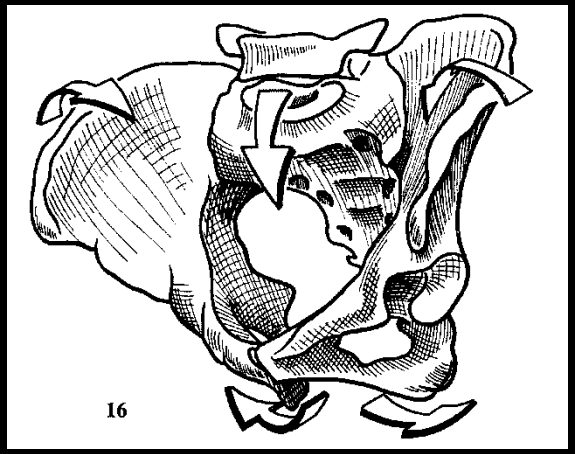
- Structure of the bony pelvis
  - Serves two functions
    - Transmits forces of the vertebral column to the lower limbs (and visa-versa)
    - Positioned strategically to relieve the torsional stress of the lower limbs during movement



The Bony Pelvis and SI Joints

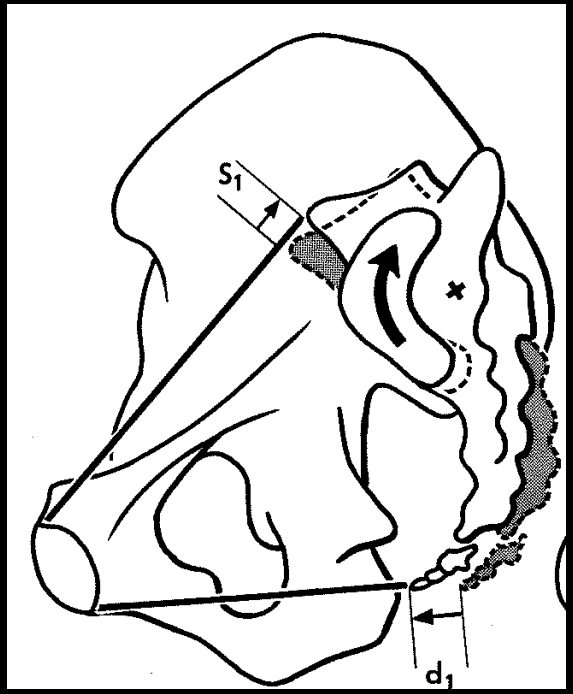
- Nutation and Counter-Nutation
  - Nutation
    - The sacrum rotates about the +θX axis
      - The A-P diameter of the pelvic brim decreases
      - The A-P diameter of the pelvic outlet increases
      - The ilia approximate
      - The ischium separate
      - Movement is limited by the sacrospinous and sacrotuberous ligaments





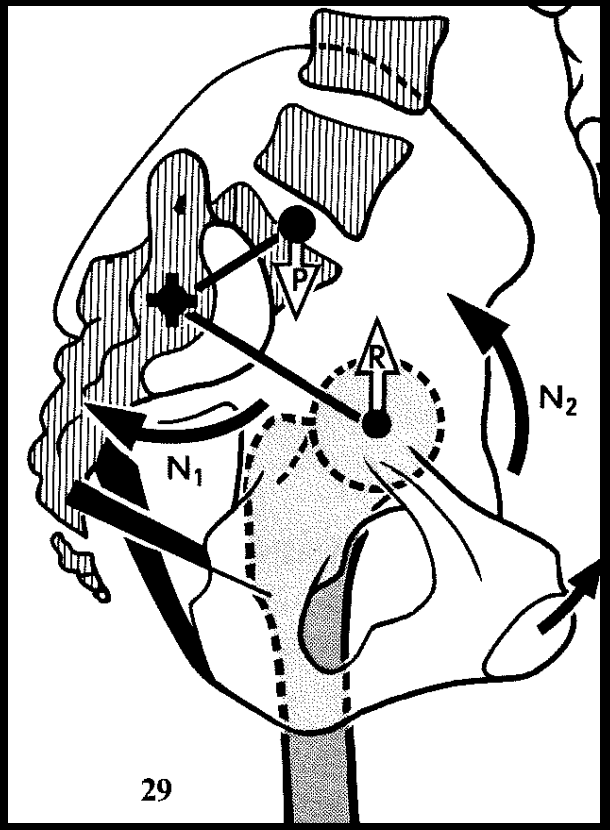
The Bony Pelvis and SI Joints

- Nutation and Counter-Nutation
  - Counter-Nutation
    - The sacrum rotates about the -θX axis
      - The A-P diameter of the pelvic brim increases
      - The A-P diameter of the pelvic outlet decreases
      - The ilia separate
      - The ischium approximate
      - Movement is limited by the sacro-iliac ligaments



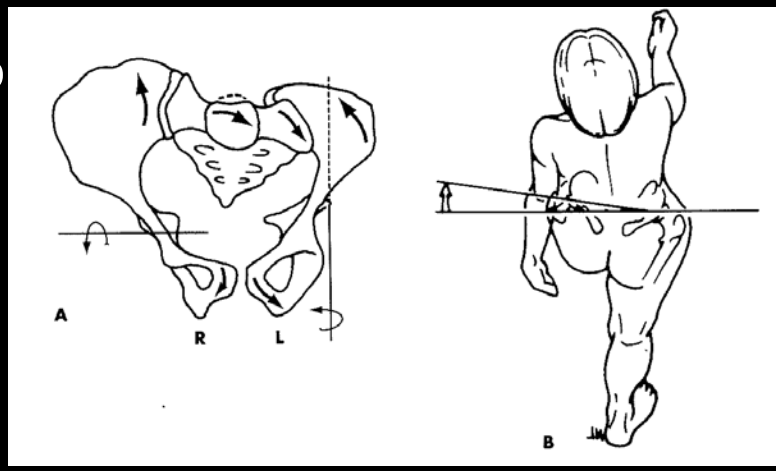
The Bony Pelvis and SI Joints

- Effect of Posture on the Pelvic Joints
  - Standing
    - Weight of the trunk on the sacrum induces sacral nutation
      - Limited by the anterior sacro-iliac ligaments, the bony locking mechanism of the SI joint and the sacrospinous and sacrotuberous ligaments
    - Rotatory couple of the reaction to the ground causes the ilia to rotate posteriorly
      - Accentuates nutation of the SI joints



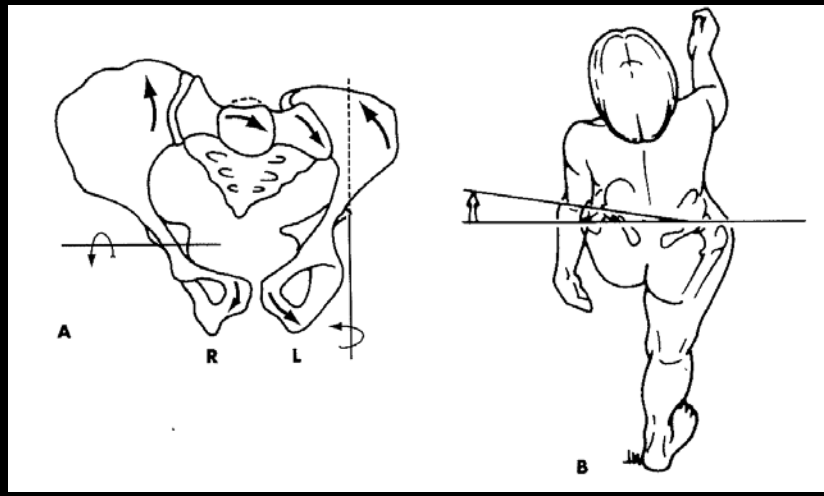
The Bony Pelvis and SI Joints

- Movements of the Pelvis
  - Compensatory movements at the sacrum and lumbosacral junction absorb pelvic torsion induced by opposing motions of flexion and extension
    - As one innominate flexes (rotates posterior and inferior)
      - The sacral base moves anterior and inferior
      - L5 moves posterior and inferior while the rest of the lumbar spine undergoes type I coupling
    - The other innominate extends (rotates anterior and superior)
      - The sacral base moves posterior and superior



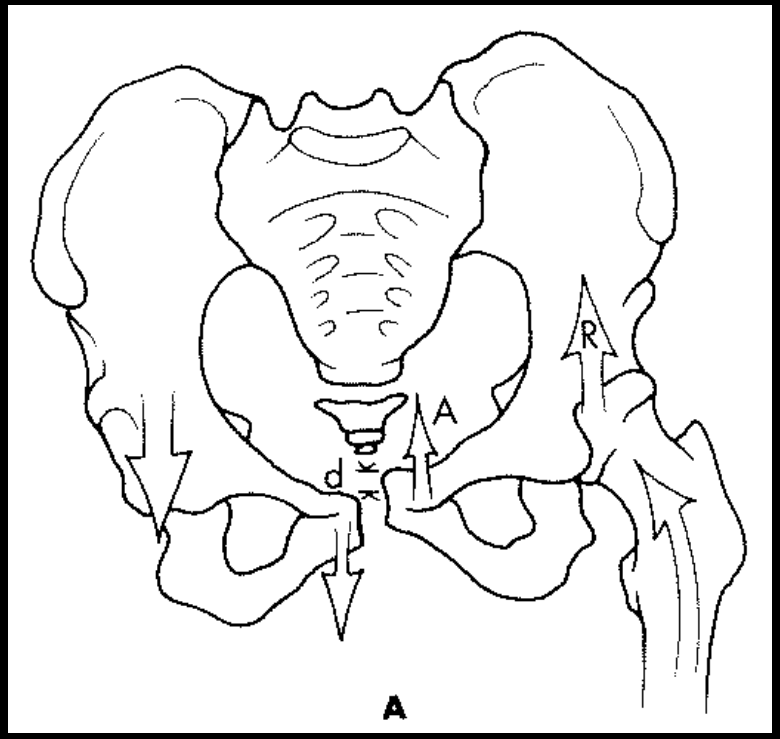
The Bony Pelvis and SI Joints

- Movements of the Pelvis
  - SI Flexion
    - Posterior inferior rotation of the Innominate (PSIS reference)
    - Anterior inferior rotation of the ipsilateral sacrum (Sacral base reference)
  - SI Extension
    - Anterior superior rotation of the Innominate
    - Posterior superior rotation of the ipsilateral sacrum

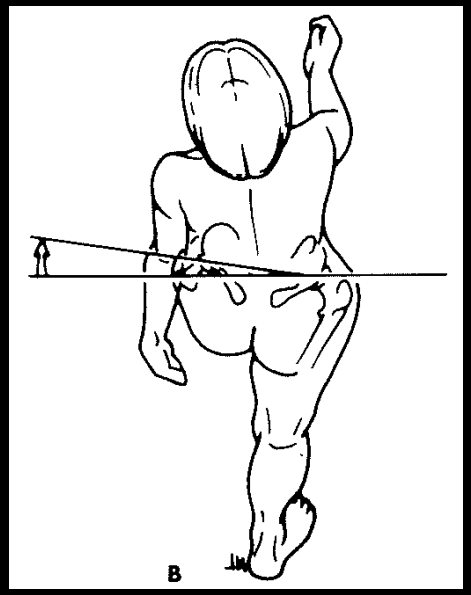


The Bony Pelvis and SI Joints

- Movements of the Pelvis
  - Pubic Symphysis
    - With flexion and extension of the SI joints
      - Pubic symphysis rotates about the transverse axis
      - Small superior and inferior translation occur as well – large amounts indicate an unstable pelvic complex



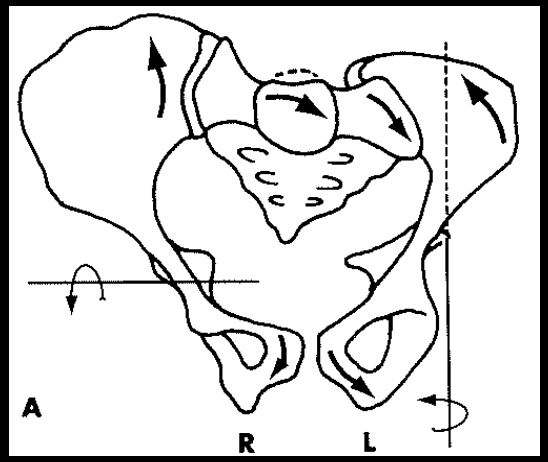
The Bony Pelvis and SI Joints



- It is accepted by most that the primary motions of the SI joint are that of flexion and extension occurring along an oblique saggittal plane

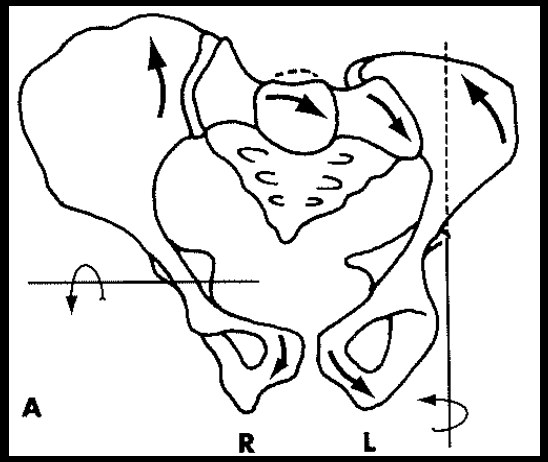
- During gait each sacroiliac joint move opposite to the other and as such the movements of the joints can be envisioned as a horizontal figure-eight motion about this plane

The Bony Pelvis and SI Joints



- During sacroiliac flexion (using the PSIS and sacral base as reference) the ilium rotates posterior and inferiorly (PI) while the sacrum rotates anterior and inferiorly (AI)

The Bony Pelvis and SI Joints



- During sacroiliac extension the ilium rotates anterior and superiorly (AS) while the sacrum rotates posterior and superiorly (PS)
- During gait these opposing motions occur simultaneously within each sacroiliac joint and thus accounts for the elliptical horizontal figure-eight motion described above

The Bony Pelvis and SI Joints

- When the sacroiliac joints move in unison:
  - During flexion both ilia rotate posterior and inferior (PI) as the entire sacral base moves relatively anterior and inferior (AI)
  - In extension both ilia rotate anterior and superior (AS) while there is relative posterior and superior (PS) motion of the sacrum

The Bony Pelvis and SI Joints

- This movement of the sacroiliac complex along the saggital plane is called nutation (when the entire sacral base moves anterior and inferior relative to the ilia)

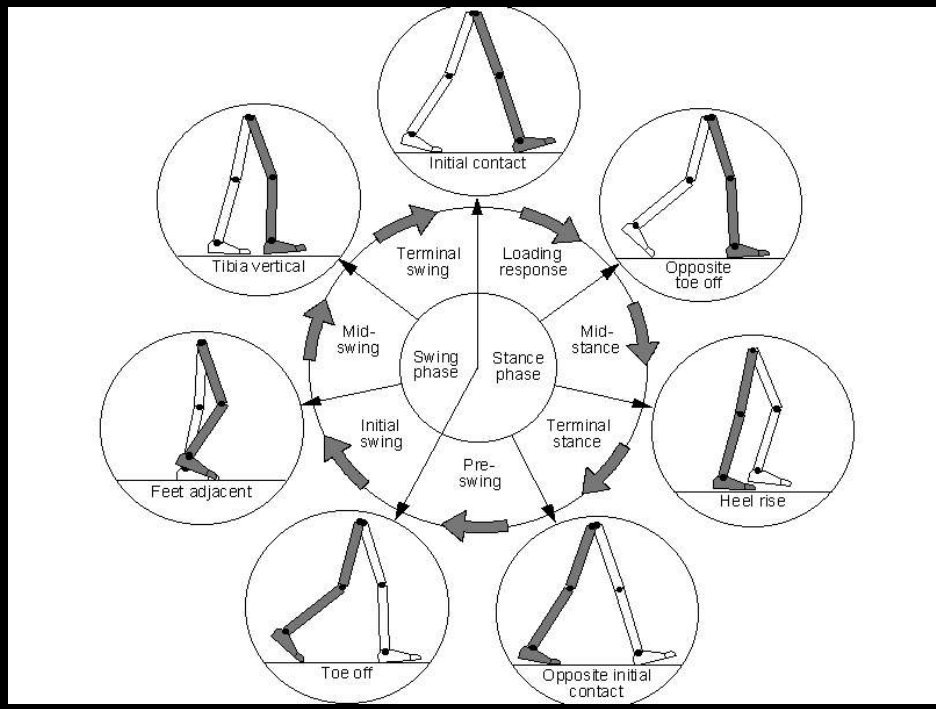
- Counter-nutation occurs when the entire sacral base moves posterior and superior relative to the ilia

The Bony Pelvis and SI Joints

- Lumbosacral joints motion during gait is opposite that of sacroiliac joints motion:
  - as the sacroiliac joint flexes the lumbosacral joint extends
  - as the sacroiliac joint extends the lumbosacral joint flexes

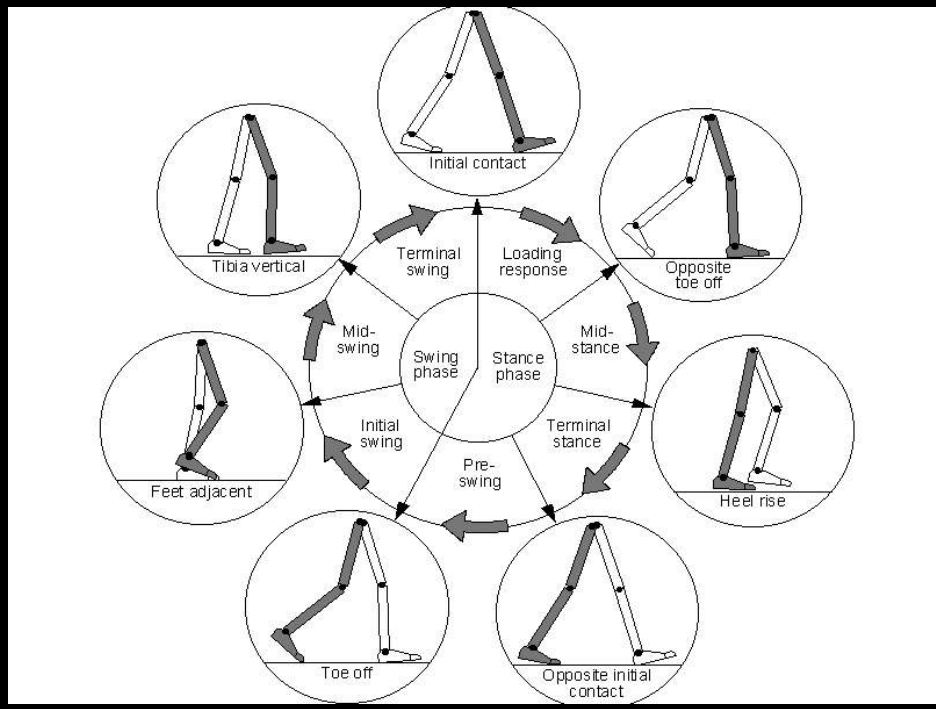
The Gait Cycle

- Gait Analysis
  - The gait cycle is broken down into two phases
    - The stance or support phase
      - Foot is in contact with the ground
    - The swing or non-contact phase
      - Foot is not in contact with the ground



The Gait Cycle

- Gait Analysis
  - The stance or support phase is broken down into two sub-phases
    - The breaking or weight acceptance phase
      - Heel strike through mid-stance
    - The propelling phase
      - Mid-stance through toe off



The Gait Cycle

- Gait Analysis
  - The swing or non-contact phase is broken down into two sub-phases
    - The forward swing (acceleration)
      - From toe-off through mid-swing
    - The forward swing (deceleration)
      - From mid-swing through heel-strike