BIOMECHANICS OF POSTURE

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Definition

Posture is the attitude assumed by the body either with support during muscular inactivity,or by means of the co-ordinated action of many muscles working to maintain stability

INTRODUCTION

- Static and Dynamic Posture
- Posture Control
- Major Goals and Basic Elements of Control

Static and Dynamic Posture

- Static- body and its segments are aligned and maintained.Eg's Sitting, Standing.
- Dynamic- body or its segments are moving.Eg's Walking, Running

Erect bipedal stance

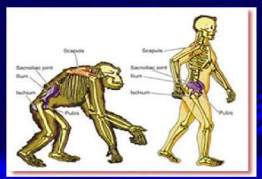
Advantage: freedom for upper extremities

Disadv: -increases work of heart
-increase stress on vertebral col.,pelvis,LE
-reduces stability
-small BOS and high COG

Quadrupedal stance

-Body weight is distributed b/w UE and LE
-Large BOS and low COG

Erect bipedal stance (Vs) Quadrupedal stance



Postural Control

It is a persons' ability-maintain stability of body and body segments in response to forces that disturb the bodys' structural equilibrium

- Posture control depends on integrity of CNS,visual, vestibular and musculoskeletal system
- It also depends on information from receptors located in and around joints (jt.capsules,tendons and ligaments) and from the sole of feet

Major Goals and Basic Elements of Control

Major goals:

- Control the bodys' orientation
- Maintain bodys' COG over BOS
- Stabilize the head vertically- eye gaze is appropriately oriented

-Absent or altered inputs:

- In absence of normal gravitational force in weightless conditions during space flight
- Occurs in decreased sensation of LE

-Altered outputs:

- Inability of the muscles to respond app. to signals from the CNS
- ms of a person in peripheral nerve damage

Muscle synergies

- "PERTURBATION" is any sudden change in conditions that displaces the body posture away from equilibrium

Perturbation

- sensory (altering of visual input)
- mechanical (displacements- movts of body segments or of entire body)

Postural responses to perturbations caused by either platform or by pushes or pulls are called REACTIVE or COMPENSATORY response

These responses are a.k.a SYNERGIES or STRATEGIES

Synergies

- Fixed- support synergies
- Change-in-support synergies

Fixed-support synergies:

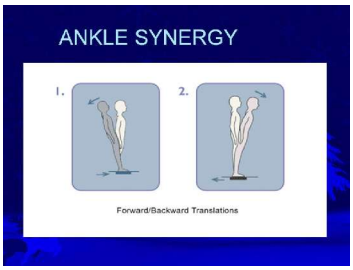
patterns of muscle activity in which the BOS remains fixed during the perturbation and recovery of equilibrium

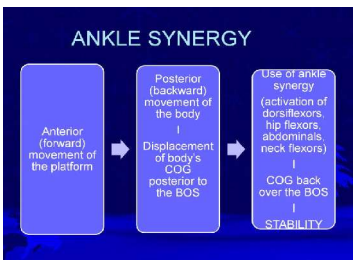
- stability is regained through movements of parts of the body but,the feet remain fixed on BOS

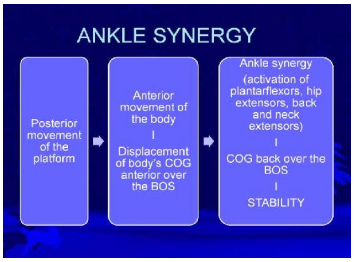
eg:Ankle synergy,Hip synergy

Ankle Synergy

Ankle synergy consists of discrete bursts of muscle activity on either the anterior or posterior aspects of the body that occur in a distal-to-proximal pattern in response to forward and backward movements of the supporting platform respectively







Hip Synergy

Hip synergy consists of discrete bursts of muscle activity opposite to ankle pattern in a proximal-distal pattern of activation

Change-in-support Synergies

- Includes stepping (forward,backward, sideways) and grasping (using one's hands to grasp a bar or other fixed support) in response to movements of the platform
- Maintains stability in the instance of large perturbation

Head Stabilizing Strategies

- Proactive strategy: occur in anticipation of initiation of internally generated forces
- Used in dynamic equilibrium situation

Eg: maintain the head during walking

Strategies for maintaining the vertical stability of head

- Head stabilization in space (HSS)
- Head stabilization on trunk (HST)

- HSS : modification of head position in anticipation of displacements of the body's COG
- HST : head and trunk move as a single unit

Kinetics and Kinematics of Posture

➢External forces: Inertia,Gravity and Ground Reaction Forces(GRF's)

➢Internal forces: muscle activity,passive tension in ligaments,tendons,jt. capsules and other soft tissue structures

Inertia

- In the erect standing posture the body undergoes a constant swaying motion called postural sway or sway envelope
- Sway envelope for a normal individual,standing with 4" b/w the feet – 12° in sagittal plane and 16° in frontal plane

Gravity

- Gravitational forces act downward from the body's COG
- In static erect standing posture,the LOG must fall within the BOS,which is typically the space defined by the two feet

GROUND REACTION FORCES

- Whenever the body contacts the ground, the ground pushes back on the body.

↓

GRF

- GRF is a composite (resultant) force having 3 components
  - One vertical component force
  - Two horizontal component forces

medial-lateral anterior-posterior

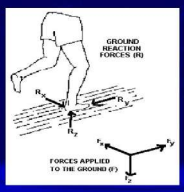
Ground Reaction Forces

•GRFV is equal in magnitude but opposite in direction to the gravitational force in erect standing posture

•The point of application of GRFV is at the body's centre of pressure(COP)

•COP is located in the foot in unilateral stance and b/w the feet in bilateral standing postures

GROUND REACTION FORCES



Coincident Action Lines

The GRFV and the LOG have coincident action lines in static erect posture

Optimal or Ideal Posture

-An ideal posture is one in which the body segments are aligned vertically and LOG passes through all the jt. axes

-Normal body structures makes it impossible to achieve,but is possible to attain a posture,close to ideal one

-In normal standing posture,the LOG falls close to,but not through most jt. axes

-Compressive forces are distributed over the weight bearing surfaces of jt's; no excessive tension exerted on ligamentous or required muscles

Analysis of Posture

•Skilled observational analysis of posture involves identification of the location of body segments relative to the LOG

•Body segments-either side of LOG-symmetrical

•A plumb line is used to represent the LOG

•Postural analysis may be performed using; radiography,photography,EMG, electrogoniometry,force plates, 3-dimensional computer analysis

LATERAL VIEW : Optimal alignment in the Sagittal plane

LOG : Anterior to joint axis	Gravitational Moment : Dorsiflexion
ANKLE	
Passive Opposing Forces : ----------	Active Opposing Forces : Soleus

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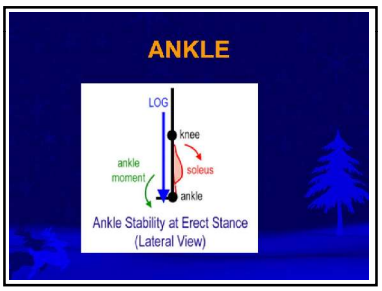
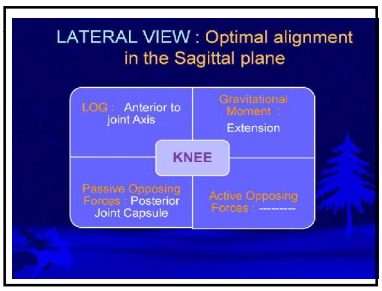
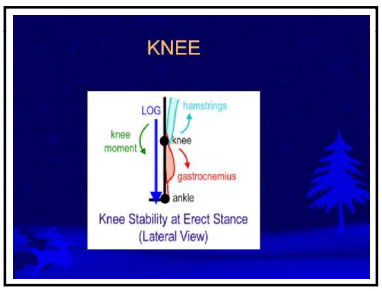
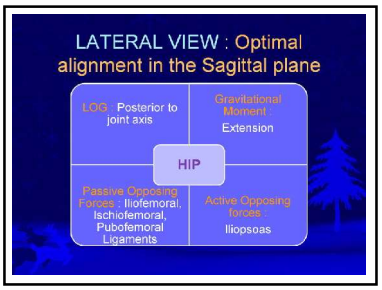
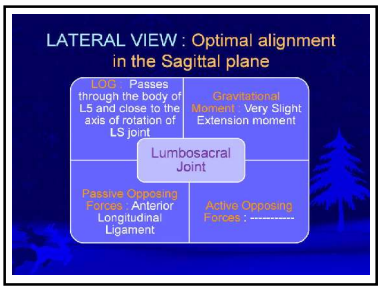
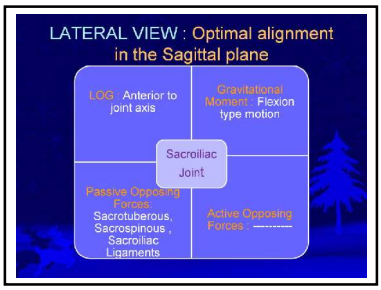

ANKLE
LOG
knee
soleus
ankle moment
ankle
Ankle Stability at Erect Stance
(Lateral View)

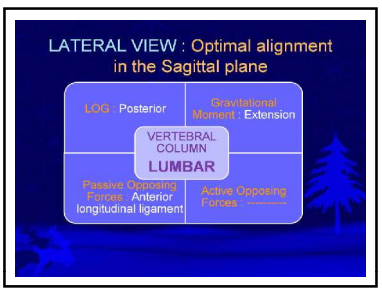

LATERAL VIEW : Optimal alignment in the Sagittal plane
LOG : Anterior to joint Axis
Gravitational Moment : Extension
KNEE
Passive Opposing Forces : Posterior Joint Capsule
Active Opposing Forces : ---------

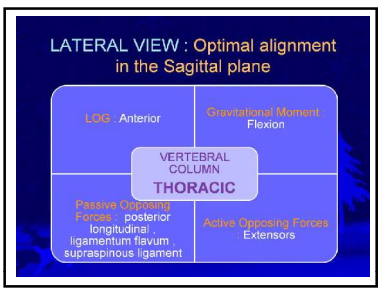

KNEE
LOG
hamstrings
knee moment
knee
gastrocnemius
ankle
Knee Stability at Erect Stance
(Lateral View)

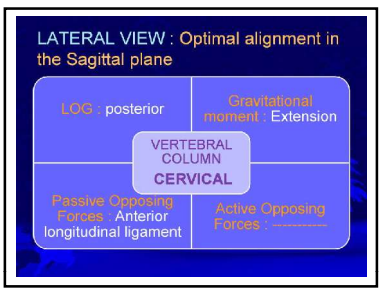

LATERAL VIEW : Optimal alignment in the Sagittal plane
LOG : Posterior to joint axis
Gravitational Moment : Extension
HIP
Passive Opposing Forces : Iliofemoral, Ischiofemoral, Pubofemoral Ligaments
Active Opposing forces : Iliopsoas

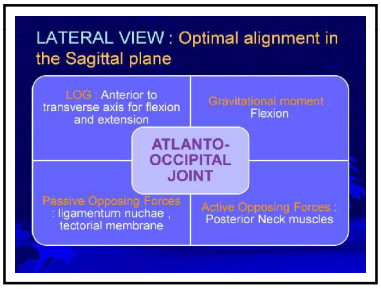

LATERAL VIEW : Optimal alignment in the Sagittal plane
LOG : Passes through the body of L5 and close to the axis of rotation of LS joint
Gravitational Moment : Very Slight Extension moment
Lumbosacral Joint
Passive Opposing Forces : Anterior Longitudinal Ligament
Active Opposing Forces : ----------


LATERAL VIEW : Optimal alignment in the Sagittal plane
LOG : Anterior to joint axis
Gravitational Moment : Flexion type motion
Sacroiliac Joint
Passive Opposing Forces : Sacrotuberous, Sacrospinous , Sacroiliac Ligaments
Active Opposing Forces : ---------


LATERAL VIEW : Optimal alignment in the Sagittal plane
LOG : Posterior
Gravitational Moment : Extension
VERTEBRAL COLUMN
LUMBAR
Passive Opposing Forces : Anterior longitudinal ligament
Active Opposing Forces : ----------


LATERAL VIEW : Optimal alignment in the Sagittal plane
LOG : Anterior
Gravitational Moment : Flexion
VERTEBRAL COLUMN
THORACIC
Passive Opposing Forces : posterior longitudinal , ligamentum flavum , supraspinous ligament
Active Opposing Forces Extensors


LATERAL VIEW : Optimal alignment in the Sagittal plane
LOG : posterior
Gravitational moment : Extension
VERTEBRAL COLUMN
CERVICAL
Passive Opposing Forces : Anterior longitudinal ligament
Active Opposing Forces : ----------



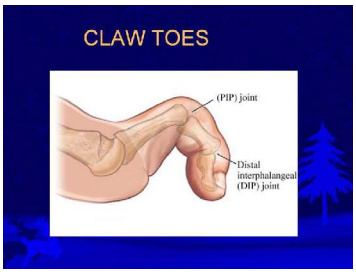
Lateral view- Deviations from optimal alignment

- Foot and Toes:
  - -Claw toe
  - -Hammer toe
- Knee:
  - -Flexed Knee Posture
  - -Genu Recurvatum
- Pelvis:
  - -Excessive Anterior Pelvic Tilt

- Vertebral coloumn:
  - -Lordosis
  - -Kyphosis
- Head:
  - -Forward Head Posture

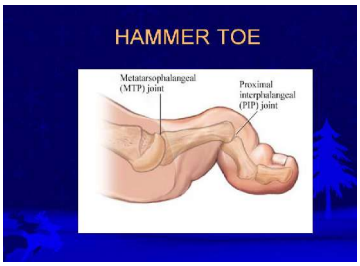
Claw Toes

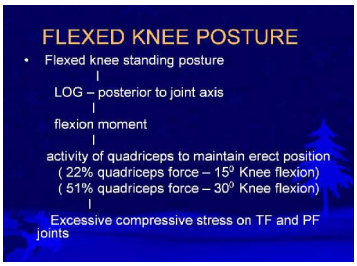
- Deformity of toes- hyperextension of MTP jt., flexion of PIP and DIP jt.'s
- Callus- dorsal aspect of flexed phalanges
- Affects all toes (2nd through 5th)



Hammer Toe

- Deformity-hyperextension of MTP and DIP jt.'s
  - flexion of PIP jt.
- Callus on superior surface of PIP jt.'s





FLEXED KNEE POSTURE

knee flexion in upright stance
↓
hip flexion and ankle dorsiflexion
↓
LOG – anterior to hip joint axis and more anterior to ankle joint axis
↓
flexion moment at hip & more dorsiflexion moment at ankle
↓
hip extensors muscle activity & increased soleus muscle activity
↓
more compressive stress on joints & more energy expenditure

GENU RECURVATUM

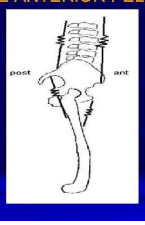
GENU RECURVATUM

LOG is very anterior to knee joint axis
↓
increase in the extensor moment
↓
considerable tension stress in posterior joint capsule (adaptive lengthening)
↓
abnormal compression on anterior joint surfaces on the femoral condyles and anterior portion of tibial plateaus
↓
degenerative changes in joint surfaces

EXCESSIVE ANTERIOR PELVIC TILT

DEVIATION	COMPRESSION	DISTRACTION	STRETCHING	SHORTENING
Excessive anterior tilt of pelvis	Posterior vertebral bodies Interdiskal pressure L5-S1 increased	Lumbosacral angle increased Shearing forces at L5-S1 Likelihood of forward slippage of L5 on S1 increased	Abdominals	Iliopsoas

EXCESSIVE ANTERIOR PELVIC TILT



Excessive anterior pelvic tilt
↓
lower lumbar vertebra are forced anteriorly
↓
upper lumbar vertebra move posteriorly to keep head over sacrum
↓
Increase in Lumbar lordosis
↓
LOG is at a greater distance from the lumbar joint axis
↓
Extension moment increased
↓
Posterior convexity of thoracic curve & anterior convexity of cervical curve increases

Lordosis

It refers to an abnormal increase in the normal anterior convexities of either the cervical or lumbar regions of the vertebral column

LORDOSIS (lumbar)

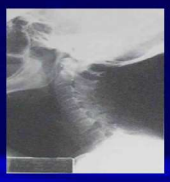
DEVIATION	COMPRESSION	DISTRACTION	STRETCHING	SHORTENING
Excessive Lumbar Lordosis	Posterior vertebral bodies and facet joints Interdiskal pressures increased Intervertebral foramina narrowed	Anterior annulus fibers	Anterior longitudinal ligament	Posterior longitudinal ligament Interspinous ligaments Ligamentum Flavum Lumbar extensors

LORDOSIS

LORDOSIS (cervical)

DEVIATION	COMPRESSION	DISTRACTION	STRETCHING	SHORTENING
Excessive cervical lordosis	Posterior vertebral bodies and facet joints Interdiskal pressure increased Intervertebral foramina narrowed	Anterior annulus fibers	Anterior longitudinal ligament	Posterior ligaments Neck extensors

LORDOSIS (cervical)



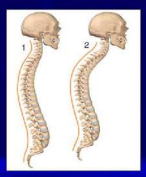
Kyphosis

It refers to an abnormal increase in the normal posterior convexity of the thoracic vertebral column

KYPHOSIS

DEVIATION	COMPRESSION	DISTRACTION	STRETCHING	SHORTENING
Excessive dorsal kyphosis	Anterior vertebral bodies Intradiskal pressures increased	Facet joint capsules and posterior annulus fibers	Dorsal back extensors Posterior ligaments Scapular muscles	Anterior longitudinal ligament Upper abdominals Anterior shoulder girdle musculature

KYPHOSIS



Gibbus

•a.k.a Hump Back is a deformity that may occur as result of TB

•It forms a sharp posterior angulation in the upper thoracic region of vertebral column

GIBBUS

Dowager's Hump

•Found in post-menopausal women with osteoporosis

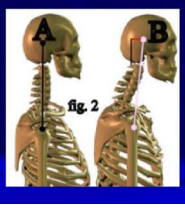
•Anterior aspect of bodies of series of vertebra collapse due to osteoporotic weakening and therefore, increase in post. convexity of thoracic area

DOWAGER'S HUMP

FORWARD HEAD POSTURE

DEVIATION	STRUCTURAL COMPONENTS	LONG-TERM EFFECTS ON STRUCTURAL FUNCTION
FORWARD HEAD	Constant isometric muscle tension to support head	Muscle ischemia, pain, fatigue

FORWARD HEAD POSTURE



FORWARD HEAD POSTURE

FORWARD HEAD POSTURE

DEVIATION	STRUCTURAL COMPONENTS	LONG-TERM EFFECTS ON STRUCTURAL FUNCTION
INCREASE IN CERVICAL LORDOSIS	Narrowing of intervertebral foramina and compression of nerve roots Compression of zygapophyseal joint surfaces	Damage to nerve roots causing paralysis Damage to cartilage and increased possibility of arthritic changes

FORWARD HEAD POSTURE

DEVIATION	STRUCTURAL COMPONENTS	LONG-TERM EFFECTS ON STRUCTURAL FUNCTION
INCREASE IN CERVICAL LORDOSIS	Compression of posterior annulus fibrosus Adaptive shortening of posterior ligaments	Changes in collagen and early disk degeneration Decrease in cervical flexion ROM

FORWARD HEAD POSTURE

DEVIATION	STRUCTURAL COMPONENTS	LONG-TERM EFFECTS ON STRUCTURAL FUNCTION
INCREASE IN CERVICAL LORDOSIS	Adaptive lengthening of anterior ligaments Increase in compression on posterior vertebral bodies	Decrease in anterior stability Osteophyte formation

FORWARD HEAD POSTURE

DEVIATION	STRUCTURAL COMPONENTS	LONG-TERM EFFECTS ON STRUCTURAL FUNCTION
MEDIAL ROTATION OF SCAPULA	Adaptive lengthening of upper posterior back muscles Adaptive shortening of anterior shoulder muscles	Increase in dorsal kyphosis and loss of height Decrease in vital capacity and ROM of shoulder and arm

Optimal alignment-Anterior aspect

Body segments	LOG location
• Head	• Middle of forehead,nose,chin
• Chest	• Middle of xyphoid process
• Abdomen/hips	• Through umbilicus
• Hips/pelvis	• Line equidistant from rt and lt ASIS and through symphysis pubis
• Knees	• Equidistant from medial femoral condyles
• Ankles/feet	• Equidistant from the medial malleoli

Optimal alignment-Posterior aspect

- Head
- Shoulders/spine
- Hips/pelvis
- Knees
- Ankles/feet
- Middle of head
- Along vertebral column in a straight line,which should bisect the back into two symmetrical halves
- Through gluteal cleft of buttocks and equidistant from PSIS
- Equidistant from medial jt. aspects
- Equidistant from medial

Anterior-posterior View – Deviations from the optimal alignment

•Foot and Toes: -Pes planus
-Pes cavus
-Hallux valgus
•Knees: -Genu valgum
-Genu varum
-Squinting or cross-eyed patella
-Grasshopper eyes patella
•Vertebral column: -Scoliosis

Pes Planus(flat foot)

•It is characterized by reduced or absent arch,which may be either rigid or flexible

•Talar head-displaced-ant.,med.,inf. and causes depression of navicular bone and lenghthening of tibialis post. muscle

•Navicular lies below the Feiss line and may even rest on the floor in severe conditions

•**Rigid flat foot:** it is a structural deformity where the medial longitudinal arch of foot is absent in NWB,WB and toe standing

•**Flexible flat foot:** the arch is reduced during normal wt. bearing,but reappears during toe standing and non wt. bearing

Pes Cavus

•The medial longitudinal arch of foot may be unusually high
•A high arch is called pes cavus

•It is a more stable position of foot than pes planus,Wt. borne-lat. borders of foot

•Lateral lig. and peroneus longus muscle stretched

Hallux Valgus

•It is a very fairly common deformity- medial deviation of the first metatarsal at tarsometatarsal jt. and lateral deviation of phalanges at MTP jt.

•Bursa on the medial aspect of first MTP head may be inflammed- Bunion

Genu Valgum (knock knee)

•In genu valgum,mechanical axes of LE are displaced lat. and patella may be displaced lat.

•If genu valgum exceeds 30° and persists beyond 8yrs of age – structural changes occur

•Medial knee jt. structures – abnormal tensile or distraction stress
•Lateral knee jt. Structures – abnormal compressive stress

Genu varum (bow legs)

•Knees are widely seperated when the feet are together
•Cortical thickening on medial concavity – on femur and tibia – increased compressive force
•Patella may be displaced medially

Squinting or Cross-Eyed Patella

•A.k.a in-facing patella

•Tilted/rotated position of patella

•Superior medial pole of patella faces medially

•Inferior pole faces laterally

•Q-angle may be increased

Grasshopper Eyes Patella

•High laterally displaced position of patella

•Patella faces upward and outward

Scoliosis

Lateral deviations of a series of vertebrae from the LOG in one or more regions of the spine may indicate the presence of lateral spinal curvature

Idiopathic Scoliosis

•Lateral flexion moment present
•Deviation of vertebrae with rotation
•Compression of vertebral body on the side of concavity of curve
•Therfore,inhibition of growth of vertebral body on that side
•This leads to wedging of vertebra
•Shortening of trunk muscle on concavity
•Convexity- stretching of muscles,ligaments and joint capsules

Non-structural Scoliosis

- A.k.a functional curves
- Can be reversed if the cause of curve is corrected
- These curves are a result of correctable imbalance such as limb length discrepancy or a muscle spasm

References

- Joint Structure and Function by Pamela K. Levangie & Cynthia C. Norkin (5th Edition) .

THANK YOU