Structure and Function of the Vertebral Column
Spine

- 33 vertebral segments divided into 5 segments
  - Cervical: 7 vertebrae
  - Thoracic: 12 vertebrae
  - Lumbar: 5 vertebrae
  - Sacral: 5 vertebrae, fused in the adult
  - Coccygeal: 4 vertebrae, also fused in adult
Spinal Column Views

Lateral (Side) Spinal Column
- Cervical
- Thoracic
- Lumbar
- Sacrum
- Coccyx

Posterior (Back) Spinal Column
- Cervical
- Thoracic
- Lumbar
- Sacrum
- Coccyx
Normal Curvature of Spine

- Lordosis: set in a curve that has its convexity anteriorly and concavity posteriorly
- Kyphosis: set in a curve that has its concavity anteriorly and convexity posteriorly

- Purpose
  - To absorb ground reaction forces
  - To transmit load of upper body throughout lower body
Which segments are lordotic and which are kyphotic?
What does this do to the lordosis in the lumbar spine?
How would you describe this woman’s thoracic spine?
Normal line of gravity – lateral view

**bony landmarks**
- sl. behind the coronal suture
- thru external auditory meatus
- thru the dens of the axis
- thru cervical vertebral bodies
- thru lumbar vertebral bodies
- thru sacral promontory
- sl. behind the hip joint
- sl. ant. to the knee joint
- sl. ant. to the ankle joint
- thru the calcaneocuboid joint

**Line of Gravity**

**surface landmarks**
- thru the ear lobe
- thru the shoulder joint
- midway of the trunk
- thru the greater trochanter
- sl. ant. to the knee joint
- sl. ant. to the ankle joint

**Plumb Line Test (Side View)**
Other methods of assessing posture

• Anterior view
• Posterior view

  – For both, looking for symmetry of bony landmarks from both sides
Postural Assessment
Ideal Posture

- There is no “normal” posture.
- Ideal posture serves as a reference point.
- Ideal posture...
  - Distributes gravitational stress for balanced muscle function.
  - Allows joints to move in their mid range to minimize stress on ligaments and articular surfaces.
Effects of Poor Posture on Muscles

- Overstressed muscles tighten.
- Favored muscles weaken.
- This imbalance perpetuates the poor posture.
Common postural dysfunctions

- Sway Back
- Lumbar Lordosis
- Thoracic Kyphosis
- Forward Head
- Good Posture
Parts of a Vertebra

Body
Vertebral Foramen
Pedicle
Lamina
Transverse Process
Articular Facet
Spinous Process
  superior
  inferior

Neural Arch

Vertebral foramen

body

pedicle

af

tp
Parts of a vertebrae

- Body
- Vertebral foramen
- Pedicles
- Transverse process
- Lamina
- Spinous process
- Articular facet
  - Superior
  - Inferior
Intervertebral Discs

- Function
  - Absorbing and transmitting forces

- Components
  - Annulus Fibrosus
    - 10-20 concentric fibrocartilaginous rings
    - Encases nucleus
  - Nucleus Pulposus
    - Gelatinous center
    - 70-90% water
    - Shock absorber
Terminology

- Individual vertebrae are numbered by region and in a cranial-sacral direction.
Terminology

- Discs are described by their position between two vertebrae
- Spinal nerves are described in the same way as the vertebrae
Osteology of the Spine

The Skull—Posterior View

- Sagittal suture
- Parietal bone
- Sutural bone
- Lambdoid suture
- Occipital bone
- Superior nuchal line
- External occipital protuberance
- Inferior nuchal line
- Occipital condyle
Cervical Vertebrae

• Smallest and most mobile
• C3-7 are similar in osteology; C1 and C2 are unique
• C3-C7
  – Transverse processes possess holes called transverse foramen (allows vertebral artery to travel through it)
  – Most spinous processes are bifid (two-pronged)
    • Allows for attachment for muscles bilaterally
C-1 Vertebrae

- Called Atlas
- Has no body, it is ring-like, and consists of an anterior and a posterior arch and two lateral masses
- Articulates with skull’s occipital condyles
  - Atlanto-occipital joint
C-2 Vertebrae

• Called Axis
  – Allows rotation of C-spine

• Atlas sits directly on top of axis
  – Articulates with inferior facet of atlas to form
Cervical Vertebrae C3-C7

- Neural arch
- Bifid spine
- Spinal canal
- Superior articular facet
- Transverse process
- Body
- Foramen for vertebral artery
- Superior articular facet
- Body
- Spine
- Inferior articular facet
Cervical Vertebrae Recap

• C1 is called atlas
  – C1 and skull form atlanto-occipital joint
• C2 is called axis
  – Vertical process called dens
  – Axis-atlas forms atlanto-axial joint (accounts for half of all rotation that occurs at neck)
• Unique features of C3-C7
  – Transverse foramen
  – Bifid spinous processes
Thoracic Vertebrae

• 12 vertebrae – 12 rib
  – Body and transverse processes have costal facets
• Unique features
  – Inferiorly projected long spinous processes
  – Posterior/lateral transverse processes
  – More round vertebral foramen
Lumbar Vertebrae

- Bigger vertebral bodies than others, why?
- Other aspects of vertebrae are stouter and broader than other areas
- Contain small mammillary and accessory processes on their bodies
Intervertebral foramen
Sacrum and Coccyx

- Sacrum
  - 5 vertebrae fused together into a triangular shaped bone
  - Do have foramen for nerves to exit which will innervate the lower extremity
- Coccyx
  - Tailbone (4 fused vertebrae)
- Together form sacrococcygeal joint
Supporting Structures of Vertebral Column

• Joints
  – Atlanto-occipital joint
    • Condyloid joint; allows flex/extension and lateral rotation
  – Atlanto-axial joint
    • Allows rotation only; pivot joint
  – Intervertebral joints (C2-S1)
    • Three ways
      – Facet joints-plane joint (allows flex/ext, lat flex, and rotation)
      – Lamina are connected via a ligament (ligamentum flavum)
      – Bodies are connected via the disc (not a synovial joint)
        » Fibrocartilaginous
Facet Joints, aka apophyseal joints
Supporting Structures of Vertebral Column

• Ligaments
  – Ligamentum flavum
    • runs between lamina of adjacent vertebrae and limits excessive flexion
  – Anterior longitudinal ligament
    • Attaches the anterior aspect of the vertebral body
  – Posterior longitudinal ligament
    • Attaches to the posterior aspect of the vertebral body
Ant and Post Longitudinal Ligament
Kinematics

• Movement in the spinal column is defined by the direction of motion of the *anterior* side of the vertebrae
  – Can be confusing because the spinous process (posterior) and the anterior side move in opposite directions.
Kinematics

• All segments of vertebral column permits:
  – Flexion/extension
  – Lateral flexion to the Right and Left
  – Rotation to the Right and Left

• Motions are graded on the summation of the entire vertebral segment, not each individual vertebrae
Kinematics

• Craniocervical (neck): most mobile of all segments

• Thoracolumbar
  – Thoracic spine allows flex/ext, and the majority of lat flex and rotation
  – Lumbar spine allows for the majority of flex/extension
Position of Pelvis affects Position of Lumbar Spine

- The pelvis can be rotated anteriorly and posteriorly.
Common Pathologies:
Scoliosis

Normal vs. Scoliosis
Common Pathologies: Disc

- Disc tear, bulge, herniation, prolapse, and dessication
- Like a wet sponge, a healthy disc is flexible. A dry sponge is hard, stiff, and can crack easily.
- Due to the position of spinal nerves exiting through the transverse foramen, disc problems can have a negative affect on those nerves
Myology of the Vertebral Column
Innervations

• Dorsal Ramus
  – Innervates most muscles of posterior neck and truck

• Ventral Ramus
  – Most muscles of ant-lateral trunk and neck
# Anterior Neck

## Sternocleidomastoid

| **Origin**          | Sternal head: superior aspect of the manubrium of the sternum  
|                     | Clavicular head: medial 1/3 of the clavicle |
| **Insertion**       | Mastoid process of the temporal bone |
| **Innervation**     | Spinal accessory n. (cranial n. XI) |
| **Action**          | **Unilateral:** Contralateral rotation of the head and neck;  
|                     | Ipsilateral lateral flexion of the head/neck  
|                     | **Bilateral:** flexes the head/neck |
# Anterior Neck

## Scalenes

| **Origin**     | Ant. Scalene: transverse processes of C3-C7  
|                | Middle Scalene: transverse processes of C2-C7  
|                | Posterior Scalene: transverse processes of C5-C7 |
| **Insertion**  | Ant. Scalene: 1\(^{st}\) rib  
|                | Middle Scalene: 1\(^{st}\) rib  
|                | Posterior Scalene: external surface of the 2\(^{nd}\) rib |
| **Innervation**| Ventral rami (C3-C7) |
| **Action**     | **Bilateral**: flexion of the neck, assist with inspiration by elevating ribs 1&2  
|                | **Unilateral**: lateral flexion |
COPD

Overuse of respiratory accessory muscles
## Posterior Neck

### Splenius Capitis

<table>
<thead>
<tr>
<th><strong>Origin</strong></th>
<th>Mastoid process and lateral superior nuchal line</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insertion</strong></td>
<td>Ligamentum nuchae and spinous processes C7-T3</td>
</tr>
<tr>
<td><strong>Innervation</strong></td>
<td>Dorsal rami C2-C8</td>
</tr>
</tbody>
</table>
| **Action** | **Bilateral:** extension  
**Unilateral:** Ipsilateral lateral flexion and rotation of head and neck |
# Posterior Neck

## Splenius Cervicis

<table>
<thead>
<tr>
<th>Origin</th>
<th>Transverse process of C1-C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion</td>
<td>Spinous process of T3-T6</td>
</tr>
<tr>
<td>Innervation</td>
<td>Dorsal rami C2-C8</td>
</tr>
</tbody>
</table>
| Action       | **Bilateral:** extension of neck  
               **Unilateral:** Ipsilateral lateral flexion and rotation of head and neck |
Class one Lever relating to neck pain

- In good posture, resistance arm is short and muscles can act on it easily.
- The further the neck is forward (bad posture of cervical or thoracic spine), the resistance arm is lengthened.
## Anterior-Lateral Trunk

<table>
<thead>
<tr>
<th>Rectus Abdominis</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origin</strong></td>
<td>Crest of the pubis</td>
</tr>
<tr>
<td><strong>Insertion</strong></td>
<td>Xiphoid process and cartilages of ribs 5-7</td>
</tr>
<tr>
<td><strong>Innervation</strong></td>
<td>Intercostal n. (T7-T12)</td>
</tr>
<tr>
<td><strong>Action</strong></td>
<td>Flexion of the trunk, posterior pelvic tilt</td>
</tr>
</tbody>
</table>
## Anterior-Lateral Trunk

### External Oblique

<table>
<thead>
<tr>
<th>Origin</th>
<th>Lateral side of ribs 4-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion</td>
<td>Iliac crest and linea alba</td>
</tr>
<tr>
<td>Innervation</td>
<td>Intercostal nerves (T8-T12)</td>
</tr>
<tr>
<td>Action</td>
<td>Bilateral: Flexion of the trunk, posterior pelvic tilt, Unilateral: contralateral Rotation of the trunk; Ipsilateral lateral flexion of the trunk</td>
</tr>
</tbody>
</table>

A superficial, lateral muscle, its fibers run downward and medially. It extends from the last eight ribs (origins) to the linea alba, pubic tubercles and iliac crest. Has actions similar to the rectus abdominis. In addition, it is used for lateral flexion and trunk rotation.
# Anterior-Lateral Trunk

## Internal Oblique

<table>
<thead>
<tr>
<th>Origin</th>
<th>Iliac crest, inguinal ligament &amp; thoracolumbar fascia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion</td>
<td>Ribs 9-12, linea alba</td>
</tr>
<tr>
<td>Innervation</td>
<td>Intercostal n. (T8-T12)</td>
</tr>
</tbody>
</table>
| Action                         | Bilateral: *flexion of the trunk, posterior pelvic tilt, increases intra-abdominal and intra-thoracic pressure*  
Unilateral: *lateral flexion of the trunk, rotation of the trunk to the ipsilateral side* |
# Anterior-Lateral Trunk

## Transverse Abdominis

<table>
<thead>
<tr>
<th>Origin</th>
<th>Iliac crest, thoracolumbar fascia cartilages of ribs 6-12, &amp; inguinal ligament</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion</td>
<td>Linea alba</td>
</tr>
<tr>
<td>Innervation</td>
<td>Intercostal n. (T7-T12)</td>
</tr>
<tr>
<td>Action</td>
<td>Increases intra-abdominal pressure, increases tension in thoracolumbar fascia</td>
</tr>
</tbody>
</table>
Increasing Intra-Abdominal pressure and thoracolumbar fascia

• By increasing tension and pressure, we stabilize the lumbar spin
  – Via thoracolumbar fascia, we have a rigid column of muscles from anterior-posterior
Without even looking at their back, who has the stronger back?
## Back Stabilizers

### Iliopsoas

| **Origin** | Psoas Major: transverse processes of T12-L5  
Iliacus: Iliac fossa |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insertion</strong></td>
<td>Lesser trochanter of the femur</td>
</tr>
<tr>
<td><strong>Innervation</strong></td>
<td>Femoral n.</td>
</tr>
<tr>
<td><strong>Action</strong></td>
<td>Hip flexion, trunk flexion, anterior pelvic tilt</td>
</tr>
</tbody>
</table>
Back stabilizers

**Quadratus Lumborum**

<table>
<thead>
<tr>
<th>Origin</th>
<th>Crest of the ilium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion</td>
<td>Transverse processes of L1-L4 &amp; 12th rib</td>
</tr>
<tr>
<td>Innervation</td>
<td>Ventral rami (T12-L3)</td>
</tr>
<tr>
<td>Action</td>
<td>Bilateral: extension of the lumbar region Unilateral: lateral flexion of the trunk</td>
</tr>
</tbody>
</table>
Erector Spinae

Large vertically oriented muscles on both sides of the spinous processes *(about one hand’s width laterally)*

- Extend and stabilize the entire vertebral column and craniocervical region
### Iliocostalis

| Superior Attachment | Lumborum: angle of ribs 6-12  
Thoracis: angle of ribs 1-6  
Cervicis: transverse processes of C4-C6 |
|---------------------|----------------------------------|
| Inferior Attachment | Lumborum: common tendon  
Thoracis: angle of ribs 6-12  
Cervicis: angle of ribs 3-7 |
| Innervation         | Dorsal rami of adjacent spinal n. |
| Action              | Bilateral: **extension**  
Unilateral: **lateral flexion** |
## Posterior Trunk

### Longissimus

| **Inferior Attachment** | Thoracis: common tendon
Cervicis: transverse processes of T1-T4
Capitis: Transverse processes of T1-T5 & near facet joints C3-C7 |
|-------------------------|---------------------------------------------------------------------|
| **Superior Attachment** | Thoracis: transverse processes of T1-T12
Cervicis: Transverse processes of C2-C6
Capitis: mastoid process of temporal bone |
| **Innervation**         | Dorsal rami of adjacent spinal n. |
| **Action**              | Bilateral: *extension*
Unilateral: *lateral flexion* |
## Posterior Trunk

### Spinalis

<table>
<thead>
<tr>
<th>Attachment</th>
<th>Thoracic</th>
<th>Cervical</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inferior</td>
<td>common tendon</td>
<td>ligamentum nuchae and spinous processes C7-T1</td>
<td>Blends with semispinalis capitis</td>
</tr>
<tr>
<td>Superior</td>
<td>Spinous processes of T1-T6</td>
<td>Pinous process of C2</td>
<td>Blends with semispinalis capitis</td>
</tr>
<tr>
<td>Innervation</td>
<td>Dorsal rami of adjacent spinal n.</td>
<td></td>
<td>Bilateral: extension</td>
</tr>
</tbody>
</table>

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![Diagram of the posterior trunk and Spinalis muscles](image-url)