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

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
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

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.

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
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

- Guidelines For Addressing Difficult Postural Problems
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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.

Center of Rotation for a freely rotating pelvis in sagittal plane is at the hip joint, or acetabulum.
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.
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Axis of Rotation

Posterior Pelvic Tilt
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Hip Extensor Thrust Movement

Starts with active hip extension
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**PART 2 – MANAGING COMPLEX POSTURES**

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### Posterior Pelvic Tilt

**Postural Analysis**

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

**Pelvic Tilt Movement Summary**

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### 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.

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### 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
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

- 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

Adjust primary seating angles and dimensions

This person has limited hip flexion and tight hamstrings which are not being accommodated with appropriate seating angles.

Seat to back support angle
Seat to lower leg support angle
Effective seat depth
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**Part 2 – Managing Complex Postures**

**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

**Block Undesired Movement or Collapse**

Possible Directions of Movement Resulting in a Posterior Pelvic Tilt

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

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

Proper seat depth required

Firm lower backrest at proper seat to lower back support angle
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

Blocking the bottom of the pelvis from rotating forward / upward:

**Using Pelvic Straps 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

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

Pelvic Belts work well because application of force is opposite to direction of movement

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

Firm upper backrest

This is 3-point control

Firm, appropriately contoured seat (not too short) under distal thighs; properly adjusted footrests
### 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

- **90° seatback angle, 0° tilt**
- **95° seatback, 5° tilt**

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

**Challenges:** Pelvic belts become less effective with significantly open seat/back angles, or with greater posterior tilt of pelvis.

Preventing sliding: Using Anterior Knee Blocks
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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

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

**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
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.

Managing Complex Postural Deviations

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KYPHOSIS

- Biomechanical analysis of posture
- Determine cause of postural deviation
- Intervention strategies/biomechanical approach
**KYPHOSIS – POSTURAL ANALYSIS**

- Center of Mass of upper body
- Gravitational line
- Bending moment

**Lever, or moment arm:** This perpendicular distance increases with increasing degree of kyphosis, increasing flexion torque on spine.

**KYPHOSIS – Postural Analysis**

*Direction of movement in collapsing, flexible kyphotic posture*

- Apex of curve acts as center of rotation

**Fixed Kyphosis**

*Typical postural adaptation*

- Fig. 1: Unbalanced: Falling forward at trunk and hips
- Fig. 2: Sliding hips forward to balance
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

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?

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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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

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.
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...
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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

Simulating a Biangular Back
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
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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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**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

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**Accommodating fixed kyphosis**

Opening seat/back angle to bring CG over base of support

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Guidelines For Addressing Difficult Postural Problems
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Managing Complex Postural Deviations

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.

Bach & Waugh, ©2016
Pelvic Obliquity and Scoliosis

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

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Biomechanics of Pelvic Obliquity Movement

- Action line of upper body weight
- Center of rotation for trunk flexion

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Biomechanics of scoliosis posture

- Developing compensatory curve
- Gravitational line – weight of upper torso
- Internal muscular forces
- Center of rotation at apex of curve
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PART 2 – MANAGING COMPLEX POSTURES

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

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

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

PELVIC OBLIQUITY/SCOLIOSIS

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PART 2 – MANAGING COMPLEX POSTURES

Blocking active movement or postural collapse into pelvic obliquity

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

- Is pelvis shifting laterally?
- Is spine collapsing laterally at convexity?

**Blocking:**
- Elevation of one side of the pelvis with an inferiorly directed force
- Limiting depression of the other side with a superiorly directed force
- Shifting of pelvis to side with medially directed force
- Controlling downward/lateral collapse of spine and pelvis on low side with a superior-medial directed force

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

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

So what happens if seat is very soft and forgiving?

May need to add lateral trunk support

FIG 1

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

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

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**PELVIC OBLIQUITY/SCOLIOSIS**

**Intervention Strategies**

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**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.
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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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PELVIC OBLIQUITY/SCOLIOSIS Intervention Strategies

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

- Level the pelvis or level the shoulders?
- Think about the person:
  - Tolerance of pressure
  - Potential for further collapse
  - Functional goals

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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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

Lower cervical flexion

Upper cervical extension

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

Direction of Movement

Blocking Forces Required

• 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

**Intervention Strategies**

- Use orientation in space to decrease gravitational moment encouraging collapse
- Provide support under occiput
- Use anterior chest or shoulder restraint to limit forward excursion

Gravitational bending moment is encouraging lower cervical flexion

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

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**Full Neck Flexion**

*Direction of Movement*

- 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

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**Full Neck Flexion**

*Intervention Strategies*

These are not very good options!!

- Forehead straps or pads
- Anterior neck supports
- Anterior shoulder support
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PART 2 – MANAGING COMPLEX POSTURES

Accommodating a large 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***

- Posterior head support
- Occipital support
- Anterior shoulder support

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**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**

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**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.

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**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?

[Diagram of Neck Rotation]

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

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.