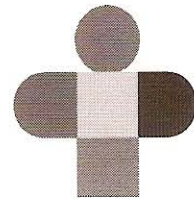


# Interactions Across Planes

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*Center for Motion Analysis  
Connecticut Children's Medical Center  
Hartford, Connecticut, USA*



## Objectives:

- Define interaction across planes
- Develop skills to evaluate “other” planes for possible causes of gait abnormalities
- Review examples

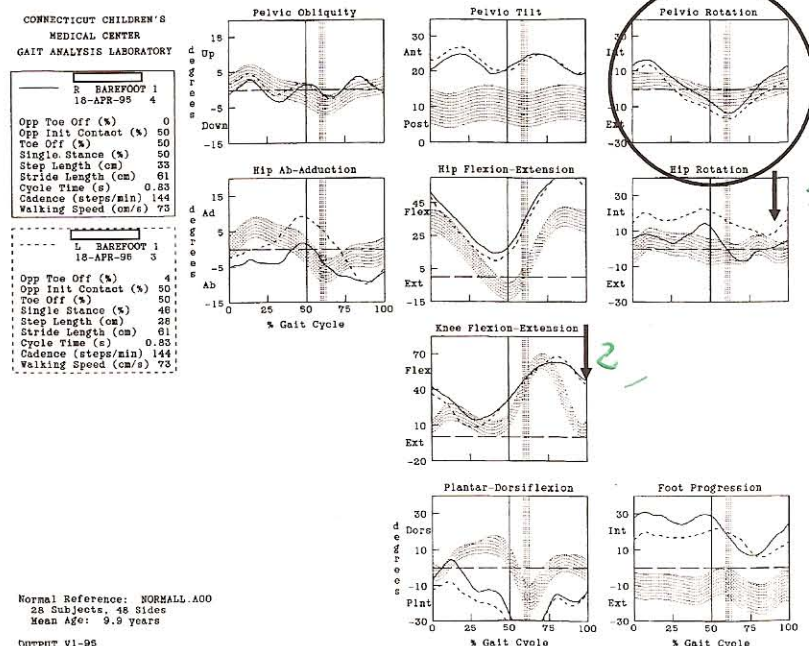
## Definition:

Interactions across planes:

- Evaluation of the relationships between motion from one plane to another
  - ◆ Differentiate between primary and secondary gait deviations
  - ◆ Determine possible causes of gait abnormalities
- Sequence of data interpretation:
  - ◆ Individual joint
  - ◆ Joints and segments within a single plane of motion
  - ◆ Joints and segments across multiple planes of motion

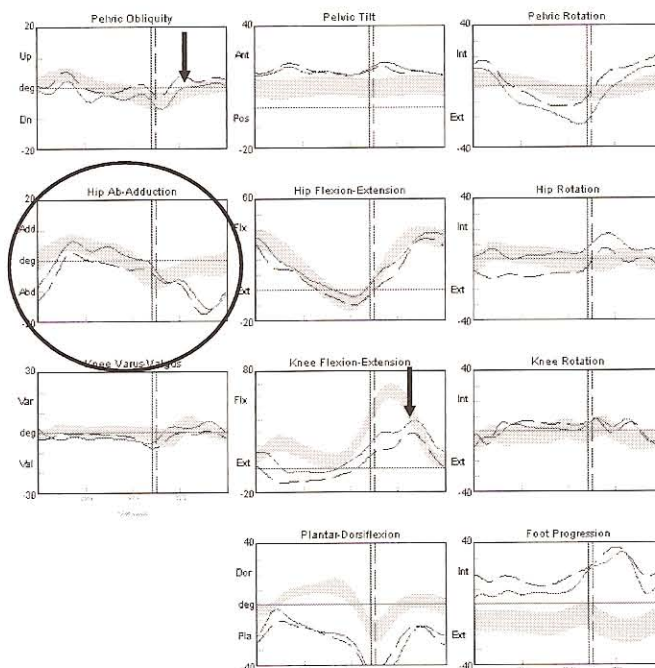
## Increased Pelvic Transverse Plane Motion

- Secondary to Reduced Knee Extension at Initial Contact



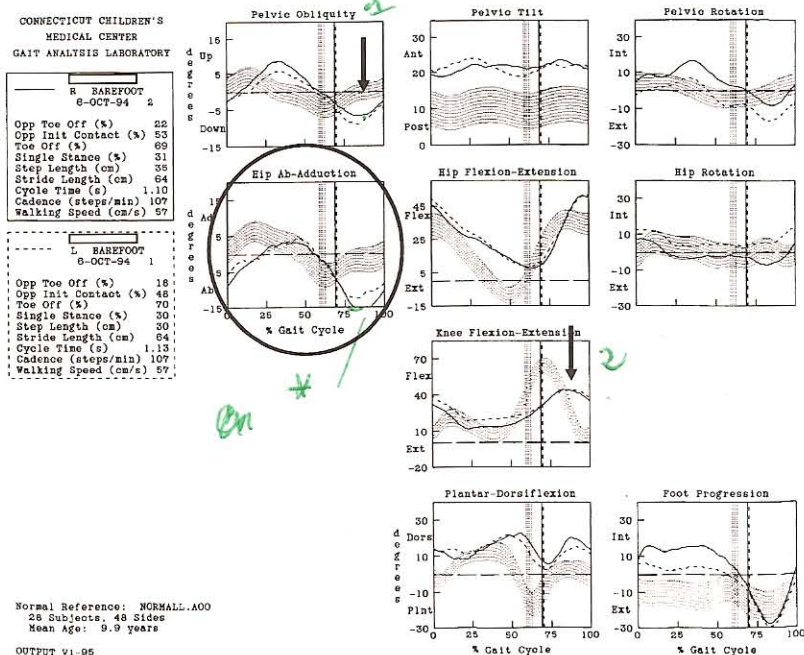
## Increased Hip Abduction in Swing

- Secondary to Reduced Sagittal Plane Knee Flexion in Swing



## Increased Hip Abduction in Swing

- Secondary to Reduced Sagittal Plane Knee Flexion in Swing





## Increased Coronal Plane Hip Abduction Initial Contact

- Secondary to Increased Transverse Plane Pelvic Motion

CONNECTICUT CHILDREN'S MEDICAL CENTER  
GAIT ANALYSIS LABORATORY

R. BAREFOOT  
17-MAY-00 2

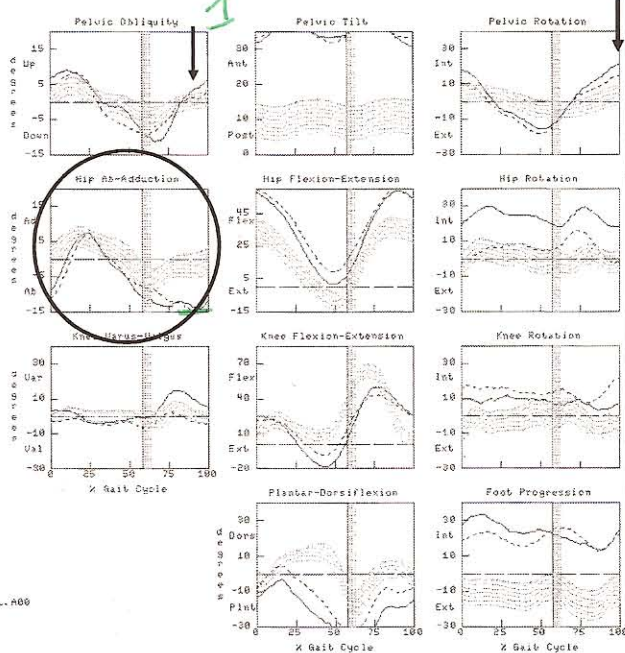
Opp Toe Off (%)	0
Opp Init Contact (%)	49
Toe Off (%)	50
Single Stance (%)	42
Step Length (cm)	48
Stride Length (cm)	102
Cycle Time (s)	0.07
Cadence (steps/min)	140
Walking Speed (cm/s)	119

L. BAREFOOT  
17-MAY-00 1

Opp Toe Off (%)	4
Opp Init Contact (%)	50
Toe Off (%)	53
Single Stance (%)	46
Step Length (cm)	52
Stride Length (cm)	102
Cycle Time (s)	0.05
Cadence (steps/min)	140
Walking Speed (cm/s)	119

Normal Reference: NORMALL.A00  
20 Subjects, 40 Sides  
Mean Age: 9.5 years

OUTPUT 01-95



## Increased Coronal Plane Hip Adduction Loading Response

- Secondary to Increased Transverse Plane Pelvic Rotation

CONNECTICUT CHILDREN'S MEDICAL CENTER  
GAIT ANALYSIS LABORATORY

R. BAREFOOT  
17-MAY-00 2

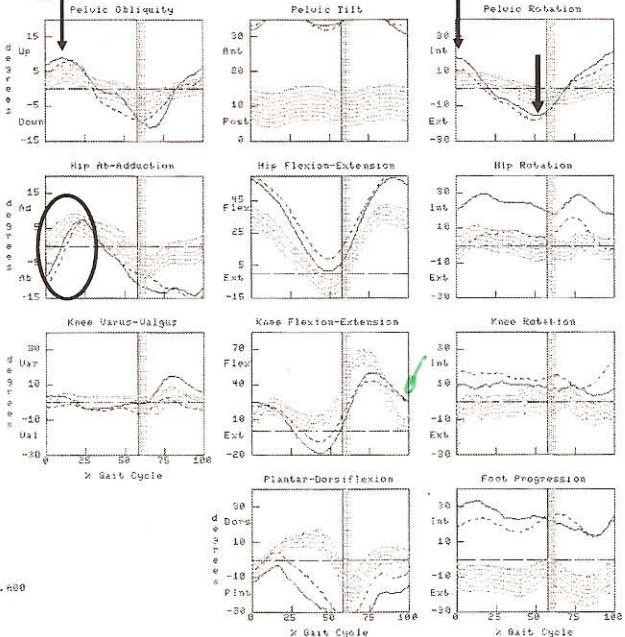
Opp Toe Off (%)	0
Opp Init Contact (%)	49
Toe Off (%)	50
Single Stance (%)	42
Step Length (cm)	48
Stride Length (cm)	102
Cycle Time (s)	0.07
Cadence (steps/min)	140
Walking Speed (cm/s)	119

L. BAREFOOT  
17-MAY-00 1

Opp Toe Off (%)	4
Opp Init Contact (%)	50
Toe Off (%)	53
Single Stance (%)	46
Step Length (cm)	52
Stride Length (cm)	102
Cycle Time (s)	0.05
Cadence (steps/min)	140
Walking Speed (cm/s)	119

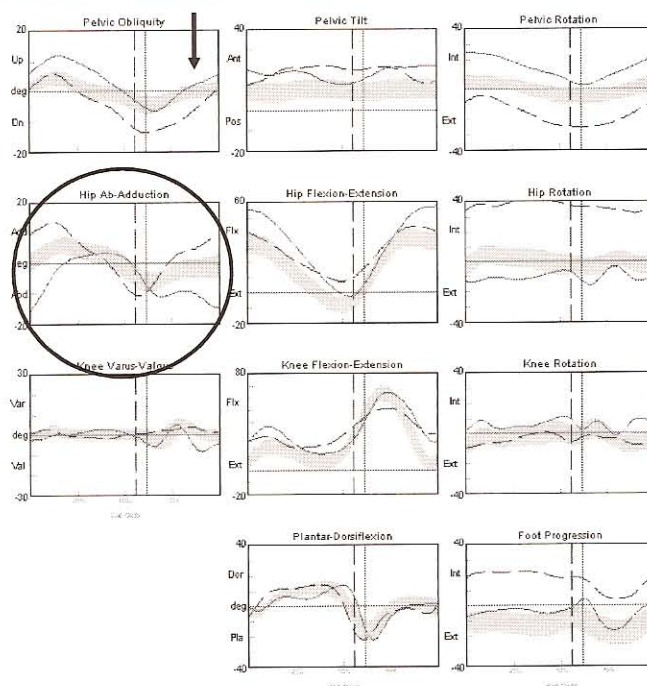
Normal Reference: NORMALL.A00  
20 Subjects, 40 Sides  
Mean Age: 9.5 years

OUTPUT 01-95



## Increased Asymmetric Coronal Plane Hip Motion

- Secondary to Transverse Plane Pelvic Asymmetry



## Hip coronal plane position?





## Increased Hip Adduction in Stance

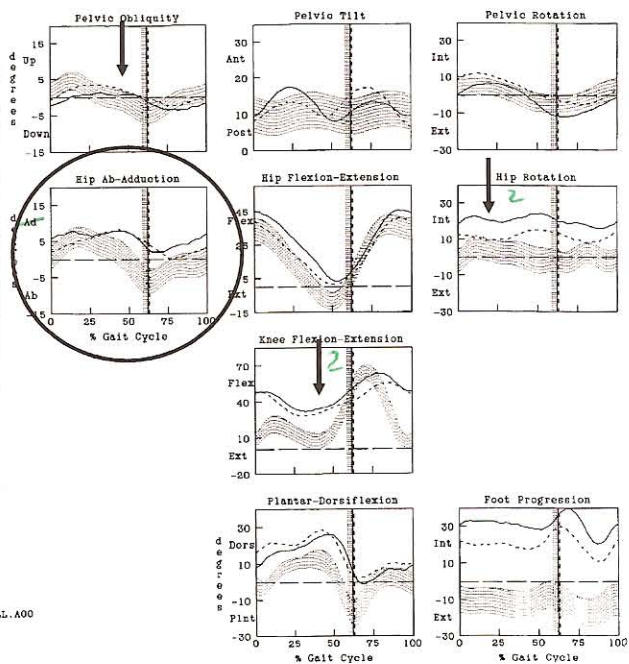
- Secondary to Knee Flexion & Internal Hip Rotation

CONNECTICUT CHILDREN'S MEDICAL CENTER  
GAIT ANALYSIS LABORATORY

R BAREFOOT 1  
24-JAN-90 1  
Opp Toe Off (%) 18  
Opp Init Contact (%) 55  
Toe Off (%) 62  
Single Stance (%) 38  
Step Length (cm) 38  
Stride Length (cm) 78  
Cycle Time (s) 1.07  
Cadence (steps/min) 114  
Walking Speed (cm/s) 74

L BAREFOOT 1  
24-JAN-90 2  
Opp Toe Off (%) 10  
Opp Init Contact (%) 47  
Toe Off (%) 63  
Single Stance (%) 37  
Step Length (cm) 40  
Stride Length (cm) 78  
Cycle Time (s) 1.03  
Cadence (steps/min) 114  
Walking Speed (cm/s) 74

Normal Reference: NORMALL.A00  
28 Subjects, 48 Sides  
Mean Age: 9.9 years  
OUTPUT VI-95



## Pelvic Obliquity

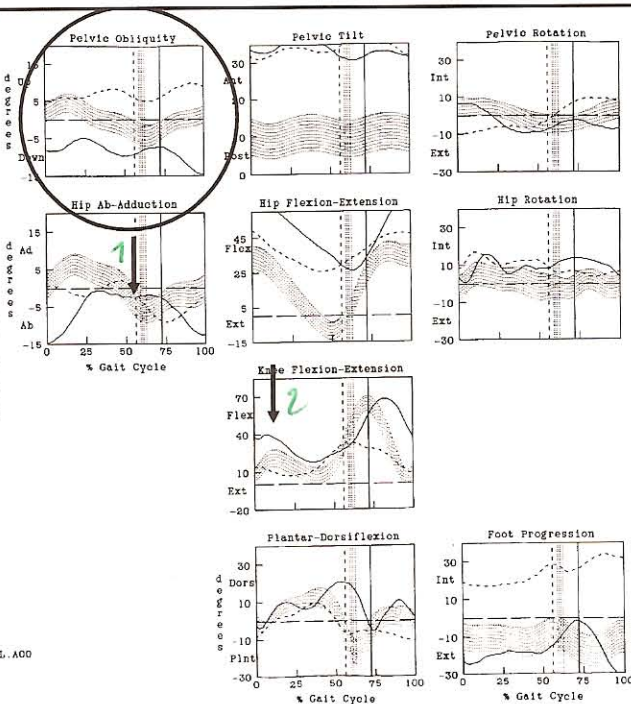
- Secondary to a Functional Leg Length Difference

CONNECTICUT CHILDREN'S MEDICAL CENTER  
GAIT ANALYSIS LABORATORY

R BAREFOOT 1  
5-SEP-91 2  
Opp Toe Off (%) 15  
Opp Init Contact (%) 58  
Toe Off (%) 72  
Single Stance (%) 42  
Step Length (cm) 35  
Stride Length (cm) 72  
Cycle Time (s) 0.90  
Cadence (steps/min) 138  
Walking Speed (cm/s) 82

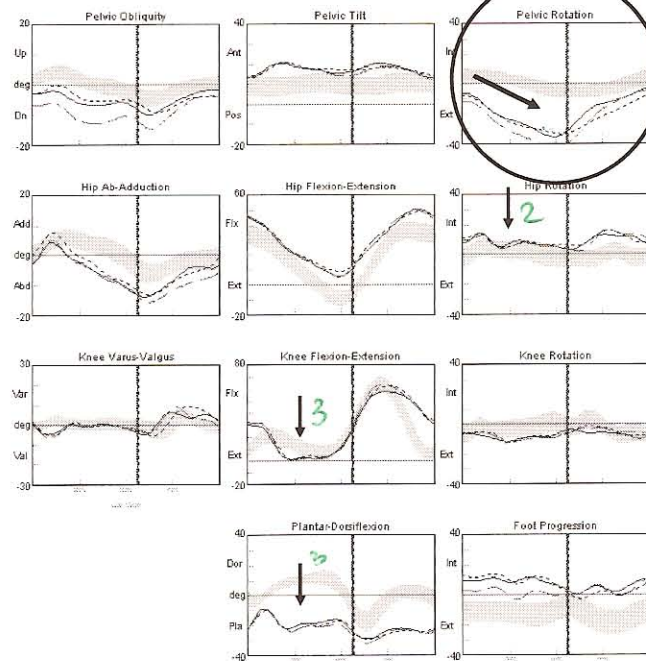
L BAREFOOT 1  
5-SEP-91 1  
Opp Toe Off (%) 12  
Opp Init Contact (%) 40  
Toe Off (%) 58  
Single Stance (%) 28  
Step Length (cm) 37  
Stride Length (cm) 72  
Cycle Time (s) 0.87  
Cadence (steps/min) 130  
Walking Speed (cm/s) 82

Normal Reference: NORMALL.A00  
28 Subjects, 48 Sides  
Mean Age: 9.9 years  
OUTPUT VI-95



## Pelvic External Rotation in Stance

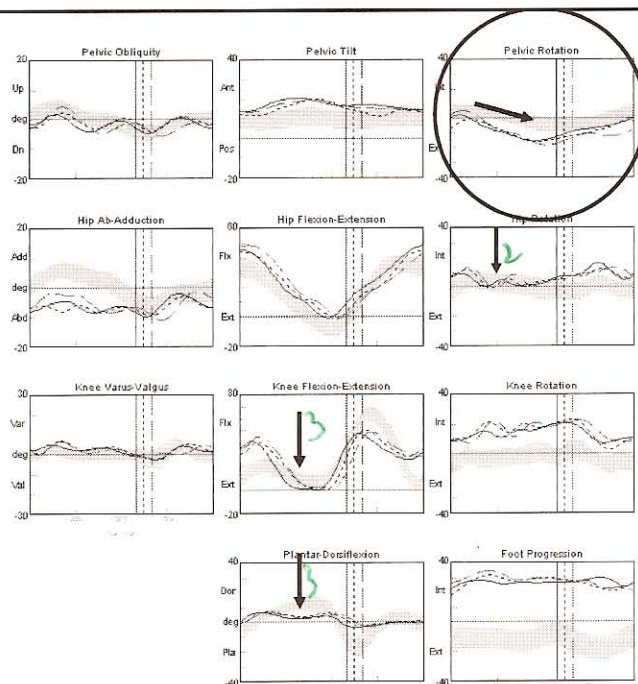
- Secondary to an Excessive Plantar Flexion Knee Extension Couple (barefoot)



external rotation

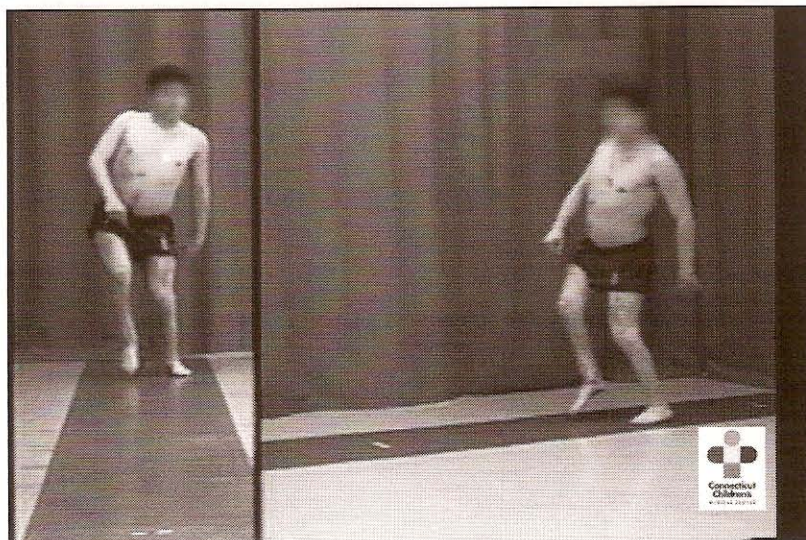
## Pelvic External Rotation in Stance (reduced)

- Reduced excessive plantar flexion knee extension couple during AFO walk





## Knee Valgus Thrust?

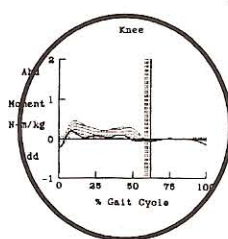


## Apparent Knee Valgus Thrust

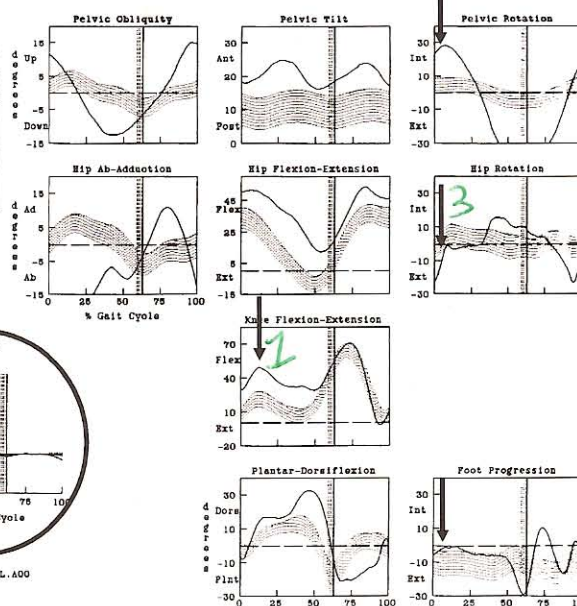
- Secondary to  
Internal Pelvic  
Rotation, Internal  
Hip Rotation,  
Increased Knee  
Flexion and  
Normal to  
External Foot  
Progression

CONNECTICUT CHILDREN'S  
MEDICAL CENTER  
GAIT ANALYSIS LABORATORY

L BAREFOOT 1  
10-FEB-91 2  
Opp Toe Off (%) 3  
Opp Inst Contact (%) 43  
Toe Off (%) 83  
Single Stance (%) 40  
Step Length (cm) 58  
Stride Length (cm) 101  
Cycle Time (s) 1.03  
Cadence (steps/min) 122  
Walking Speed (cm/s) 105



Normal Reference: NORMAL.A00  
28 Subjects, 48 Sides  
Mean Age: 9.3 years

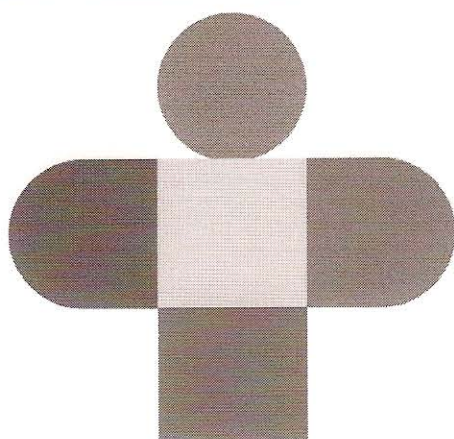




## Summary:

### Interactions across planes:

- Evaluation of the relationships between motion from one plane to another
  - ◆ Differentiate between primary and secondary gait deviations
  - ◆ Determine possible causes of gait abnormalities
- ★ ■ Sequence of data interpretation:
  - ◆ Individual joint
  - ◆ Joints and segments within a single plane of motion ✕
  - ◆ Joints and segments across multiple planes of motion



**Connecticut  
Children's**  
MEDICAL CENTER