Scoliosis

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Normal Curvature of the Spine

- The spine normally has gentle curves when viewed from the side (sagittal plane). These curves help absorb shock, maintain balance, and distribute body weight efficiently.
- Normal *Spine: Cervical Lordosis* + *Thoracic Kyphosis* + *Lumbar Lordosis*
- **Normal spinal curves:**
- **Cervical Lordosis** (neck) – inward curve.
- **Thoracic Kyphosis** (upper back) – outward curve.
- **Lumbar Lordosis** (lower back) – inward curve.
- **Sacral Kyphosis** (sacrum) – outward curve.
- When viewed from the **front or back**, the spine should appear relatively straight, with the head centered over the pelvis.

Scoliosis

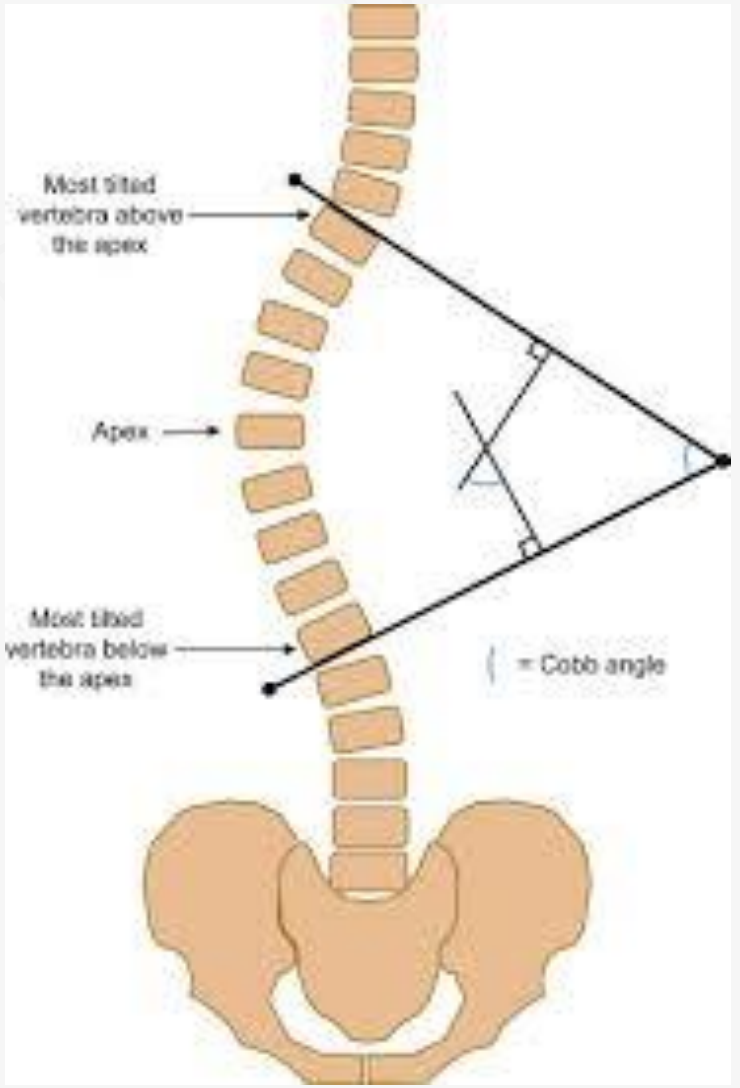
- Lateral curvature of the spine accompanied by vertebral rotation
- Three-dimensional deformity
- Involves:
  - Spine
  - Rib cage
  - Pelvis
- May affect cervical, thoracic and lumbar regions

Key Point

- Scoliosis is not simply a side-bending deformity; rotation is equally important.

Important Terminology

- **Apex**
- Vertebra farthest from midline
- **Span**
- Distance covered by the curve
- **Major Curve**
- Largest curve
- **Minor Curve**
- Compensatory curve
- **Transitional Vertebra**
- Vertebra where one curve ends and another begins



- The **Cobb angle** is the standard measurement used to quantify the degree of spinal curvature, most commonly in scoliosis.
- The angle is measured on a spinal X-ray by:
- Identifying the **most tilted vertebra** at the top of the curve.
- Identifying the **most tilted vertebra** at the bottom of the curve.
- Drawing lines along the superior endplate of the top vertebra and the inferior endplate of the bottom vertebra.
- Measuring the angle formed by the intersection of perpendiculars to these lines.

Severity Classification

< 10°: Not considered scoliosis

Mild Curve

- Up to 20°

Moderate Curve

- 20°–50°

Severe Curve

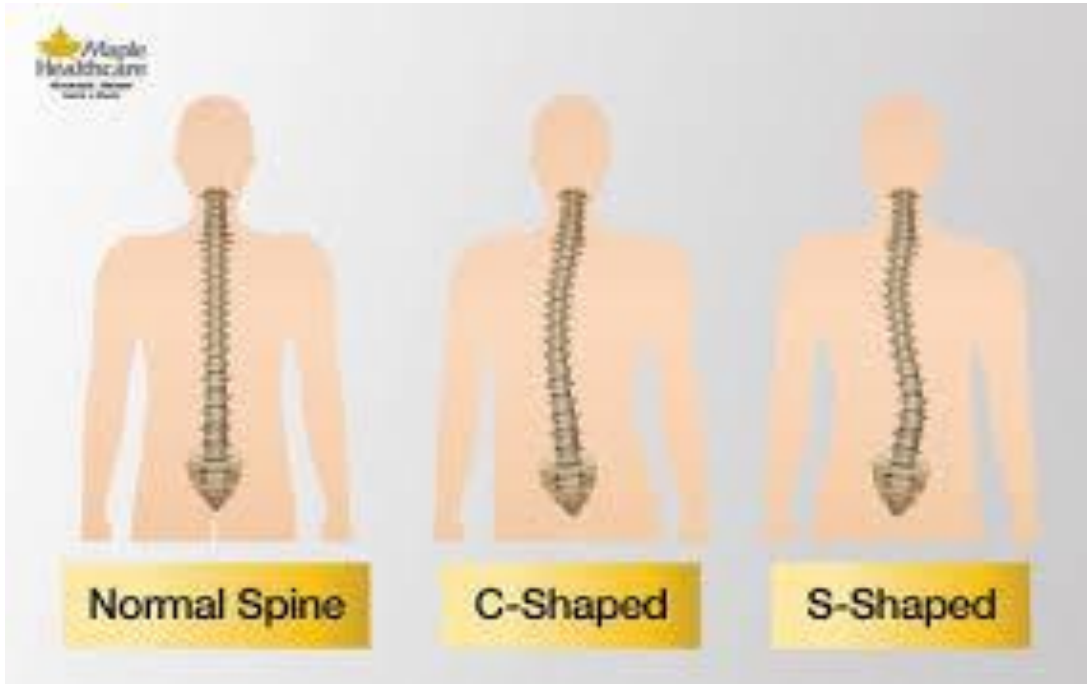
- Greater than 50°

Clinical Significance

- Mild curves often manageable conservatively
- Moderate curves may require bracing
- Severe curves may require surgery

Types of Curves

- **C-Curve**
- Single curve
- One primary convexity
- **S-Curve**
- Two major curves
- Usually includes compensatory curve



Functional vs Structural Scoliosis

Functional	Structural
Reversible	Fixed
Postural	Bony deformity
Correctable	Not correctable manually
Often muscular	Vertebral wedging
Responds well to exercise	May require brace/surgery

Mild, Moderate and Severe Scoliosis

Severity	Typical Features	Management
Mild Scoliosis	Small spinal curve, minimal structural changes	Observation, postural correction, stretching and strengthening exercises
Moderate Scoliosis	Curve progresses, early bony remodeling begins	Bracing plus exercise therapy
Severe Scoliosis	Significant spinal deformity, rib cage involvement, reduced lung function	Surgical correction may be required

Why severe scoliosis is serious:

- Compression and distortion of the rib cage can reduce lung expansion.
- Children may develop decreased pulmonary function.
- Adults are at increased risk of spinal degeneration and osteoarthritis.
- Chronic pain and functional limitations become more common.

Epidemiology

Idiopathic Scoliosis

- Approximately 85% of cases
- **Age Groups**
- Infantile (0–3 years)
- Juvenile (4–9 years)
- Adolescent (10–16 years)
- **Gender**
- Progression more common in females

Causes of Idiopathic Scoliosis

Central Nervous System Factors
- Abnormal proprioception (muscle spindle dysfunction)
- Inner ear (vestibular/labyrinth) asymmetry affecting posture
- Impaired postural control mechanisms

Biomechanical Factors
- Natural body asymmetries (vertebrae, ribs, limbs)
- Increased joint flexibility/hypermobility
- Uneven muscle forces acting on the spine

Muscle Imbalances
- Concave side: short, tight, fibrotic muscles
- Convex side: increased muscle activity
- Possible collagen/connective tissue abnormalities

Hereditary & Hormonal Factors
- Genetic predisposition
- Growth and sex hormones may influence development
- More common and more progressive in adolescent females

Functional Causes (Reversible)

- Leg length discrepancy (short tibia, femur, or hemipelvis)
- Trigger points (especially quadratus lumborum)
- Habitual poor posture (weight shifted to one side)
- Soft tissue tightness/contractures
- Antalgic scoliosis due to pain, disc herniation, or sciatica

Key Feature

- Curve improves with position changes.

Structural Causes

Neuromuscular Disorders

- **Cerebral palsy**:Cerebral palsy is a neurological condition that affects a person's ability to control muscles, movement, balance, and posture.
- **Muscular dystrophy** :Muscular Dystrophy is a group of genetic diseases that cause progressive weakness and loss of muscle mass
- **Friedreich's ataxia** (Detail in Next Slide)
- **Spinal cord lesions**
- **Post-polio syndrome**

Mechanism

- Muscle weakness
- Muscle imbalance
- Poor postural control

Friedreich's Ataxia (FA)

- Friedreich's Ataxia (FA) is a rare inherited genetic disorder that primarily affects the nervous system and heart. It is caused by mutations in the **FXN gene**, leading to reduced production of **frataxin**, a protein important for mitochondrial function and iron regulation.
- **Key Features**
- **Progressive loss of coordination (ataxia)** affecting walking, balance, and limb movements
- **Muscle weakness**
- **Difficulty speaking (dysarthria)**
- Loss of sensation and reflexes, especially in the legs
- Scoliosis (curvature of the spine)
- Foot deformities such as high arches (pes cavus)
- Fatigue

Congenital Causes

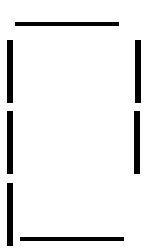
Structural Abnormalities

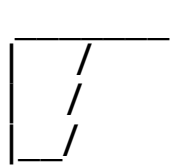
- Hemivertebra
- **Vertebral wedging:** A vertebra becomes **wedge-shaped** instead of rectangular because one side grows less than the other.
- **Vertebral bridging** (Failure of Segmentation):Two or more vertebrae fail to separate properly during fetal development and become connected by a **bony bridge (bar)**.
- Rib deformities like missed or malformed ribs

Result

- Permanent structural curve development

Vertebral Wedging

- Normally, a vertebra is roughly rectangular when viewed from the front.
- **Normal Vertebra**
- 
- In scoliosis, uneven forces act on the vertebra over many years:
- **Concave side** = increased compression
- **Convex side** = decreased compression (relative tension)

- According to **Wolff's Law**, bone adapts to these forces.
- The compressed side grows less, while the opposite side grows more. As a result, the vertebra gradually develops a wedge shape.
- **Wedged Vertebra**
- 
- **Why Does This Happen?**
- In a growing child or adolescent:
- Compression slows growth on the concave side.
- Reduced compression allows relatively more growth on the convex side.
- Over time the vertebral body becomes triangular (wedged).
- **Effect on the Curve**
- The wedged vertebra actually increases the spinal curve:

- Normal vertebrae stacked
  |_|
  |_|
  |_|

  Wedged vertebrae stacked
   /|
  /_|
   /|
  /_|
- This creates more lateral bending, which causes even more uneven loading—a cycle that can worsen scoliosis.

Vertebral Wedging

A vertebra becomes **wedge-shaped** instead of rectangular because one side grows less than the other.

- **How it causes scoliosis:**
- Increased pressure occurs on the **concave side** of the spinal curve.
- Growth of the vertebral growth plate slows on that side.
- The vertebra gradually becomes wedge-shaped.
- The wedge pushes the spine further sideways, increasing the curve.
- **Key point:**
- Can be **congenital** (present at birth) or develop during growth.
- Often contributes to **progression of scoliosis** in children and adolescents.

Vertebral Bridging (Failure of Segmentation)

Definition:
Two or more vertebrae fail to separate properly during fetal development and become connected by a **bony bridge (bar)**.

How it causes scoliosis:

- One side of the vertebrae is fused together.
- The fused side cannot grow normally.
- The opposite side continues to grow.
- Unequal growth causes the spine to bend toward the fused side, creating a scoliotic curve.

Key point:

- A congenital cause of scoliosis.
- Often results in a **progressive curve** as the child grows.
- Also called a **unilateral unsegmented bar** when the fusion occurs on one side

Iatrogenic Causes:

Iatrogenic means a condition caused unintentionally by a medical treatment or surgery.

- Previous chest surgery
- Pneumonectomy (surgical removal of one lung)
- Open-heart surgery involving rib resection

Key Point:

These surgeries **do not directly cause scoliosis**, but the changes they create in the chest wall, ribs, muscles, and growth patterns can allow a spinal curve to develop later, especially in children whose bones are still growing.

Scoliosis is a Three-Dimensional Deformity

Many people think scoliosis is simply a side bend of the spine., In reality, scoliosis affects:

Spine

- Lateral bending
- Vertebral rotation
- Altered spinal curves

Rib Cage

- Rib crowding on the concave side
- Rib spreading on the convex side
- Rib hump develops due to vertebral rotation

Pelvis

- Pelvic tilt
- Pelvic rotation (torque)
- One innominate may rotate anteriorly compared to the other

Shoulder Girdle

- One shoulder becomes elevated
- Scapular asymmetry develops

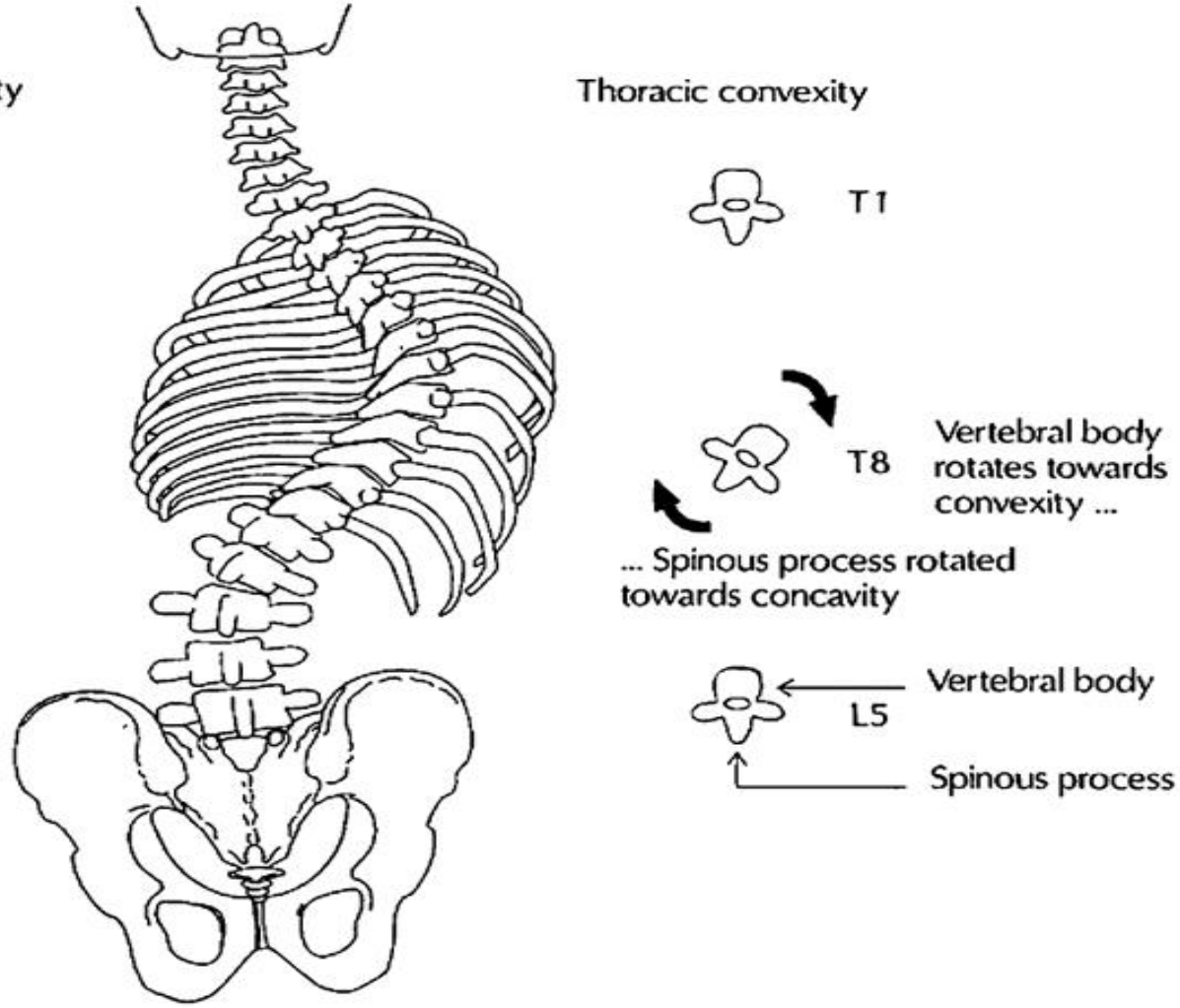


Figure 44.2
Rotation of vertebral bodies, position of spinous processes and rib spread on the convex side of the thoracic curve.

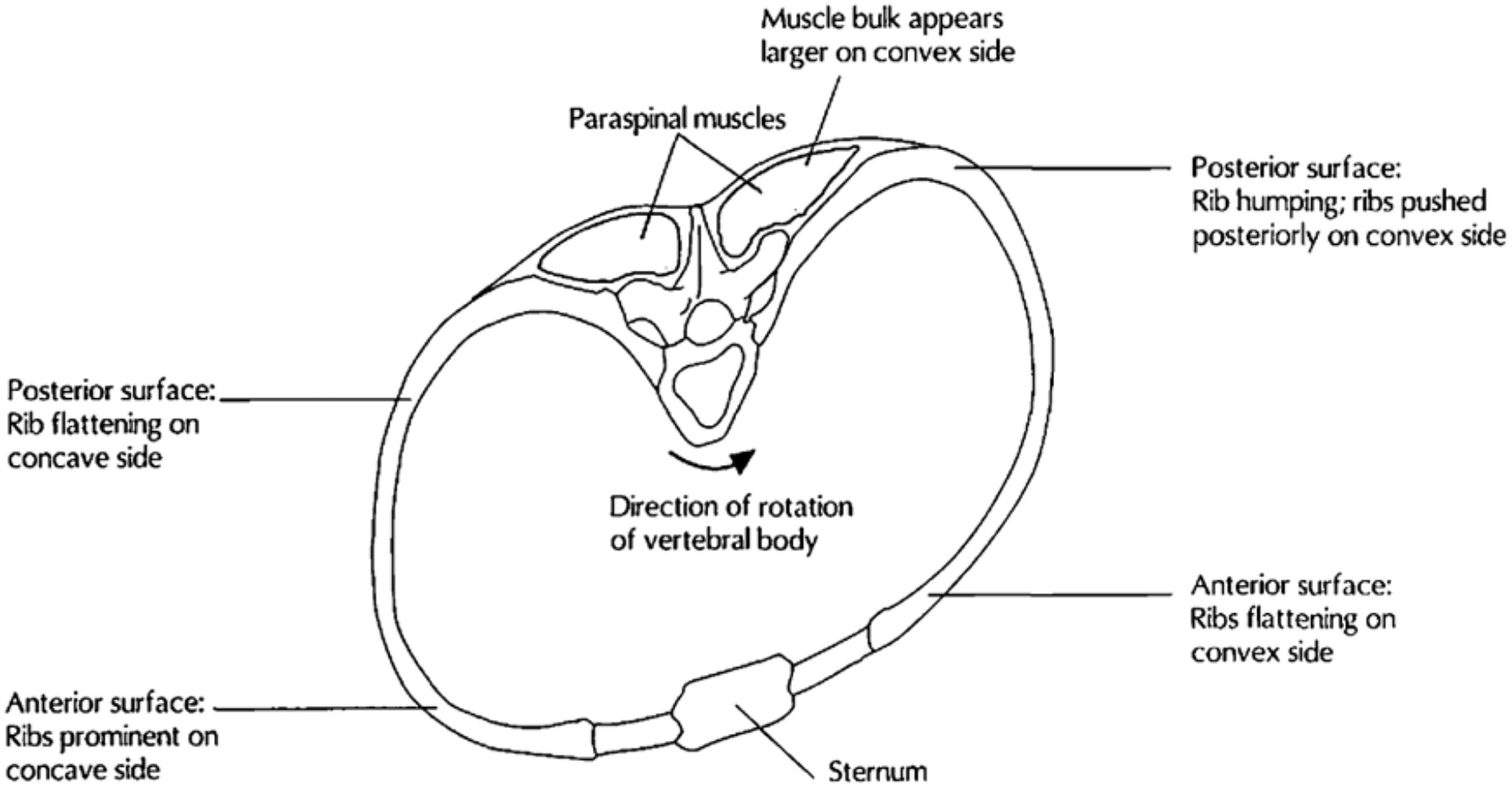


Figure 44.3
True bulk of paraspinal muscles is misleading.

Vertebral Rotation

- **What Happens?**
- Vertebral bodies rotate toward convexity
- Spinous processes rotate toward concavity
- **Effects**
- Rib prominence
- Rib flattening
- Thoracic asymmetry

The spinal curve causes vertebral rotation, and vertebral rotation causes rib cage deformity.

Sequence:

- Spinal curvature → Vertebral rotation → Rib displacement → Rib hump & rib flattening → Thoracic asymmetry
- This is why scoliosis is considered a **three-dimensional spinal deformity**, not simply a side-bending of the spine.

Vertebral Bodies Rotate Toward the Convexity

- Imagine a thoracic scoliosis curve that bulges to the **right**.
- The **vertebral body** (large weight-bearing part at the front of the vertebra) rotates toward the **right convex side**.
- At the same time, the posterior part of the vertebra rotates in the opposite direction.

Example:

- Right thoracic scoliosis
- Vertebral body rotates to the **right (convex side)**

Spinous Processes Rotate Toward the Concavity

- The **spinous process** is the bony projection you can feel when touching someone's back.
- As the vertebra rotates:
- The spinous process moves toward the **concave side** of the curve.
- **Example:**
- Right thoracic scoliosis
- Spinous process rotates toward the **left (concave side)**
- This is why the spinous processes do not appear centered beneath the skin.

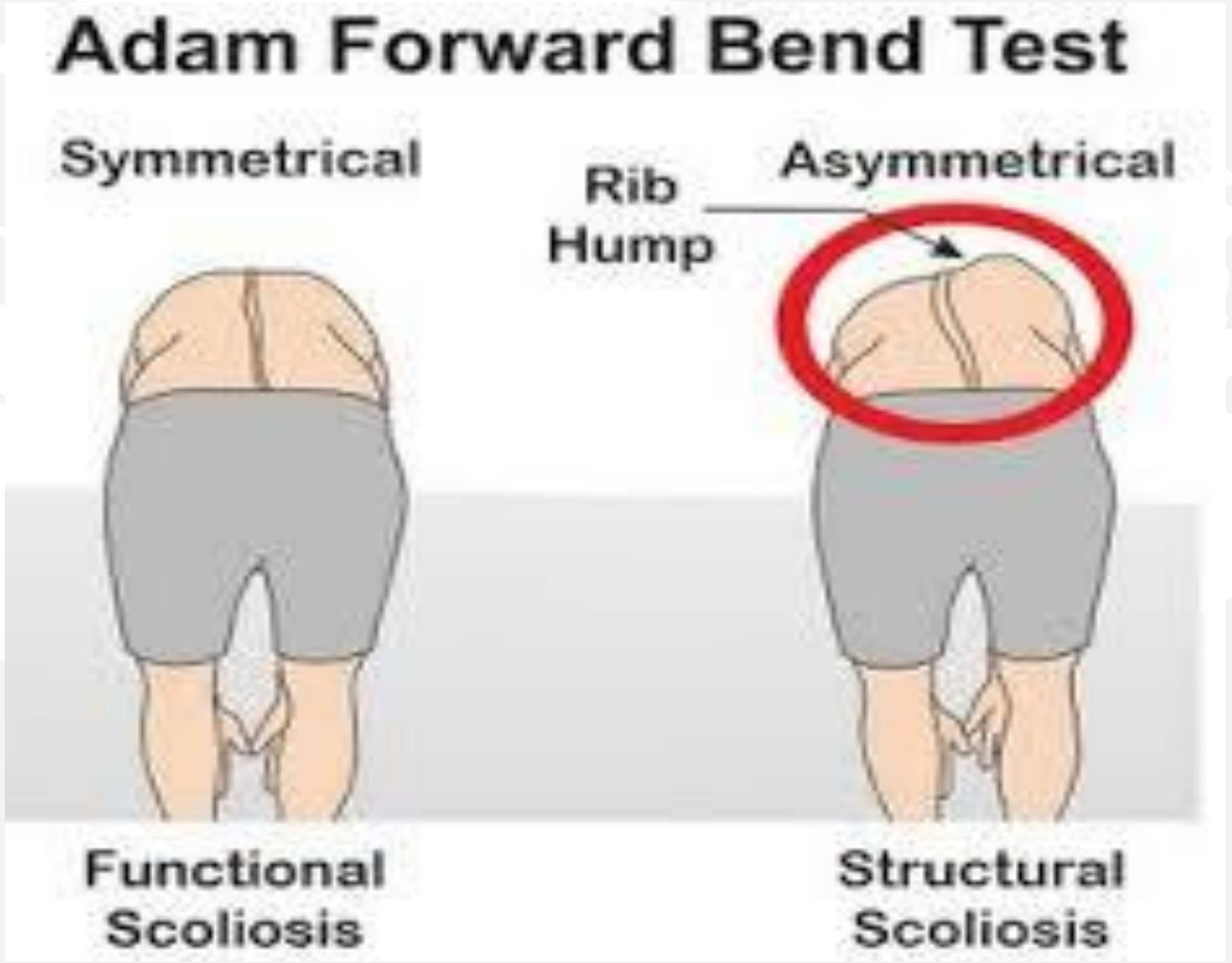
Why Does Rib Prominence Occur?

- The ribs attach directly to the thoracic vertebrae.
- When the vertebra rotates:
- Ribs on the **convex side** are pushed backward (posteriorly).
- These ribs stick out more.
- This creates the **rib hump (rib prominence)** seen during the **Adam's Forward Bend Test**.
- **Example:**
- Right thoracic scoliosis
- Right ribs project backward
- Right rib hump becomes visible

Adam's Forward Bend Test.

- **Adams Forward Bend Test** is a simple clinical screening test used to detect **scoliosis** (abnormal lateral curvature of the spine).
- **How it is performed**
- The patient stands with feet together and knees straight.
- The patient bends forward at the waist until the spine is parallel to the floor, letting the arms hang freely.
- The examiner observes the back from behind and from the side.
- **Positive test**
- Presence of **rib hump** or **lumbar prominence** on one side.
- Indicates **vertebral rotation**, which is characteristic of **structural scoliosis**.
- **Interpretation**
- **Structural scoliosis:** Asymmetry (rib hump) remains visible during forward bending.
- **Postural/non-structural scoliosis:** Curvature tends to disappear on forward bending.

Adam Forward Bend Test



Pelvic Lift Test (Block Test / Ischial Lift Test)

It is used to assess:

- **Functional scoliosis**
- **Pelvic obliquity (tilt)**
- **Leg length discrepancy (functional vs structural)**
- If placing a lift under the **lower ischium/hemipelvis**:
- reduces or neutralizes spinal curve → **functional scoliosis**
- no change in curve → possible **structural scoliosis**

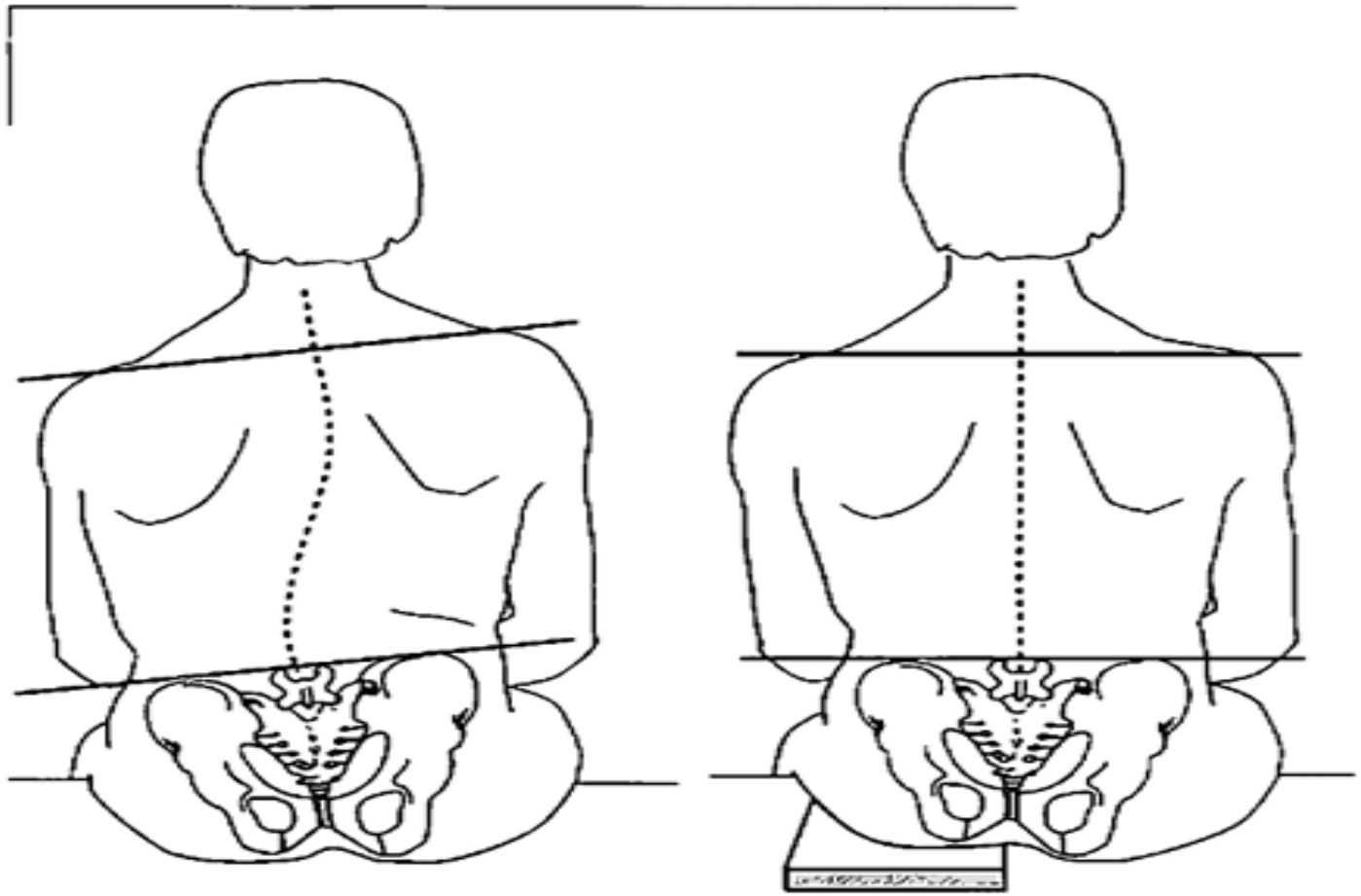


Figure 44.7
A small left hemipelvis causing a functional S-curve is assessed with a lift placed under the ischium. If the curve neutralizes the scoliosis is functional.

Functional leg length discrepancy test

It is commonly called:

- **Heel lift test**
- **Pelvic leveling test**
- **Functional leg length discrepancy test**
- Sometimes included in **standing block test**

How it works

- The patient stands in a natural posture.
- A **small lift (block or towel)** is placed under one heel (usually the short leg side).
- The therapist gradually adjusts the height of the lift.
- Observation is made for:
  - Pelvic alignment (does it level?)
  - Spinal curve (does the C-curve reduce or disappear?)

- **What the results mean**
- If the scoliosis **improves when the lift is added** → it suggests:
  - **Functional scoliosis due to leg length difference**
- If no change occurs → it may suggest:
  - **Structural scoliosis (bony curve)**

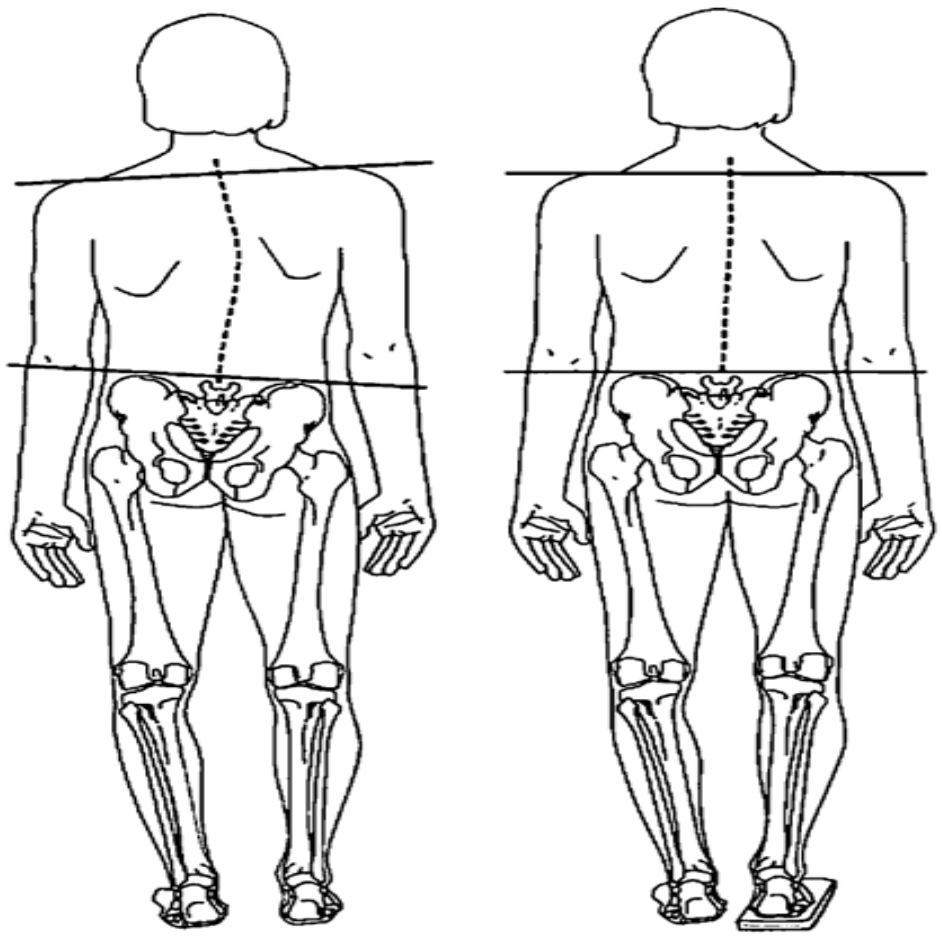


Figure 44.8
A short right leg causing a functional C-curve is assessed with a lift placed under the heel. The lift placed under the short leg balances the curves in a functional scoliosis.

Why Does Rib Flattening Occur?

- On the **concave side**:
- Ribs move forward and inward.
- The intercostal spaces between ribs become smaller.
- The chest wall appears flatter.
- **Example:**
- Left side of a right thoracic curve
- Ribs are compressed and appear flattened

Clinical Significance

- Restricted breathing mechanics

Why Does Thoracic Asymmetry Occur?

- Because one side of the rib cage protrudes while the other side flattens:
- Shoulders become uneven
- Scapulae appear uneven
- Rib cage becomes asymmetrical
- Waist contours may differ
- Trunk may shift to one side
- This creates the characteristic appearance of scoliosis.

Pelvic Torque

What is Pelvic Torque?

- Pelvic torque occurs when:
- One innominate bone rotates anteriorly.
- The opposite innominate rotates posteriorly.
- Result:
- Pelvis becomes twisted.
- Leg lengths may appear unequal.
- Weight distribution becomes asymmetrical.
- This contributes to compensatory spinal curves.

Righting Reflex and Scoliosis Compensation

- **What is the Righting Reflex?**
- The righting reflex is the body's automatic attempt to:
- Keep the eyes level.
- Maintain balance.
- Keep the center of gravity over the feet.
- Allow normal movement and function.
- The brain constantly tries to keep the head upright.

Righting Reflex

- **Example 1: Head Tilt**
- Imagine your head is tilted to the right.
- The body compensates by:
- Creating a cervical curve.
- Elevating the right shoulder.
- Creating a thoracic curve.
- This produces secondary compensatory curves.

Righting Reflex

Example 2: One Shoe with a Heel

- If one leg becomes functionally longer:
- Pelvis tilts.
- Lumbar spine bends.
- Thoracic spine bends in opposite direction.
- Head returns to midline.
- This demonstrates how scoliosis compensation develops.

Wolff's Law and Scoliosis

Wolff's Principle

- Bones remodel according to the forces placed upon them.
- Over time:
- Bone shape changes.
- **Vertebrae become wedged.**
- **Ribs become distorted.**
- Connective tissue adapts.
- Muscles shorten or lengthen.
- Even visceral structures may adapt.

Muscle Imbalances

Concave Side (Inside of the Curve)

- The **concave side** is the side where the curve bends inward.

What happens?

- Muscles become **shortened and tight** because the distance between the vertebrae decreases.
- They may develop increased resting tension and stiffness.

Common muscles affected:

- **Multifidi**
- **Erector spinae**
- **Intercostal muscles**

Compensatory Curve Pattern

- Head
  |
  Secondary Cervical Curve
  |
  Primary Thoracic Curve
  |
  Compensatory Lumbar Curve
  |
  Pelvis

Purpose:

- To keep the eyes level and maintain balance.

Muscle Imbalances

Clinical findings:Concave Side (Inside of the Curve)

- Muscle tightness
- Reduced flexibility
- Restricted spinal movement
- Rib crowding in thoracic scoliosis
- **Example:**
  If the thoracic curve bends to the right, the left side may become the concave side. The muscles on the left become shortened and tight.

Muscle Imbalances

Convex Side (Outside of the Curve)

- The **convex side** is the side that bulges outward.
- **What happens?**
- Muscles are placed in a lengthened position.
- They are often **overstretched**.
- They may show **increased electrical activity** because they work harder to stabilize the curved spine.
- Despite increased activity, they can become relatively weak due to chronic overstretching.

Clinical findings:

- Muscle fatigue
- Poor endurance
- Relative weakness
- Difficulty maintaining posture

Why Increased Activity but Weakness?

- Think of a stretched elastic band:
- It is under tension all the time.
- It works hard to maintain position.
- Over time it loses efficiency and strength.
- Similarly, on the **convex side**:
- Muscles are constantly trying to control the curve.
- EMG studies often show increased muscle activity.
- However, because they remain lengthened for long periods, they become mechanically disadvantaged and relatively weak.

Muscle	RIGHT SIDE (Convex side)	LEFT SIDE (Concave side)	Functional Effect
Quadratus Lumborum (QL)	Lengthened, weak	Shortened, tight, overactive	Left QL hikes pelvis → trunk shifts right
Iliopsoas	Lengthened, less active	Shortened, tight	Left lumbar compression + anterior pelvic tilt
Adductors	May be lengthened/weak	Tight/overactive	Pelvic pull toward left + rotational imbalance
Tensor Fascia Latae (TFL)	Often overactive (compensation)	Relatively less active	Right lateral hip tension + IT band tightness
Gluteus Medius	lengthened + weak (unstable side)	shortened + tight (overactive side)	**Right pelvic instability → left pelvic drop during right stance**
Latissimus Dorsi	Lengthened, weak	Tight/shortened	Left trunk pull + rib/pelvic asymmetry
Obliques (Int/Ext)	Weak or stretched	Overactive	Left trunk rotation dominance + waist asymmetry

Symptom Picture in Scoliosis

- **General Features**
- One or more **lateral + rotational spinal curves**
- Involves **cervical, thoracic, or lumbar spine**
- **Rib hump (humping)** on the **convex side** of thoracic curve
- **Lateral pelvic tilt** is commonly present
- Curve patterns may be:
  - **C-curve (single curve)**
  - **S-curve (double curve)**
- Severity:
  - Mild
  - Moderate
  - Severe

- **Functional Scoliosis**
- Muscle imbalance + shortening present
- Hypertonicity + trigger points in shortened muscles
- Reduced ROM (especially away from concave side)
- Restricted rib mobility
- Pain due to:
  - Tight ischemic tissues
  - Overstretched tissues
- Poor posture habits
- May have associated issues:
  - Pes planus
  - Thoracic outlet syndrome
  - Intercostal neuralgia

- **Structural Scoliosis**
- All functional findings PLUS:
  - Vertebral body wedging
  - Disc displacement (nucleus pulposus shift)
  - Facet joint irritation
  - Osteoarthritis changes
- Concave side compression → nerve root narrowing
- Possible chronic pain (often worse at night)
- Idiopathic type in children: usually painless
- Severe cases:
  - Reduced lung function
  - Possible visceral compression

Contraindications (Scoliosis)

- **Refer to physician** if suspected but undiagnosed pathology (spinal lesion, degeneration, ↓ pulmonary function)
- **Do not mobilize fused segments** (spinal rods/fusion areas)
- **Avoid hypermobile vertebrae**, especially adjacent to fused segments
- **Avoid rib springing / joint play** in rib hypermobility or history of rib subluxation
- **Do not stretch or apply strong longitudinal work on convex side muscles** (already overstretched)
- **Avoid heat over metal rods** (can retain heat → pain/discomfort)
- **Do not randomly stretch fascia –** assess first and treat only restricted areas

Treatment: Scoliosis

Treatment Planning

- Treat **one region at a time**
  - Pelvis → then lumbar → thorax → shoulders → neck
- Start from **foundation (pelvis)**

Treatment Goals

- Reduce **muscle tension and fascial restrictions**
- Improve **pelvic alignment**
- Balance **tight vs weak muscles**
- Decrease **pain and compensation patterns**
- Calm **nervous system (relaxation response)**

- **Positioning**
- Prone / Supine / Side-lying
- Based on area being treated
- Use pillows for comfort and alignment

Heat / Hydrotherapy

- Heat applied to **tight muscles first**
- Helps soften tissue before massage
- Cold applied to **weak muscles after treatment**
- Work in a “patchwork” sequence across body

Treatment Techniques

- Diaphragmatic breathing (relaxation)
- Petrissage
- Fascial spreading
- Skin rolling
- Cross-hand techniques
- Myofascial release

Treatment: Scoliosis

- Goals:
- Reduce tightness, pain, and trigger points
- Improve circulation & metabolite removal
- Mobilize hypomobile joints
- Strengthen weak muscles
- Stretch shortened muscles
- Key muscle focus:
- Tight: QL, latissimus dorsi, pectoralis minor, scalenes, SCM
- Weak: intercostals (convex side), rhomboids, gluteus medius (imbalanced)
- Techniques used:
- PIR (post-isometric relaxation) for QL, iliopsoas, rectus femoris
- Active resisted breathing for intercostals
- Diaphragm release + rib mobilization
- Fascial + Swedish integration for full body balance

Scoliosis Self-Care Plan

- Avoid uneven postures that increase spinal curve (leaning, asymmetrical sitting/standing)
- Adjust workstation to keep body balanced (support arms, correct height)
- Stretch tight muscles on the **concave side** (PIR + gentle spinal stretching)
- Do heel-sitting stretch to improve spinal flexibility and lengthening
- Strengthen weak muscles on the **convex side** to improve posture balance
- Combine stretching + strengthening + posture awareness daily
- Refer for assessment if curve is severe, structural, or linked with leg length difference
- Movement retraining (e.g., Feldenkrais, Alexander technique) helps improve long-term posture control

Feldenkrais Technique

- A **gentle movement education method**
- Focuses on **slow, mindful movements**
- Helps improve:
  - Body awareness
  - Coordination
  - Posture habits
- Works by **retraining the nervous system**, not forcing muscles
- Goal: move with less strain and better alignment

Alexander Technique

- Focuses on **posture and body use in daily life**
- Teaches how to **stop harmful habitual tension**
- Emphasizes:
  - Head–neck–spine alignment
  - Reducing unnecessary muscle tension
- Applied during everyday actions (sitting, standing, walking)
- Goal: improve posture by changing movement habits

Structure	**C-Curve RIGHT Scoliosis (single right convex curve)**	**S-Curve RIGHT Scoliosis (double curve: thoracic right + lumbar left compensation)**
Overall spine shape	Single curve: spine forms a **C shape bending to RIGHT (convex right)**	Two curves: **thoracic curve right convex + lumbar curve left convex (compensatory S shape)**
Vertebral body	Vertebral bodies rotate toward **right (convex side)** with wedging (compression on left, opening on right)	Two rotation centers: thoracic vertebrae rotate **right**, lumbar vertebrae rotate **left** (opposite patterns)
Spinous process	Spinous processes deviate toward **left (concave side)** due to vertebral rotation	Spinous processes shift **left in thoracic region**, but shift **right in lumbar region** (alternating direction)
Ribs (thoracic spine)	**Right rib hump present** (posterior rib prominence); left ribs compressed and flattened	**Right thoracic rib hump present**, but lower rib cage becomes more balanced due to lumbar compensation
Scapula	**Right scapula prominent, elevated, posteriorly displaced**; left scapula flattened	Scapular asymmetry present but may appear less obvious due to compensatory lumbar curve
Pelvis	Pelvis often drops on **left (concave side)** due to unbalanced spinal loading	Pelvis appears more level but often **rotated due to lumbar compensatory curve (left convex lumbar curve)**
Shoulder level	**Right shoulder elevated**, left shoulder lower	Shoulder imbalance mainly from thoracic curve; lumbar curve partially compensates so asymmetry may appear reduced
Muscles (right side – convex)	Right side muscles **lengthened + weak** (erector spinae, QL, intercostals, glute med)	Same in thoracic region, but lumbar region shows opposite pattern depending on curve level
Muscles (left side – concave)	Left side muscles **shortened + tight + overactive**	Thoracic left side remains tight, but lumbar left side may become **lengthened due to compensatory curve**
Gluteus medius	**Right gluteus medius weak**, left side tight/overactive for stability	Asymmetry becomes mixed: thoracic pattern influences upper pelvis, lumbar curve alters lower pelvic muscle balance
Weight distribution	More load on **right convex side initially**, but body shifts for balance	Load is distributed between two curves → more “balanced appearance” but uneven internal loading persists
Center of gravity	Shifted toward **right side of thorax**	More centrally aligned due to compensatory lumbar curve
Spinal mobility	Reduced, especially bending toward left (concave side restriction)	More complex restriction: movement limited in both thoracic and lumbar regions differently
External appearance	Clear asymmetry (visible rib hump + shoulder tilt)	May appear less obvious externally but structurally more complex


Thank You