BASIC PRINCIPLES OF BIOMECHANICS

SPINAL

A simple guide to pick up on Normal and Abnormal biomechanical behaviour:

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*Main source of referencing acquired from:

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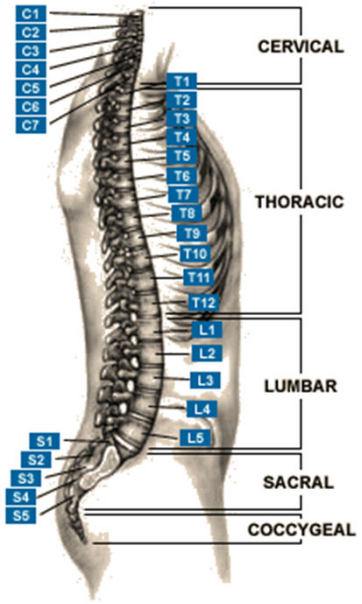
Unit Content

- GENERAL SPINAL BIOMECHANICS
- REGIONAL FACET ORIENTATION
- POSTURE
- BIOMECHANICAL SYNDROMES OF SPINAL POSTURE

GENERAL SPINAL BIOMECHANICS

- The vertebral column resembles a curved rod, composed of 33 vertebrae and 23 intervertebral disks.
- Divided into the following five regions:
  - Cervical (7)
  - Thoracic (12)
  - Lumbar (5)
  - Sacral (5)
  - Coccygeal (4)
- The vertebrae adhere to a common basic structural design but show regional variations in size and configuration that reflect the functional demands of a particular region.



GENERAL SPINAL BIOMECHANICS

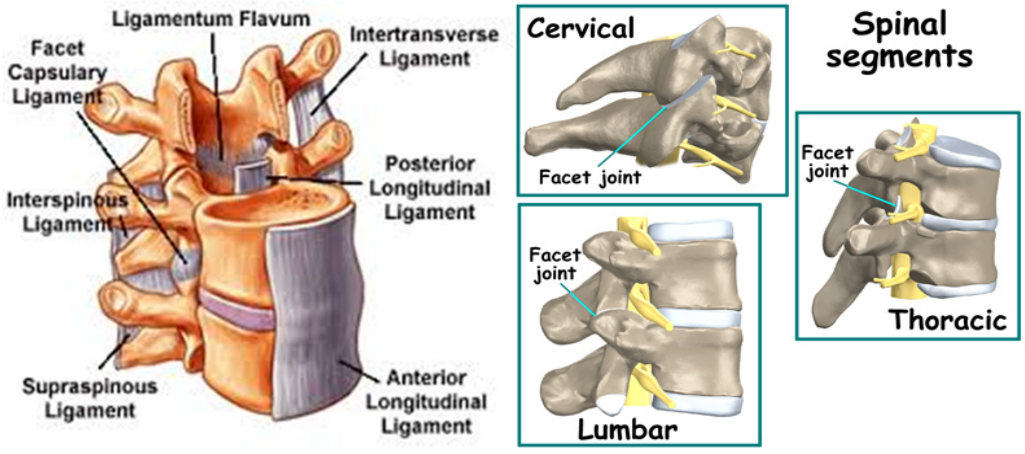
- Increase in size from the cervical to the lumbar regions.
- In fetal life exhibits one long curve that is convex posteriorly as the C-Shaped 1^0 Curve.
- 2^0 curves develop in infancy.

Thoracic and **Sacral** 1^0 curves (Convex Posteriorly/Kyphosis)

Cervical and **Lumbar** 2^0 curves (Convex Anteriorly/Lordosis).

- Develops as a result of the accommodation of forces on the skeleton to the upright posture.
- A curved vertebral column provides significant advantage to that of a straight rod in that it is able to resist much higher compressive loads (Up to 4x own body weight).

GENERAL SPINAL BIOMECHANICS



GENERAL SPINAL BIOMECHANICS
Anatomy of a typical vertebra

Consists of two major parts:

Anterior (vertebral body)

- The vertebral body is designed to be the weight-bearing structure of the spinal column.
- It is suitably designed for this task, given its block like shape with generally flat superior and inferior surfaces.
- The vertebral body is not a solid block of bone but a shell of cortical bone reinforced by trabeculae which provide resistance to compressive forces.

Posterior (vertebral or neural arch)

- Pedicles
- Laminae
- Articular processes
- Spinous process
- Transverse processes.
- The Posterior arch is designed to serve more as a bony protection of the neural arch from compression, and torsion more than bearing weight.

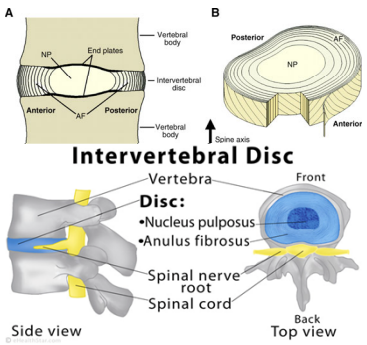
GENERAL SPINAL BIOMECHANICS
Anatomy of a typical vertebra

The intervertebral disc

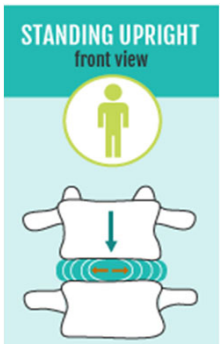
- Fibrocartilage rings with amorphous nucleus
- Has two principle functions:
- To separate two vertebral bodies, thereby increasing available motion
- To transmit load from one vertebral body to the next.
- The size of the intervertebral disk is related to both the amount of motion and the magnitude of the loads that must be transmitted.

Composed of:

- Annulus Fibrosus
- Nucleus Pulposus



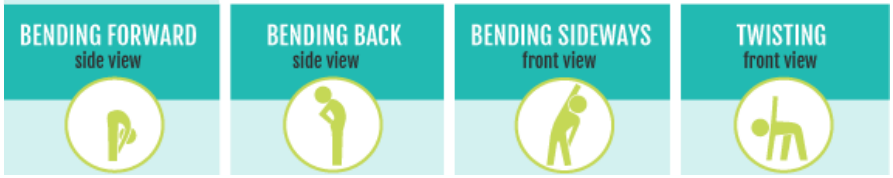
GENERAL SPINAL BIOMECHANICS
Function of the spine as a whole



The motions available to the column:

- flexion and extension
- lateral flexion
- rotation

These motions appear to occur independently of each other; however, at the level of the individual motion segment, these motions are often coupled motions.



GENERAL SPINAL BIOMECHANICS
Function of the spine as a whole

Flexion

- Anterior tilting and gliding of the superior vertebra on the vertebra below.
- Widening of the intervertebral foramen and separation of the spinous processes.

Tension in the supraspinous and interspinous ligaments resists separation of the spinous processes and thus limits the extent of flexion. Passive tension in the zygapophyseal joint capsules, ligamentum flavum, PLL, posterior anulus fibrosus, and the back extensors also imposes controls on excessive flexion.

GENERAL SPINAL BIOMECHANICS
Function of the spine as a whole

Extension

- Posterior tilting and gliding of the superior vertebra over the vertebra below and causes narrowing of the intervertebral foramen
- The spinous processes move closer together
- The amount of motion available in extension, is limited by bony contact of the spinous processes and passive tension in the zygapophyseal joint capsules, anterior fibres of the anulus fibrosus, anterior trunk muscles, and the anterior longitudinal ligament.
- The only ligament that limits extension is the anterior longitudinal ligament.

GENERAL SPINAL BIOMECHANICS
Function of the spine as a whole

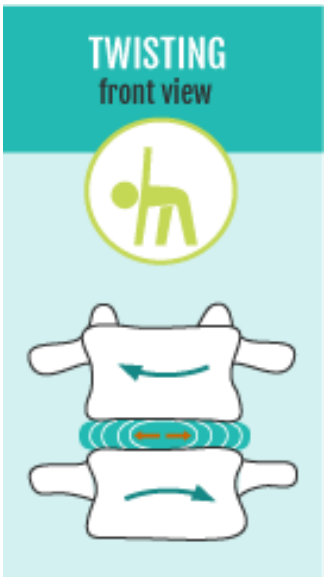
Lateral flexion

- The superior vertebra laterally tilts over the vertebra below
- Rotates, and translates over the adjacent vertebra below.

- **The anulus fibrosus** is compressed on the concavity of the curve and stretched on the convexity of the curve.
- **Passive tension** in the anulus fibers, intertransverse ligaments, and anterior and posterior trunk muscles on the convexity of the curve limits lateral flexion.
- **The direction of rotation** that accompanies lateral flexion differs slightly from region to region because of the orientation of the facets.

11

GENERAL SPINAL BIOMECHANICS
Function of the spine as a whole



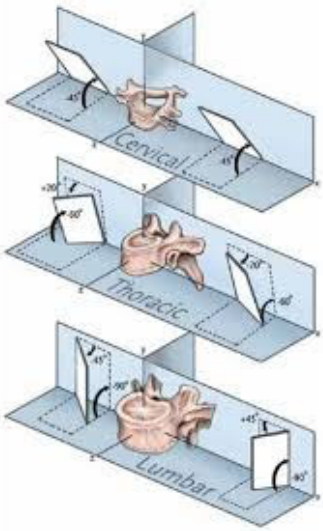
Rotation

- The superior vertebra rotates axially over the vertebra below
- Rotates, and translates (less than Lateral Flexion)

- The anulus fibrosus fibres are slightly angulated and alternate in direction in each layer. This creates a central compressive force as the disc is twisted.
- Passive tension in the anulus fibers, intertransverse ligaments, and anterior and posterior trunk muscles on the convexity of the curve limits rotation.

12

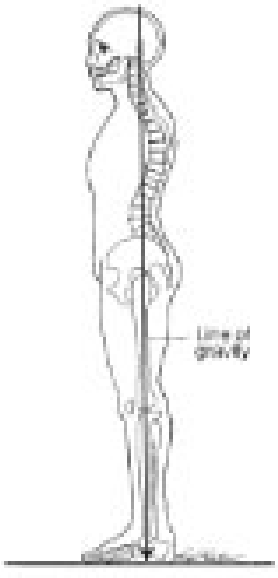
FACET JOINT ORIENTATION



Each vertebral section has small differences to accommodate force:

- The vertebrae are depicted as follows and have favourable functions to deal with the varying loads and shift of Centre of Gravity (COG) through each region.
- The angulation of the spinal facets vary between segments:
  - C-Spine: Coronal & 45^0 S/I Tilt
  - T-Spine: 40^0 to 60^0 lateral & 30^0 S/I tilt
  - L Spine: 45^0 Lateral & Saggital (90^0)

POSTURE: KEY CONCEPTS



Postural Control:

- The ability to maintain stability of the body and body segments in response to forces applied on the body.

Base of support (BOS):

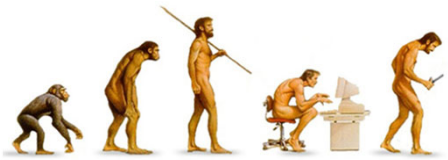
- Area bounded posteriorly by the heels and anteriorly by a line joining the tips of the toes.

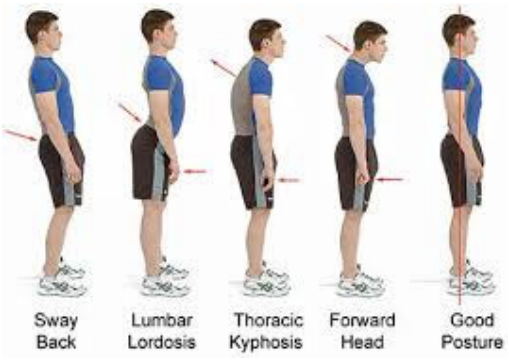
Centre of Gravity (COG):

- The line of gravitational force as it transmits down the spine to the BOS.

- **Perturbation**
  - Any sudden change in conditions that displaces the body posture away from equilibrium.

POSTURE: KEY CONCEPTS



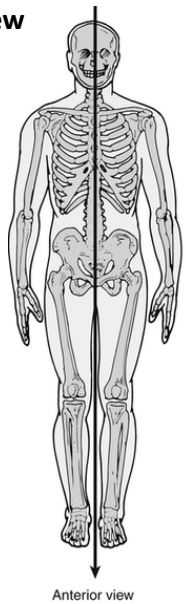


Basic Elements of Control:

- Control the body's orientation in space.
- Maintain the body's COG over the BOS, and stabilize the head with respect to the vertical so eye gaze appropriately oriented.
- Requires optimal function of an intact CNS, visual system and musculoskeletal system.
- Control depends on correct information from proprioceptors in joint capsules, tendons, ligaments, and the soles of the feet.

POSTURE: ANALYSIS

Anterior View

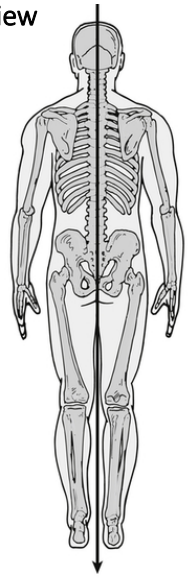


Key Landmarks to identify on Anterior view:

- Level of the eyes
- Level of the ears (EAM)
- Facial Features (Hemiplegia/ptosis/bells palsy)
- AC Joint
- Manubruim Sterni
- Antecubital Fossae
- ASIS
- Knee Joint line (Valgus/Varus)
- Patellae (Alta/Baja/Squinting/Divergent)
- Medial arch of foot
- Angulation of the first rays

POSTURE: ANALYSIS

Posterior View

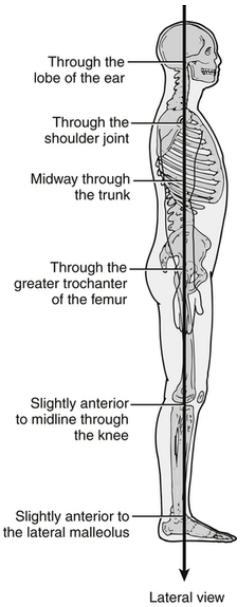


Key Landmarks to identify on Posterior view:

- EOP
- EAM
- AC Joint/ Spine of scapula on Ectomorphic patient body types
- Inferior angle of scapula
- Elbow Joint line (Carrying Angle)
- PSIS (Dimples)
- Gluteal folds
- Popliteal Fossa
- Achilles Tendons
- Calcaneous (Vulgus/Varus)

POSTURE: ANALYSIS

Lateral View



Key Landmarks to identify on Lateral view:

- Anterior/Posterior Head Carriage
- C/T Junction (Dowager's Hump/ Pottenger's Saucer)
- Thoracic Profile (Hyper/Hypo-Kyphosis)
- Chest Profile (Pectus Cavus / Pectus Carinatum)
- Anterior/Posterior pelvic tilt (ASIS/PSIS levels)
- Gluteal Profile
- Knees
  - (Semi Flexed → Posterior pelvic tilt / hyperextended/genu recurvatum)
- Foot profile (Plantar flexion or heel lift)

POSTURE

General Postural Syndromes:

Kyphosis

- Refers to an abnormal increase in the normal posterior convexity of the thoracic spine.
- May be a compensation for an increase in the lumbar spine lordosis
  - OR a result of poor postural habits
  - OR diseases like TB or AS.
- A gibbus / humpback deformity can result due to vertebral fractures.

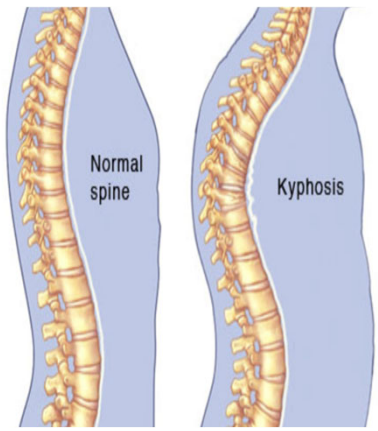
- **A Dowager's hump** is a common recognizable condition often found in post-menopausal women especially if they have osteoporosis.
- It is also a common postural problem developed from prolonged anterior head carriage and results in collapse of the vertebral bodies anteriorly increasing compression due to of a lack of anterior support resulting in a 'hump'.

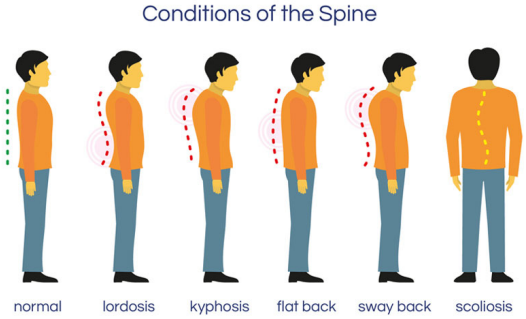
19

POSTURE

General Postural Syndromes:

Kyphosis





20

POSTURE

General Postural Syndromes:

Scoliosis

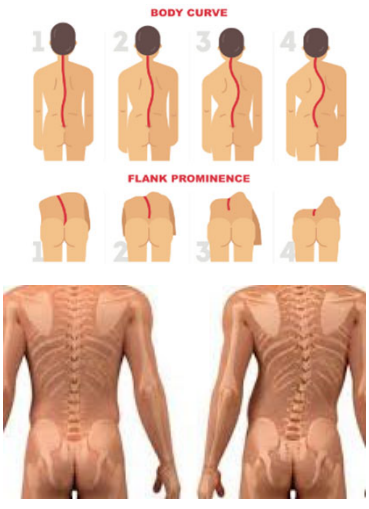
- Involves lateral flexion and rotation of the vertebrae – coupled motion.
- Adolescent idiopathic type makes up 80% of all scoliosis.
- These curves are defined as structural curves.
- Named according to the direction of the convexity and the location of the curve.
- Assymetrical growth and development causes wedging of the vertebral bodies.
- Functional / non structural scoliosis can be reversed if the cause of the curve is corrected and structural changes are not present.
- Examples: Leg Length Inequality (functional) or muscle spasm.

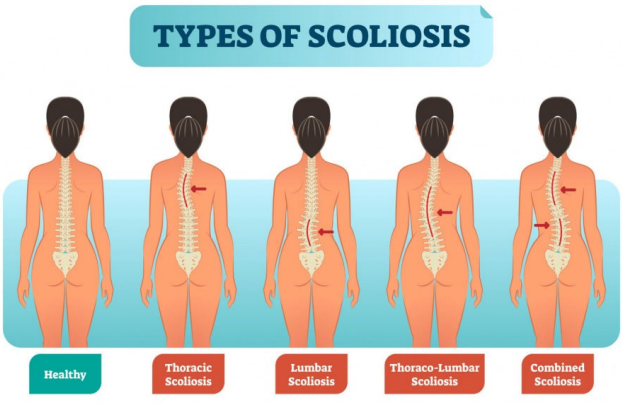
21

POSTURE

General Postural Syndromes:

Scoliosis





22

POSTURE

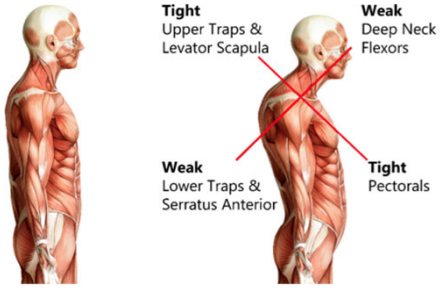
Postural Syndromes of the athlete:

Upper Crossed Syndrome (UCS)

- Tightness of the upper trapezius and Levator Scapula on the dorsal side crosses with tightness of the Pectoral muscles.
- Weakness of the deep cervical flexors ventrally crosses with weakness of the middle and lower trapezius.

- This pattern of imbalance creates joint dysfunction, at the atlanto-occipital joint, C4-C5 segment, cervicothoracic joint, glenohumeral joint, and T4-T5 segment.

- Specific postural changes are seen in UCS, including forward head posture, increased cervical lordosis and thoracic kyphosis, elevated and protracted shoulders, and rotation or abduction and winging of the scapulae.



POSTURE

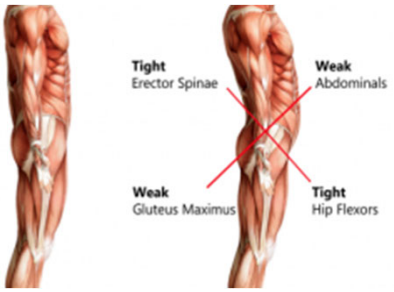
Postural Syndromes of the athlete:

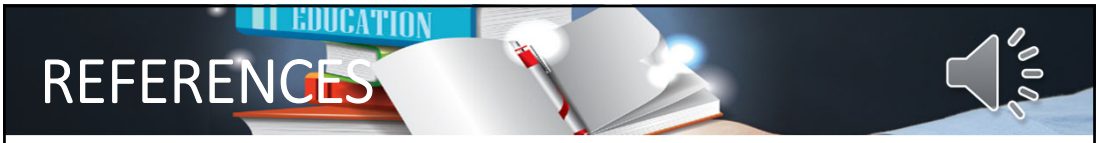
Lower Crossed Syndrome (LCS)

- **Tightness** of the thoracolumbar extensors on the dorsal side crosses with the Hip Flexor muscles.
- **Weakness** of the deep abdominal muscles ventrally crosses with weakness of the gluteal muscles.

- This pattern of imbalance creates joint dysfunction, particularly at the L4-L5 and L5-S1 segments, SI joint, and hip joint.
- Specific postural changes seen in LCS include anterior pelvic tilt, increased lumbar lordosis, lateral lumbar shift, lateral leg rotation, and knee hyperextension.

- If the lordosis is deep and short, then imbalance is predominantly in the pelvic muscles; if the lordosis is shallow and extends into the thoracic area, then imbalance predominates in the trunk muscles.





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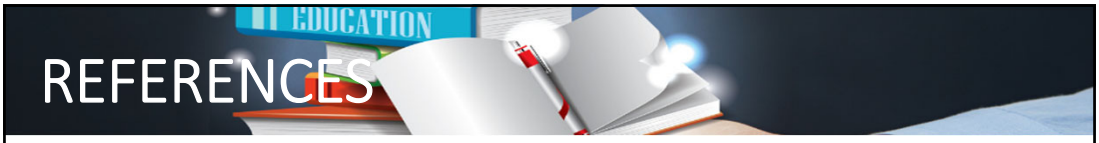

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