# Using Biomechanical Principles in the Management of Complex Postural Deviations in Sitting

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## Using Biomechanical Principles in the Management of Complex Postural Deviations in Sitting

I. **BASIC PRINCIPLES**
   - **REVIEW OF BIOMECHANICS PRINCIPLES**
   - **GENERAL SEATING APPLICATION**

II. **MANAGING COMPLEX POSTURAL DEVIATIONS USING A BIOMECHANICAL APPROACH**

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## Managing Complex Postural Deviations

- Guidelines For Addressing Difficult Postural Problems
- Posterior Pelvic Tilt and Sliding
- Kyphosis
- Pelvic Obliquity and Scoliosis
- Abnormal Postures of the Head/Neck

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## Guidelines for Addressing Difficult Postural Problems

1. **Always ask *WHY***
   - Remember to address the source of the problem, not just the symptom
   - What is the cause of the postural deviation?
2. **Always assess flexibility**
   - Correct the flexible components within comfort, accommodate fixed components.
   - The body "core" usually takes priority for orientation when there are fixed components, to maximize function

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## Guidelines for Addressing Difficult Postural Problems

3. **Simulate the basic seating equipment parameters first**
   - Determine 3 primary relative seating angles and basic dimensions, based on mat exam, then simulate.
   - Many postural problems can be solved, or lessened just by providing the correct angles and dimensions.

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## Guidelines for Addressing Difficult Postural Problems

4. **Differentiate between active movement and postural collapse**
   - If postural collapse: balance forces to decrease gravity's mechanical advantage
   - If active movement: what is cause, or what facilitates the movement?
5. **Be least restrictive - you must have a rationale for blocking movement**
   - The client or caregiver has the final say

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## Guidelines for Addressing Difficult Postural Problems

6. **Set very specific postural objectives**
   - What is this person's most optimal aligned position for health, comfort, and function?
   - Each body area
   - Especially critical if planning to do a custom contoured seating system.

## In general, you will be dealing with one of three conditions:

1. **Posture is totally flexible**
   - Goal is neutral resting alignment, MAX BALANCE WITH MINIMUM EFFORT, control of undesired movement patterns, and support of functional movement
2. **Posture is partially fixed, with flexibility**
   - Goal is to maintain optimal alignment, by accommodating fixed component, and then blocking the abnormal movement or postural collapse causing the increase in deviation
3. **Posture is totally fixed, with no flexibility**
   - Support the body area in the most appropriate **orientation** for function, comfort and health

## Managing Complex Postural Deviations

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## POSTERIOR PELVIC TILT & SLIDING

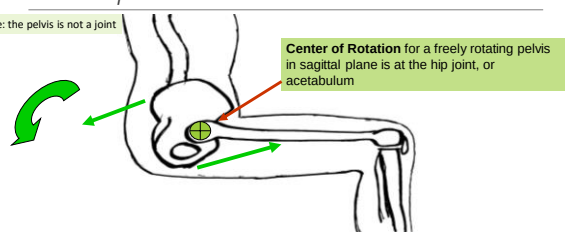
- Biomechanical analysis of posture
- Determine cause of postural deviation
- Intervention strategies/biomechanical approach

## Posterior Pelvic Tilt
*Postural Analysis*

- **Pelvic Tilt Movement – Rotational**
- **Pelvic Tilt Movement – Translational**
- **Hip Extensor Thrust Movement**
- **Pelvic Tilt Movement Summary**

## Rotational Pelvic Tilt Movement
*- Description*

Note: the pelvis is not a joint



## Rotational Pelvic Tilt Movement *– Direction of Movement*

The direction of movement of different areas of the pelvis depends on its starting position.

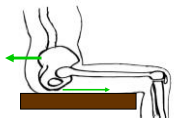


Fig. 1: Slight anterior tilt start position

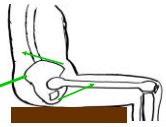


Fig 2: Posterior tilt start position

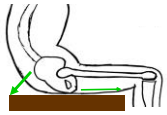


Fig.3: Severe PPT start position

**How does this impact seating intervention?**

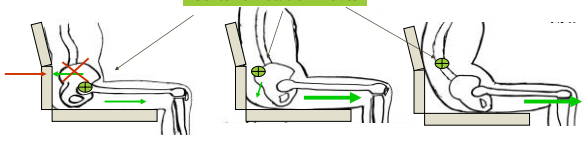
**What is relationship to hip flexion/extension?**

## Posterior Pelvic Tilt *Postural Analysis*

- **Pelvic Tilt Movement – Rotational**
- **Pelvic Tilt Movement – Translational**
- **Hip Extensor Thrust Movement**
- **Pelvic Tilt Movement Summary**

## Pelvic Tilt Movement *– Translational*

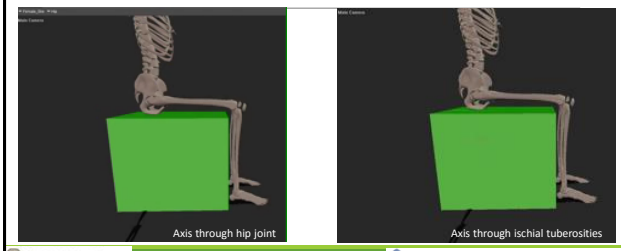
**Center of rotation moves**



Once you block one component of a movement, the movement often changes.

Posterior Pelvic Tilt movement changes from being purely rotational, to a combination of rotational and translational movement, and the individual slides forward on the seat

## Axis of Rotation




## Posterior Pelvic Tilt
*Postural Analysis*

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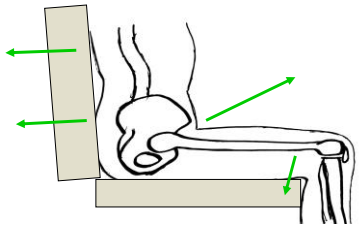
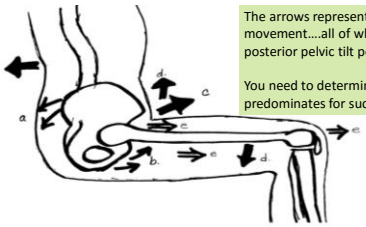
## Hip Extensor Thrust Movement



## Posterior Pelvic Tilt
### *Postural Analysis*

- **Pelvic Tilt Movement – Rotational**
- **Pelvic Tilt Movement – Translational**
- **Hip Extensor Thrust Movement**
- **Pelvic Tilt Movement Summary**

## *Summary of Pelvic Tilt Movement Possibilities*



The arrows represent directions of movement….all of which may result in a posterior pelvic tilt posture.

You need to determine which movement predominates for successful intervention.

## Posterior Pelvic Tilt
### *Determine Cause*

- Limitations in range of motion of spine, hips or knees
- Inaccurate seating dimensions or seating angles
- Postural collapse into posterior tilt
- Body searching for stability
- Abnormal movement pattern with spasticity
- Adaptation to functional need

## Posterior Pelvic Tilt
*Determine objectives and intervention strategy*

**Set Objectives** based on the cause of the posterior pelvic tilt posture, and overall functional goals of client

***Ask yourself:***
- What is this client's optimal pelvic tilt position and overall thigh/trunk angle?
- What movements need to be blocked/reduced?
- What movements need to be allowed?

## Posterior Pelvic Tilt
*Intervention Strategies*

- Accommodate Range of Motion Limitations in Hips, Knees and Spine
- Adjust/Correct Primary Seating Dimensions and angles
- Block Active Movement or Postural Collapse into Posterior Tilt
- Manage severe extensor tone and spasticity
- Adapt seating environment to accommodate functional needs as necessary

*Case example: Limited hip flexion range of motion*

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*Limited hip flexion range of motion*

The specific Thigh to Trunk Angle required in order to maintain optimal pelvic/spinal alignment should be determined by an experienced practitioner as part of the initial seating assessment

## Posterior Pelvic Tilt
### *Intervention Strategies*

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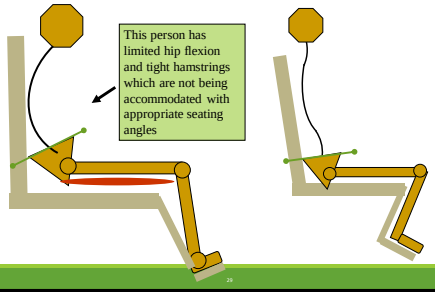
## Adjust primary seating angles and dimensions




## Adjust primary seating angles and dimensions

**Seat to back support angle**

**Seat to lower leg support angle**

**Effective seat depth**

## Posterior Pelvic Tilt
### *Intervention Strategies*

- Accommodate Range of Motion Limitations in Hips, Knees and Spine
- Adjust/Correct Primary Seating Dimensions and angles
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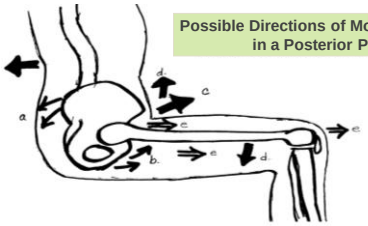
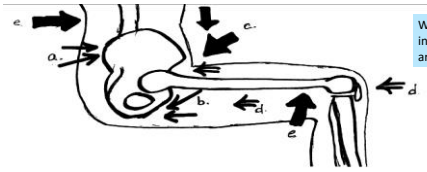
## Block Undesired Movement or Collapse

**Possible Directions of Movement Resulting in a Posterior Pelvic Tilt**



## Block Undesired Movement or Collapse

**Possible Blocking Forces Required**



What type of seating interventions do these arrows represent?

## Block Undesired Movement or Collapse

- Blocking the top of the pelvis from moving backwards (and downward)
- Blocking the bottom of the pelvis from rotating forward/upward
- Blocking hip extensor thrust
- Blocking forward translational movement, or sliding

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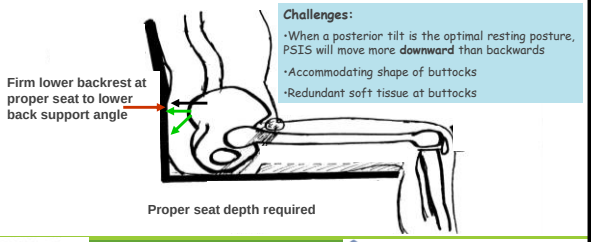
Blocking the top of the pelvis from moving back and down:
***Using a firm lower back support surface contacting sacrum***




***Challenges:***

- When a posterior tilt is the optimal resting posture, PSIS will move more **downward** than backwards
- Accommodating shape of buttocks
- Redundant soft tissue at buttocks

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## Block Undesired Movement or Collapse

- Blocking the top of the pelvis from moving backwards (and downward)
- Blocking the bottom of the pelvis from rotating forward/upward
- Blocking hip extensor thrust
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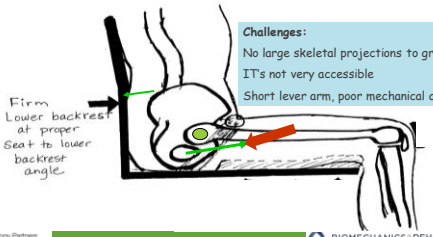
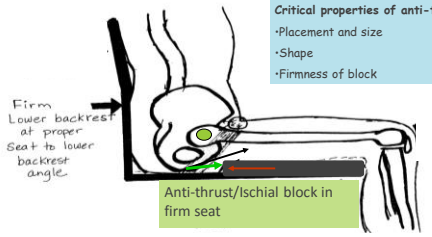
Blocking the bottom of the pelvis from rotating forward / upward
***Requires a posterior/inferiorly directed force at bottom of pelvis***




**Challenges:**
No large skeletal projections to grab
IT's not very accessible
Short lever arm, poor mechanical advantage



Blocking the bottom of the pelvis from rotating forward/upward:
***Using an Anti-Thrust Seat design/ischial block***

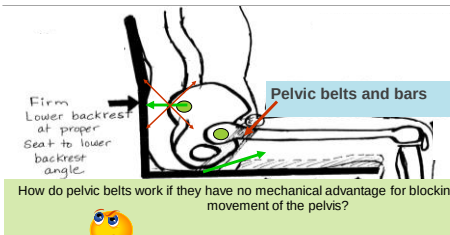



**Critical properties of anti-thrust block:**
·Placement and size
·Shape
·Firmness of block

Anti-thrust/Ischial block in firm seat



Blocking the bottom of the pelvis from rotating forward / upward :
***Using Pelvic Straps and Bars***




**Pelvic belts and bars**

How do pelvic belts work if they have no mechanical advantage for blocking the rotational movement of the pelvis?

## Block Undesired Movement or Collapse

- Blocking the top of the pelvis from moving backwards (and downward)
- Blocking the bottom of the pelvis from rotating forward/upward
- Blocking hip extensor thrust
- Blocking forward translational movement, or sliding

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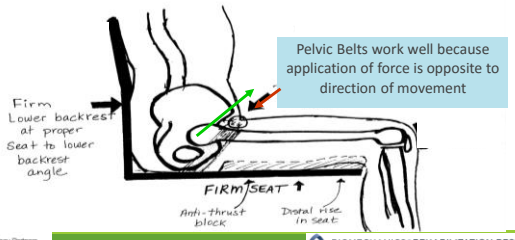
## Blocking Hip Extension Movement – Upward thrust of hips: **Using Pelvic Belts**

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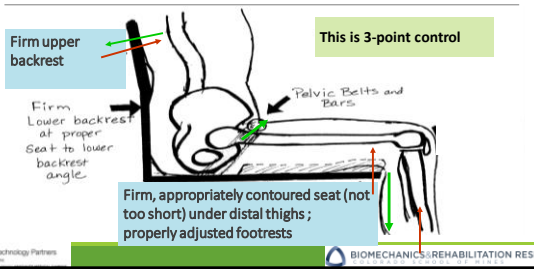
## Blocking Hip Extension - Downward movement of thighs and/or trunk extension backwards

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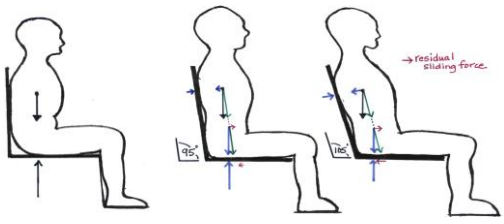
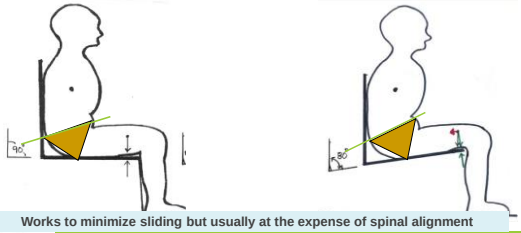
## Block Undesired Movement or Collapse

- Blocking the top of the pelvis from moving backwards (and downward)
- Blocking the bottom of the pelvis from rotating forward/upward
- Blocking hip extensor thrust
- Blocking forward translational movement, or sliding

## Increased sliding forces occur with increasing seat to back support angles

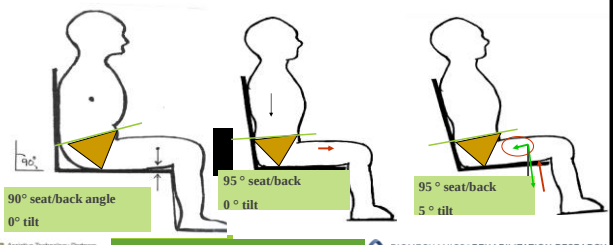



## Preventing sliding:
*Using Inclined (or "wedged") Seat*

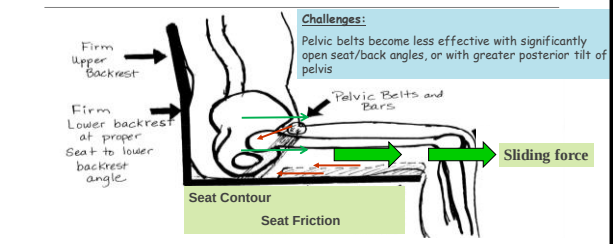



Works to minimize sliding but usually at the expense of spinal alignment

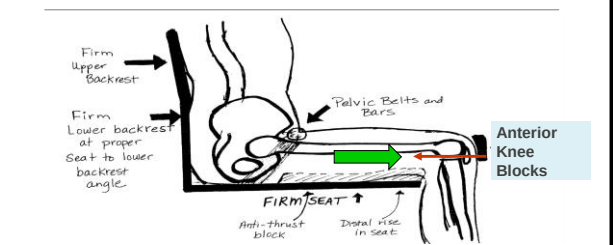
Preventing Sliding:
*Using Seat Tilt*




Preventing sliding:
*Using pelvic belt, seat friction, seat contour*




Preventing sliding:
*Using Anterior Knee Blocks*



## Posterior Pelvic Tilt
### *Intervention Strategies*

- Accommodate Range of Motion Limitations in Hips, Knees and Spine
- Adjust/Correct Primary Seating Dimensions and angles
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- Manage severe extensor tone and spasticity
- Adapt seating environment to accommodate functional needs as necessary

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## ***Suggestions for Managing Severe Extensor Tone / Spasticity***

1. Support pelvis/thighs in person's maximum, comfortable true hip flexion
2. Respect and accommodate range of motion limitations throughout body
3. Maintain thighs in significant degree of abduction to help break up extension/adduction pattern
4. Maintain knees in 90 degrees or more flexion, and block active knee extension
5. Increase contour of seat and back support surfaces

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*Examples of functional tasks which may result in a posterior pelvic tilt posture:*

Attempts to self-propel with feet require person to slide forward on seat. *Can you lower seat surface to floor height?*

Effort required to reach joystick or AAC device increases hip extensor spasticity. *What would make this task easier?*

Effort required to verbalize increases hip extensor spasticity. *What would make this task easier?*

Effort required to propel manual WC requires increased proximal stability which seating does not offer, so person "fixes" in PPT. *Increase stability through seating surface features*



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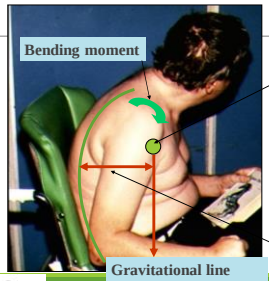
## KYPHOSIS

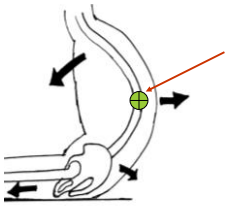
- Biomechanical analysis of posture
- Determine cause of postural deviation
- Intervention strategies/biomechanical approach

## KYPHOSIS – POSTURAL ANALYSIS

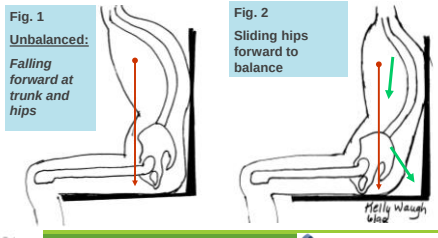



## KYPHOSIS – Postural Analysis

Direction of movement in collapsing, flexible kyphotic posture




## Fixed Kyphosis
## Typical postural adaptation



## KYPHOSIS
## Determine cause

- Anything which is causing a posterior pelvic tilt will often result in a postural kyphosis
- Postural Collapse of Trunk
  - *Low tone, muscle weakness or paralysis, fatigue*
- Active trunk flexion
  - *Flexion tone, spastic pattern, righting response, functional need*
- Fixed rib hump from scoliosis
- Fixed or Partially fixed Kyphosis Deformity

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## KYPHOSIS
## *Determine objectives and intervention strategy*

**Set Objectives** based on the cause of the kyphotic posture, and overall functional goals of client

***Ask yourself:***
- What is this client's optimal pelvic/spinal alignment and thigh/trunk angle?
- What movements need to be blocked/reduced?
- What movements need to be allowed?

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## KYPHOSIS
## Intervention Strategies

- **Address underlying posterior pelvic tilt:**
  - Accommodate hip and knee ROM limitations
  - Adjust primary seating dimensions, especially seat depth
  - Address sliding, tone, extensor spasticity/thrust, etc
- **Correct flexible kyphosis posture**
- **Accommodate fixed kyphosis deformity**

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## Accommodating a limitation in range at hips/knees to correct a flexible kyphosis

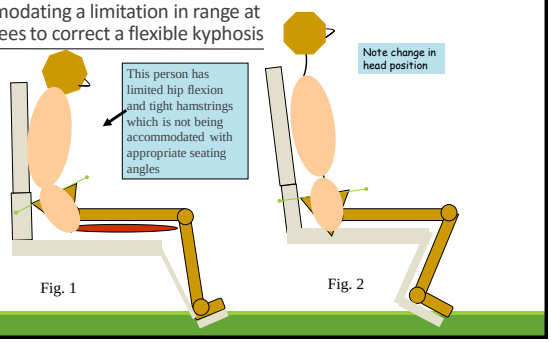


Fig. 1 Fig. 2

## KYPHOSIS
## Intervention Strategies

- **Address underlying posterior pelvic tilt:**
  - Accommodate hip and knee ROM limitations
  - Adjust primary seating dimensions, especially seat depth
  - Address sliding, tone, extensor spasticity/thrust, etc
- **Correct flexible kyphosis posture**
- **Accommodate fixed kyphosis deformity**

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## Correct flexible kyphotic posture

- Block active movement or postural collapse into kyphotic posture using 3 point control
- Encourage thoracic extension by minimizing gravity's bending moment on the spine
- Inhibit abnormal flexor tone/spasticity (or influence of primitive reflexes) with positioning, orientation in space and changes in seating angles.

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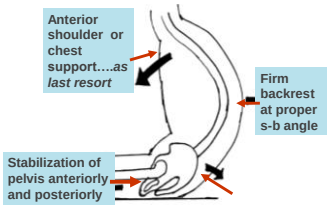
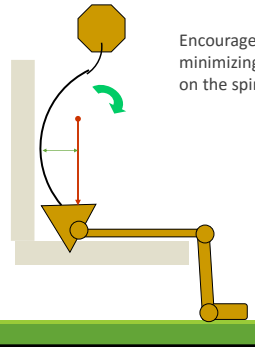
## Correct flexible kyphosis
*Using 3-point control*



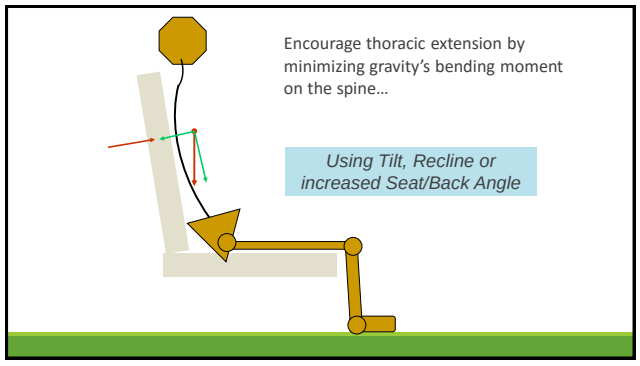

- Surface at apex of curve + posterior to sacrum to block backward collapse
- Stabilization of pelvis anteriorly to prevent sliding forward, and
- Sometimes anteriorly at chest/shoulders (try reducing gravity's pull first)

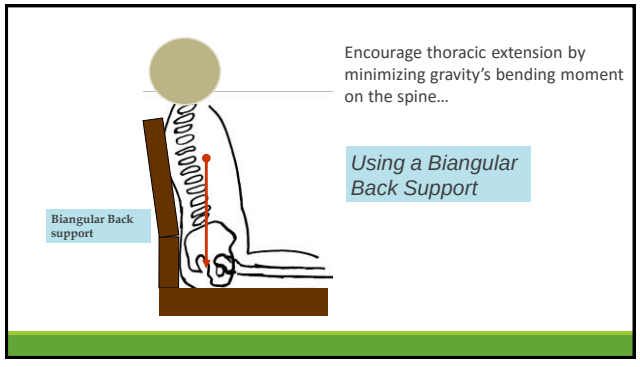
## Correct flexible kyphotic posture

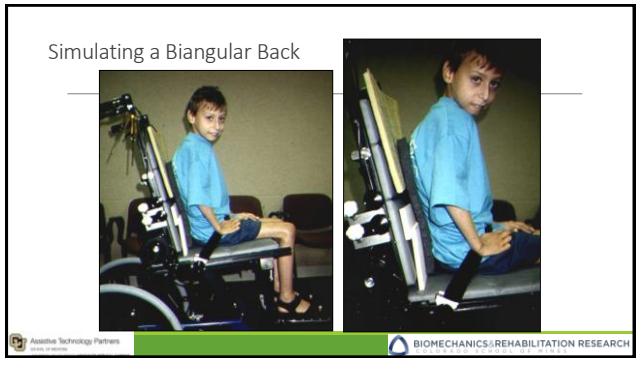
- Block active movement or postural collapse into kyphotic posture using 3 point control
- Encourage thoracic extension by minimizing gravity's bending moment on the spine
- Inhibit abnormal flexor tone/spasticity (or influence of primitive reflexes) with positioning, orientation in space and changes in seating angles.



Encourage thoracic extension by minimizing gravity's bending moment on the spine…


Encourage thoracic extension by minimizing gravity's bending moment on the spine…
*Using Tilt, Recline or increased Seat/Back Angle*


Encourage thoracic extension by minimizing gravity's bending moment on the spine…
*Using a Biangular Back Support*
Biangular Back support


Simulating a Biangular Back
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Biangular back can allow active thoracic extension

Using back support shape to accommodate increased thoracic convexity, protruding scapula, etc.

## Correct flexible kyphotic posture

- Block active movement or postural collapse into kyphotic posture using 3 point control
- Encourage thoracic extension by minimizing gravity's bending moment on the spine
- Inhibit abnormal flexor tone/spasticity (or influence of primitive reflexes) with positioning, orientation in space and changes in seating angles.

## KYPHOSIS
## Intervention Strategies

- **Address underlying posterior pelvic tilt:**
  - Accommodate hip and knee ROM limitations
  - Adjust primary seating dimensions, especially seat depth
  - Address sliding, tone, extensor spasticity/thrust, etc
- **Correct flexible kyphosis posture**
- **Accommodate fixed kyphosis deformity**

## Accommodate a Fixed Kyphosis

- Use angles and/or contour to bring the center of gravity back over the hips for improved stability and balance.
- Positioning options and backrest solutions for a person with fixed kyphosis depend on available mobility in other areas of the body

## Accommodating fixed kyphosis
Opening seat/back angle to bring CG over base of support

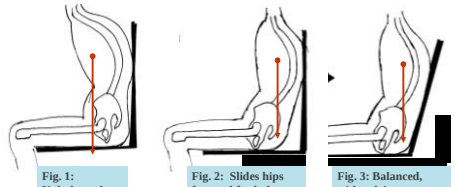
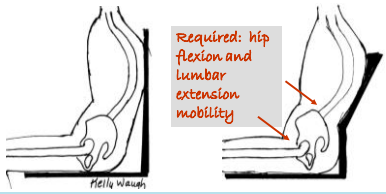


Fig. 1: Unbalanced

Fig. 2: Slides hips forward for balance, but no pelvic support

Fig. 3: Balanced, with pelvic support

Taking advantage of hip flexion and lumbar extension mobility to create greater "lift" of rib cage, help prevent sliding, while also accommodating fixed thoracic kyphosis higher up




**This shows one positioning option, if person has good hip flexion mobility as well as lumbar extension mobility below the level of the kyphosis. Custom contour likely needed**

Using custom contour to accommodate a more significant fixed kyphosis deformity

## Managing Complex Postural Deviations

- Guidelines For Addressing Difficult Postural Problems
- Posterior Pelvic Tilt and Sliding
- Kyphosis
- Pelvic Obliquity and Scoliosis
- Abnormal Postures of the Head/Neck

## Pelvic Obliquity and Scoliosis

- Biomechanical analysis of posture
- Determine cause of postural deviation
- Intervention strategies/biomechanical approach



## Biomechanics of Pelvic Obliquity Movement

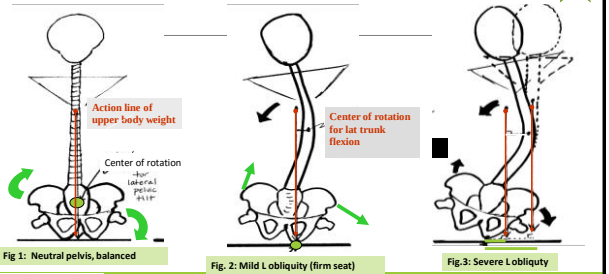


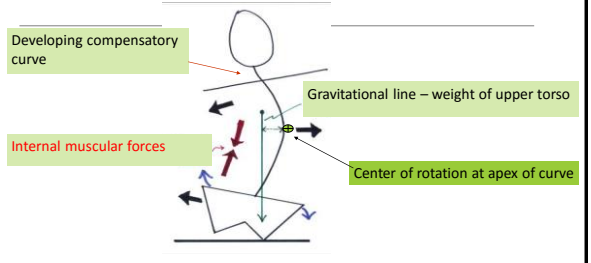

Fig 1: Neutral pelvis, balanced

Fig. 2: Mild L obliquity (firm seat)

Fig.3: Severe L obliquty



## Biomechanics of scoliosis posture



## PELVIC OBLIQUITY/SCOLIOSIS Determine Cause

1. **Range of Motion Limitation in Hips**
   - Unilateral hip flexion limitation
   - Unilateral hip internal rotation limitation
2. **Pelvic Bone Deformity or Asymmetry**
3. **Asymmetry of Buttock Tissue**

These can cause person to sit with a pelvic obliquity



## PELVIC OBLIQUITY/SCOLIOSIS Determine Cause

4. **Active Movement or Postural Collapse, due to:**
   - Asymmetry of tone, muscle strength or flexibility in the trunk
   - Active shortening one side of trunk
   - Fixing for stability
   - Adaptation to functional need
5. **Fixed or Partially Fixed Pelvic Obliquity / Scoliosis**



## PELVIC OBLIQUITY/SCOLIOSIS Intervention Strategies

- *First,* accommodate for any limitations in range of motion at hips and knees, and correct improper seating angles and dimensions in basic simulation set up
- Block active movement or postural collapse into pelvic obliquity
- Use 3-point control to block active movement or postural collapse into lateral trunk flexion or flexible scoliosis posture
- Accommodate a fixed pelvic obliquity and scoliosis
- Accommodate any fixed deformities associated with the scoliosis, such as a rib hump

## Accommodating unilateral limitation in hip flexion to help correct pelvic obliquity



## Accommodating unilateral limitation in hip internal rotation to help correct pelvic obliquity


## PELVIC OBLIQUITY/SCOLIOSIS Intervention Strategies

- *First,* accommodate for any limitations in range of motion at hips and knees, and correct improper seating angles and dimensions in basic simulation set up
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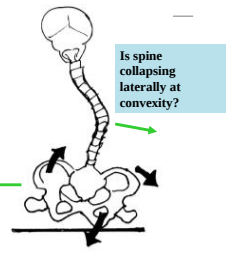
## Blocking active movement or postural collapse into pelvic obliquity

**REMEMBER: You must first analyze the direction of active movement or postural collapse**



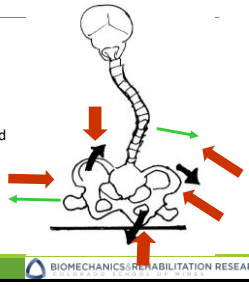

## To control pelvic obliquity movement or collapse you may need to:

Block elevation of one side of the pelvis with an inferiorly directed force

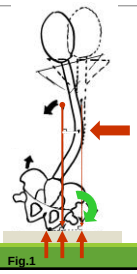
Block, or limit, depression of the other side with a superiorly directed force.

Block shifting of pelvis to side with medially directed force

Control downward/lateral collapse of spine and pelvis on low side with a superior-medial directed force



## Blocking pelvic depression on low side – *Using the seat surface and/or lateral supports*



The seat surface provides the upward force to prevent downward movement/collapse of the pelvis on the low side

So what happens if seat is very soft and forgiving?

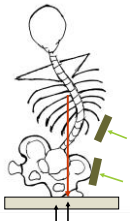
May need to add lateral trunk support

Fig.1

Blocking pelvic depression on low side –
*When person cannot tolerate high pressures under low ischial*

How to block collapse into greater obliquity while also decreasing peak pressures under the low ischial?

- Share the load!!
- Increase contour
- Tilt/recline
- Control collapse in trunk with laterals, tilt



## PELVIC OBLIQUITY/SCOLIOSIS Intervention Strategies

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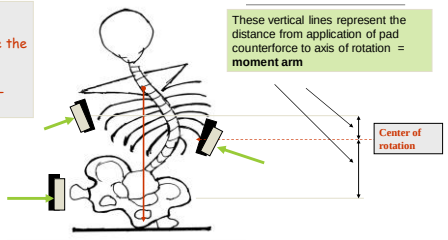
- Accommodate a fixed pelvic obliquity and scoliosis
- Accommodate any fixed deformities associated with the scoliosis, such as a rib hump

## Using 3 point control to block active movement or postural collapse into increasing scoliotic posture

Also, remember to use recline or tilt when appropriate to decrease the magnitude of the gravitational moment tending to cause lateral-inferior collapse



## PELVIC OBLIQUITY/SCOLIOSIS Intervention Strategies

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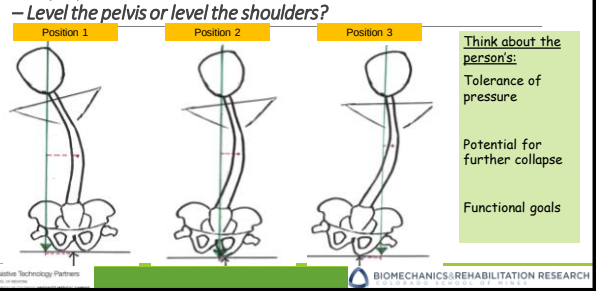
## Determining the desired orientation in frontal plane when obliquity/scoliosis is fixed

***– Level the pelvis or level the shoulders?***




Think about the person's:

Tolerance of pressure

Potential for further collapse

Functional goals

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## PELVIC OBLIQUITY/SCOLIOSIS Intervention Strategies

- *First,* accommodate for any limitations in range of motion at hips and knees, and correct improper seating angles and dimensions in basic simulation set up
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## Managing Complex Postural Deviations

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- Abnormal Postures of the Head/Neck

## Abnormal Postures of the Head/Neck

- Sagittal Plane Deviations
  - The "Forward Head" Posture
  - Full Neck Flexion
  - Full Neck Extension
- Frontal Plane Deviations – Lateral Neck Flexion
- Transverse Plane Deviations – Neck Rotation

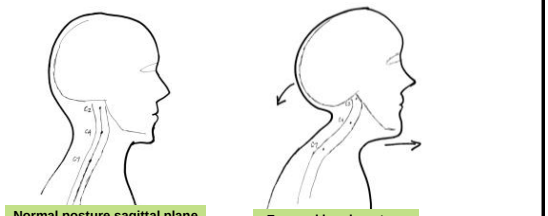
## Abnormal Postures of the Head/Neck
### *Sagittal Plane Deviations*

The "Forward Head" Posture:
- lower cervical flexion + upper cervical extension

Full Neck Flexion:
- lower + upper cervical flexion

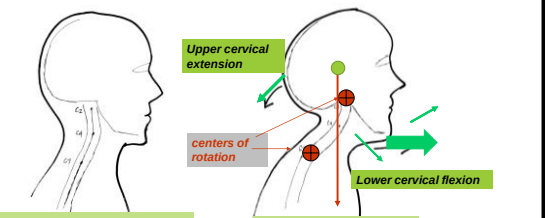
Full Neck Extension:
- lower + upper cervical extension

## The Forward Head Posture
*Direction of Movement*

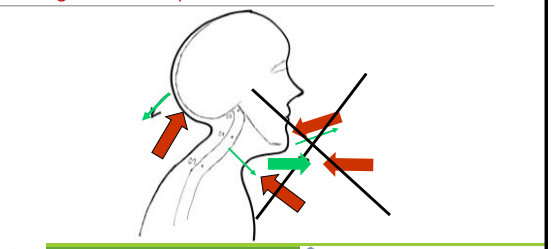



## The Forward Head Posture
*Direction of Movement*

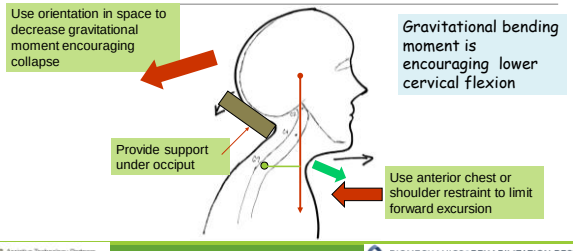
- Where is the Center of Mass of the head?
- Where are the centers of rotation?
- Where is the action line of gravity falling relative to the centers of rotation?



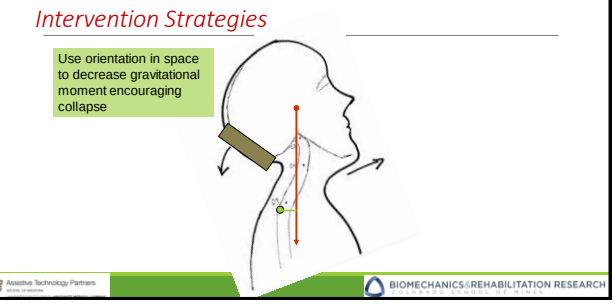

## The Forward Head Posture
*Blocking Forces Required*



## The Forward Head Posture
*Intervention Strategies*




## The Forward Head Posture
*Intervention Strategies*




## The Forward Head Posture – case study

## Abnormal Postures of the Head/Neck
### *Sagittal Plane Deviations*

The "Forward Head" Posture:

- lower cervical flexion + upper cervical extension

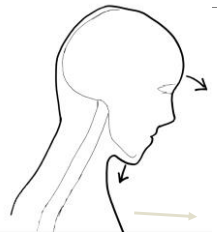
Full Neck Flexion:

- lower + upper cervical flexion

Full Neck Extension:

- lower + upper cervical extension

## Full Neck Flexion
### *Direction of Movement*



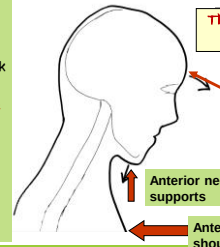
## Full Neck Flexion
### *Intervention Strategies*

A better option is to position body so that gravity is encouraging neck extension:

Use tilt or more open seat/back angle

+

Back support which supports upper thoracic extension



These are not very good options!!

Forehead straps or pads

Anterior neck supports

Anterior shoulder support

## Accommodating a large occiput

2 yrs old, SMA Type I

He has a large protruding occiput, and the headrest is pushing him into too much flexion, interfering with breathing/swallowing

Placed head support surface several inches behind back support surface to accommodate occiput

## Abnormal Postures of the Head/Neck
### *Sagittal Plane Deviations*

The "Forward Head" Posture:

- lower cervical flexion + upper cervical extension

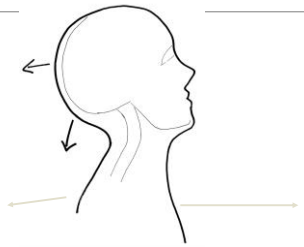
Full Neck Flexion:

- lower + upper cervical flexion

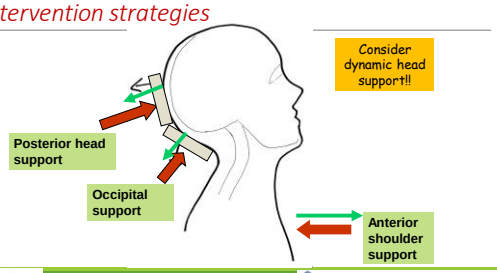
Full Neck Extension:

- lower + upper cervical extension

## Full Neck Extension
### *Direction of Movement*



## Full Neck Extension
*Intervention strategies*




## Abnormal Postures of the Head/Neck

- Sagittal Plane Deviations
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- Transverse Plane Deviations – Neck Rotation

## ABNORMAL POSTURES IN FRONTAL PLANE
*Lateral Neck Flexion*

Determine direction of movement/collapse, and think about 3 -point control

ABNORMAL POSTURES IN FRONTAL PLANE

*Lateral Neck Flexion*

Blocking lateral neck flexion with lateral temporal pad

Balancing the head when there is a fixed scoliosis

## Abnormal Postures of the Head/Neck

- Sagittal Plane Deviations
  - The "Forward Head" Posture
  - Full Neck Flexion
  - Full Neck Extension
- Frontal Plane Deviations – Lateral Neck Flexion
- Transverse Plane Deviations – Neck Rotation

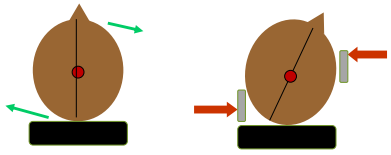
## ABNORMAL POSTURES IN TRANSVERSE PLANE
*Neck Rotation*

❖It is very restrictive to block neck rotation, as this movement is a fundamental means of interacting with one's environment through visual scanning and attention

❖However, there are times when it is necessary to control neck rotation movement in order to keep someone safe, comfortable and improve their functional skills.

## Neck Rotation
*Center of rotation and direction of movement*

Is head rotating about a central axis, so back of head moves one way, front of head another?

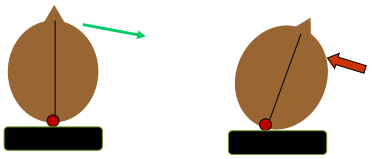


*Top view*

## Neck Rotation

*Center of rotation and direction of movement*

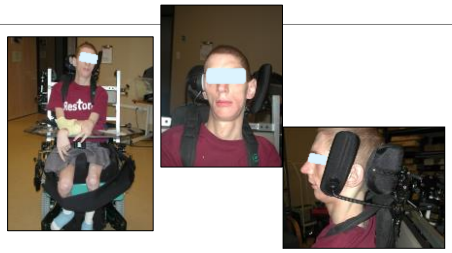
Or, is head is rotating about a point at back of head, where it rests on the headrest?



*Top view*



*Restricting head/neck rotation in one direction order to improve access to switch on other side*





*Addressing abnormal extension/rotation/lateral flexion movement*

What movements do we want to block, and what movements need to be allowed and encouraged?

*Custom head support with surfaces to block/inhibit excessive extension and lateral flexion to right, but allows right rotation to hit switch, and full left rotation*




## Questions/Comments/Discussion