

## Problems Possible Causes: Sagittal Plane

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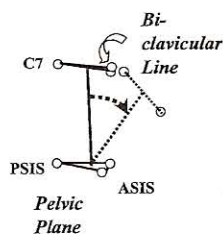
## Problem Possible Causes Lectures

- Develop a **SYSTEMATIC** process of interpreting gait data
  - Individual joint/segment level
  - Within a plane of motion
  - Across planes of motion
- Help us to determine relationships between what we see and what is actually happening to joint/segments during motion

## Upper Body

### • Angle definition

- the inclination of the shoulder girdle plane
- as viewed by an observer looking along a line connecting the right and left clavicle markers



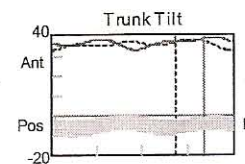
## Upper Body: Increased Tilt

### • Primary Causes

- Assist in forward progression
- Position required with ambulatory aids\*

### • Secondary Causes

- Anterior pelvic tilt

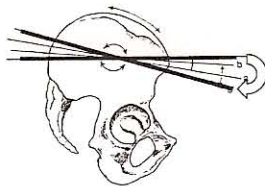


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## Pelvis

### • Angle Definition

- the inclination (typically forward) of the pelvic plane
- as viewed by an observer looking along a line connecting the ASIS's



## Pelvis: Anterior Tilt

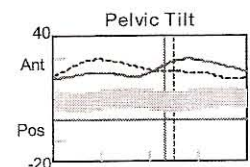
- correlated with relaxed standing position

### • Primary Causes

- Hip extensor and abdominal weakness\*
- Hip flexor contracture
- Hip flexor spasticity

### • Secondary Causes

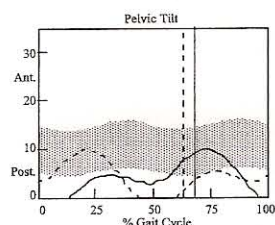
- Balance
- Distal deformity
- Excessive plantar flexion knee extension couple



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## Pelvis: Posterior Tilt

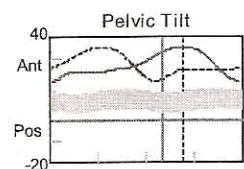
- **Primary Causes**
  - Hip extensor tightness
  - Severe medial and lateral hamstring tightness\*
- **Secondary Causes**
  - Spinal deformity
  - Age – post adolescent growth spurt
  - Male > female



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## Pelvis: Single Bump Pattern

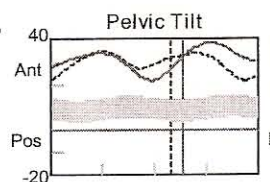
- **Primary Causes**
  - Reduced dissociation between pelvis and femur on involved side
    - Hip flexor spasticity/contracture
    - Hip extensor spasticity/contracture
  - Hip extensor weakness
- **Secondary Causes**
  - Distal deformity
  - Excessive plantar flexion knee extension couple



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## Pelvis: Double Bump Pattern

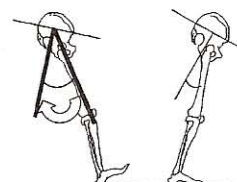
- **Primary Causes**
  - Reduced dissociation between pelvis and femur, bilaterally\*
    - Hip flexor spasticity/contracture
    - Hamstring spasticity/contracture
- **Secondary Causes**
  - Distal deformity – excessive plantar flexion knee extension couple



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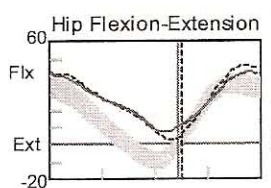
## Hip

- **Angle Definition**
  - the relative angle between the long axis of the thigh and a perpendicular to the pelvic plane
  - as viewed by an observer looking along a line connecting the ASIS's



## Hip: Delayed Extension in Stance

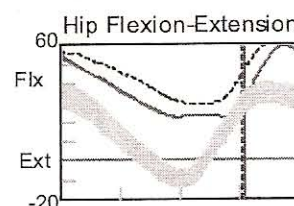
- **Primary Causes**
  - Hip extensor weakness\*
  - Hip flexor tightness/spasticity
- **Secondary Causes**
  - Anterior pelvic tilt
  - Excessive knee flexion\*
  - Ankle plantar flexor weakness



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## Hip: Flexion Bias 100% GC

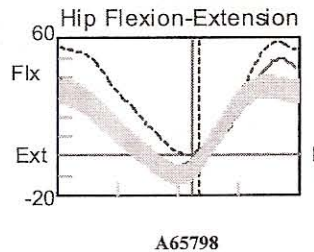
- **Primary Causes**
  - Hip flexion contracture
  - Hip extensor weakness\*
- **Secondary Causes**
  - Increased anterior pelvic tilt\*
  - Excessive knee flexion



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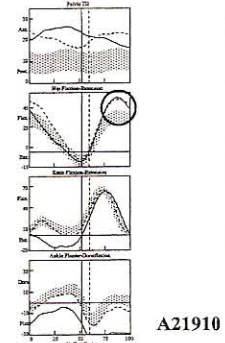
## Hip: Increased Flexion in Swing (1)

- **Primary Causes**
  - Flexor synergy for forward progression\*
- **Secondary Causes**
  - Single bump pelvic tilt
  - Voluntary compensation to aid in clearance
  - Anterior pelvic tilt



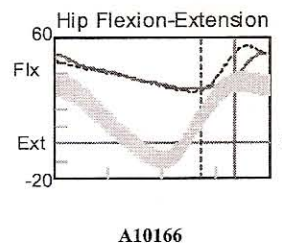
## Hip: Increased Flexion in Swing (2)

- **Primary Causes**
  - Flexor synergy
- **Secondary Causes**
  - Compensation for excessive equinus in swing (solid line)\*
  - Simultaneous increased anterior pelvic tilt (dashed line)\*



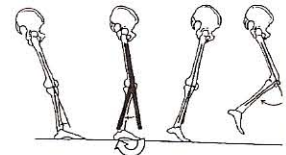
## Hip: Reduced Range of Motion

- **Primary Causes**
  - Reduced disassociation between pelvis and femur, bilaterally
    - Hip flexor spasticity/contracture
    - Hamstring spasticity/contracture
  - Lower extremity weakness\*
- **Secondary Causes**
  - Crouch\*
  - Reduced step lengths



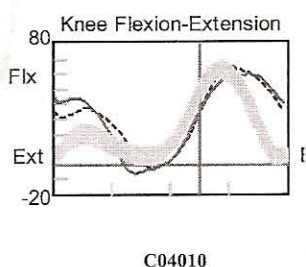
## Knee

- **Angle Definition**
  - the relative angle between the long axis of the thigh and shank segments
  - as viewed by an observer looking along the knee flexion/extension axis



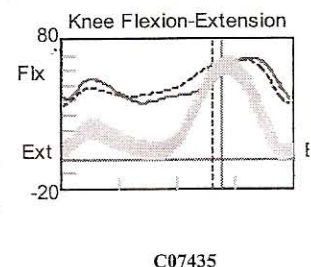
## Knee: Increased Flexion at Initial Contact

- **Primary Causes**
  - Spasticity of the hamstrings/tightness\*
  - Knee flexion contracture
  - Poor quadriceps control
- **Secondary Causes**
  - Excessive equinus at initial contact
  - Hip flexion contracture
  - Poor motor control



## Knee: Increased Flexion in Stance

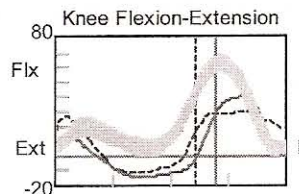
- **Primary Causes**
  - Hip extensor weakness\*
  - Co-spasticity of the quadriceps and hamstrings\*
  - Hamstring contracture/spasticity\*
- **Secondary Causes**
  - Excessive ankle plantar flexor weakness\*
  - Excessive ankle plantar flexor length\*
  - Hip flexion contracture





### Knee: Hyper-extension in Stance

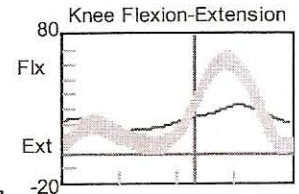
- **Primary Causes**
  - Excessive ankle plantar flexion (spasticity/tightness)
  - Poor quadriceps control
  - Passive knee hyperextension
- **Secondary Causes**
  - Forward trunk/pelvic lean



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### Knee: Reduced Flexion in Swing

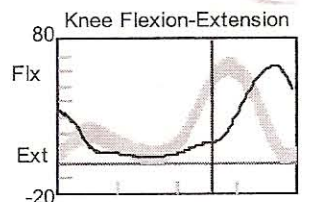
- **Primary Causes**
  - Rectus femoris activity in swing phase\*
  - Increased “stiffness” associated with age
- **Secondary Causes**
  - Hip flexor weakness
  - Ankle plantar flexor weakness\*
  - Excessive knee flexion in stance
  - Rotational abnormalities



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### Knee: Delayed Peak Flexion in Swing

- **Primary Causes**
  - Flexor synergy for forward progression\*
  - Rectus femoris activity
- **Secondary Causes**
  - Lower extremity weakness



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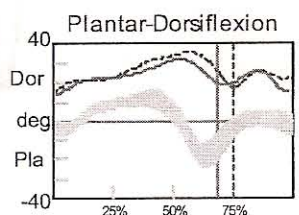
### Ankle

- **Angle Definition**
  - the relative angle between the long axis of the shank and the plantar aspect of the foot
  - as viewed by an observer looking along an axis perpendicular to the shank-foot plane



### Ankle: Increased Dorsiflexion in Stance

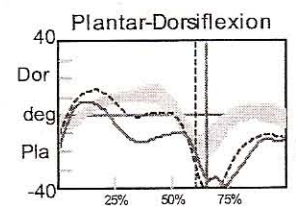
- **Primary Causes**
  - Ankle plantar flexor weakness\*
  - Excessive ankle plantar flexor length\*
- **Secondary Causes**
  - Contracture of anterior tibial muscles



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### Ankle: Premature Plantar Flexion in Stance

- **Primary Causes**
  - Spasticity of the ankle plantar flexors\*
  - Voluntary vault on non-involved side
- **Secondary Causes**
  - Rapid knee extension



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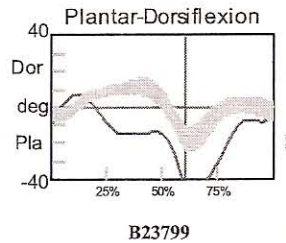
### Ankle: Increased Plantar Flexion at Toe Off

- **Primary Causes**

- Increased lower extremity weakness\*
- Foot drag at toe off\*
- Plantar flexor contracture/spasticity\*

- **Secondary Causes**

- None



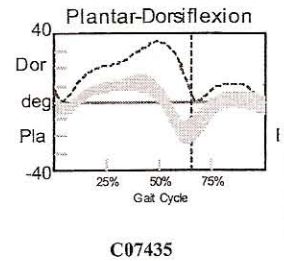
### Ankle: Increased Dorsiflexion in Swing

- **Primary Causes**

- Excessive dorsiflexion in stance\*
- Anterior tibialis contracture developed over time\*
- Flexor synergy

- **Secondary Causes**

- None



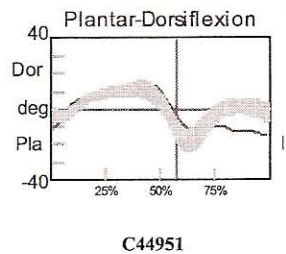
### Ankle: Increased Plantar Flexion in Swing

- **Primary Causes**

- Anterior tibialis weakness\*
- Plantar flexor contracture
- Plantar flexor spasticity

- **Secondary Causes**

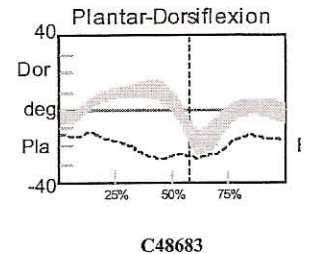
- Foot drag (due to lower extremity weakness)



### Ankle: Increased Plantar Flexion 100% GC

- **Primary Causes**

- Plantar flexor contracture\*
- Plantar flexor spasticity\*



### Misconceptions in Interpretation

- Complex interactions across multiple joints within a plane of motion
- Visual vs. actual – why what I see is not what is actually happening

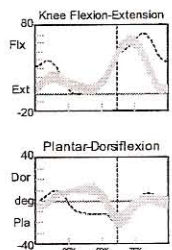
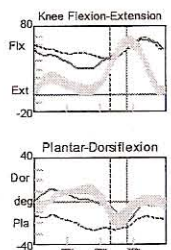
### Toe Walking versus Equinus

- Toe walking may be a result of
  - 1) greater than typical plantar flexion and/or
  - 2) knee flexion
- Typical ankle position with excessive knee flexion may = toe-walking
- Foot position (relative to floor) does not equal ankle angle
- Passive ankle range of motion may not = ankle motion during gait

## Toe Walking versus Equinus

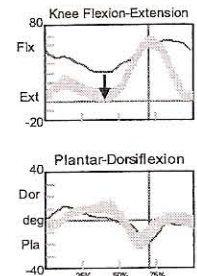
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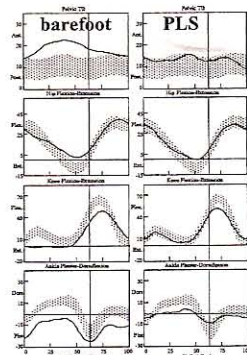
## Ankle Dorsiflexion & Knee Flexion

- Typical dorsiflexion in stance may not = typical gastrocnemius length
- Increased knee extension may result in decreased dorsiflexion (Silverskold)
- Complex role of double joint muscles must be considered



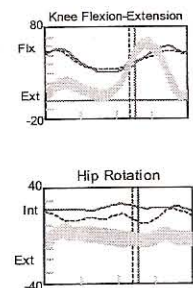
## Ankle Motion and Related Pelvic Motion

- Increasing anterior pelvic tilt in stance may = excessive plantar flexion knee extension couple which delays the forward progression of the tibia and requires anterior shift of the pelvis to move the center of gravity forward (left column)
- In brace walk pelvic motion in stance is typical (right column)



## Hip Internal Rotation – Crouch

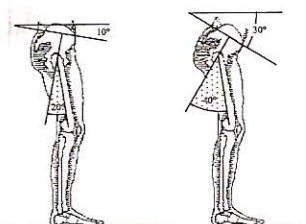
- Due to out of plane motion (hip transverse and/or coronal plane motion), sagittal view (view seen from video) of knee motion can be distorted



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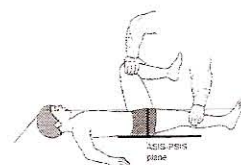
## Thigh Position versus Hip Extension

- Thigh position in space is not a good estimate of hip angle



## Kinematic vs. Clinical Examination Angle Definitions

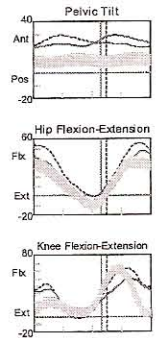
- Hip Extension versus the Thomas Test
  - to match angle definition with the clinical examination the line connecting the ASIS and the PSIS must be vertical





## Anterior Pelvic Tilt

- Greater than typical anterior pelvic tilt may = hip flexor contracture
- Anterior pelvic tilt in combination with knee hyperextension = increased hip ranges
- Assess hip motion and standing pelvic tilt position to help determine cause of pelvic position in sagittal plane during gait

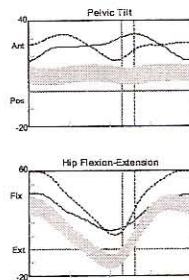


## Single Bump Pelvic Tilt and Related Hip Motion

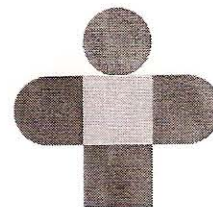
- Common in unilateral hip involvement in hemiplegia
- Resulting asymmetrical pelvic motion = asymmetry in hip motion
- Uninvolved limb = increased hip range of motion secondary to single bump of involved limb
  - increased hip flexion in swing when pelvis is in most anterior position
  - increased hip extension in stance when pelvis is in most posterior position

## Single Bump Pelvic Tilt and Related Hip Motion

- Right involved = solid line
- Left non-involved = dashed line



Thank You



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