Introduction to Human Walking & Clinical Gait Analysis

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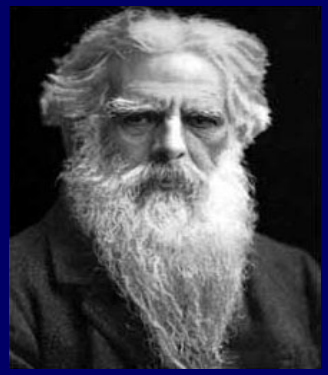
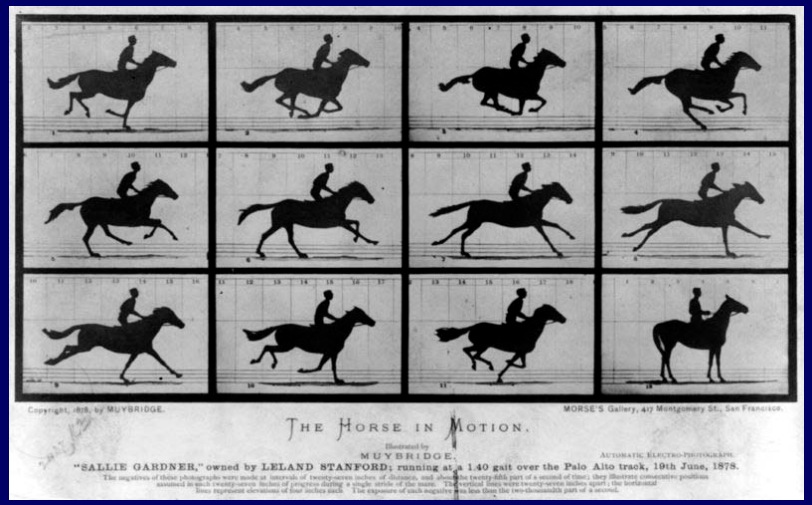
Teaching Points

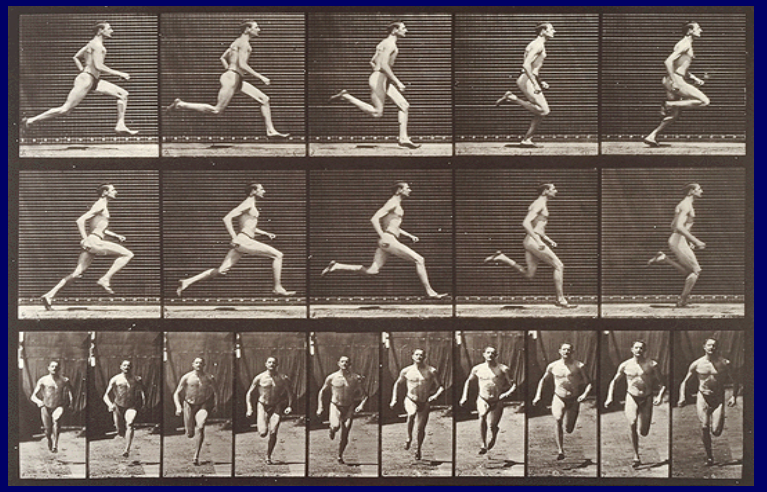
- Phases of the Gait Cycle
- Primary Muscle Actions during Gait
- Common Gait Disorders & Treaments

Motion Analysis at Stanford

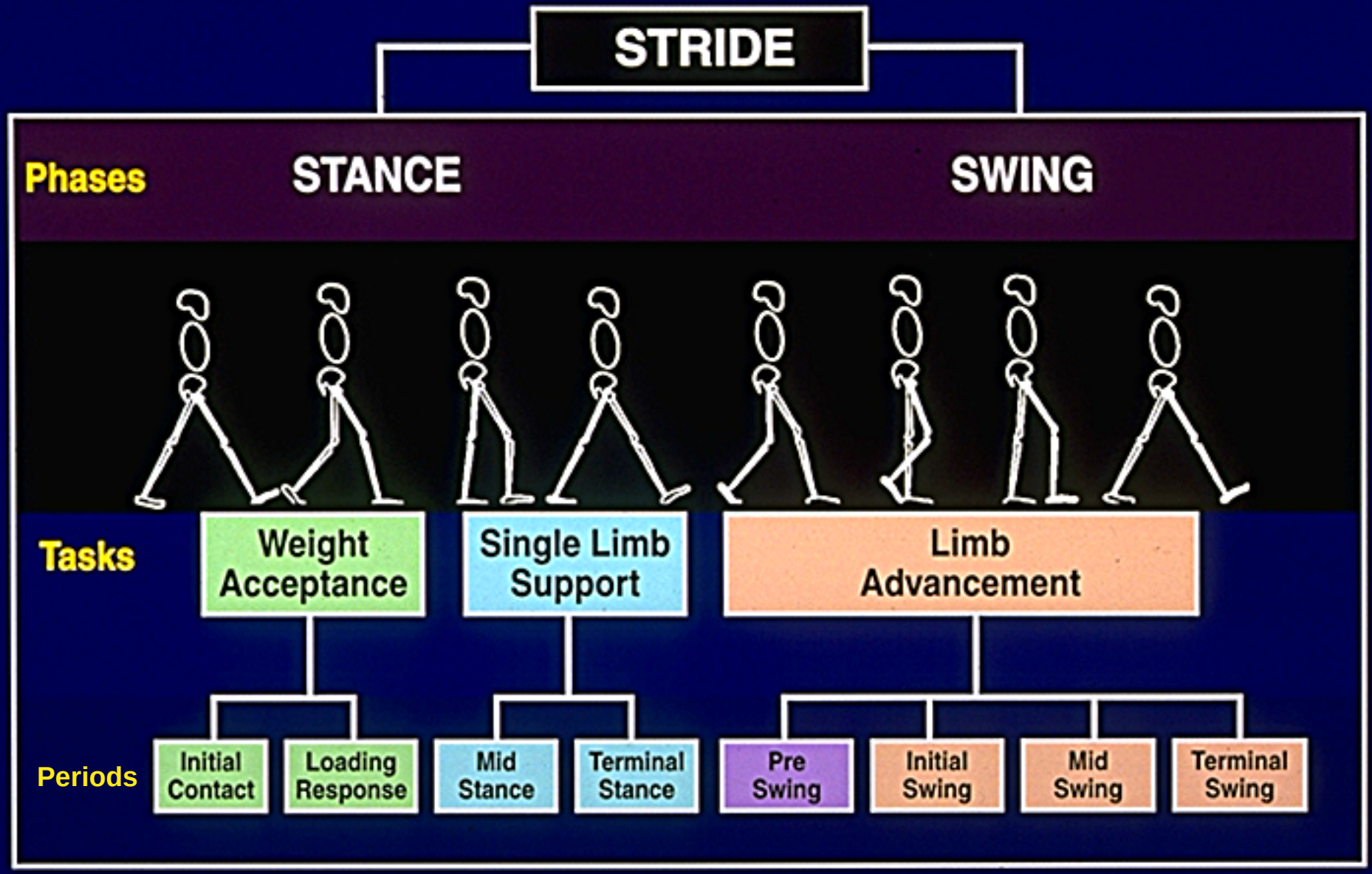
Edweard Muybridge & Leland Stanford 1878



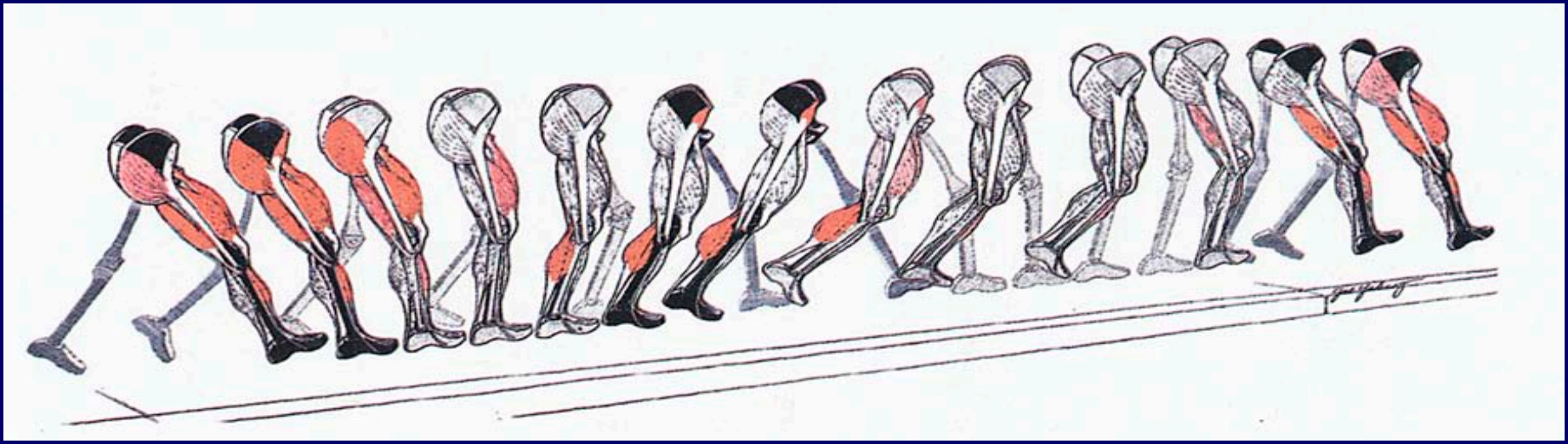




The Gait Cycle



Muscle Activity During Gait

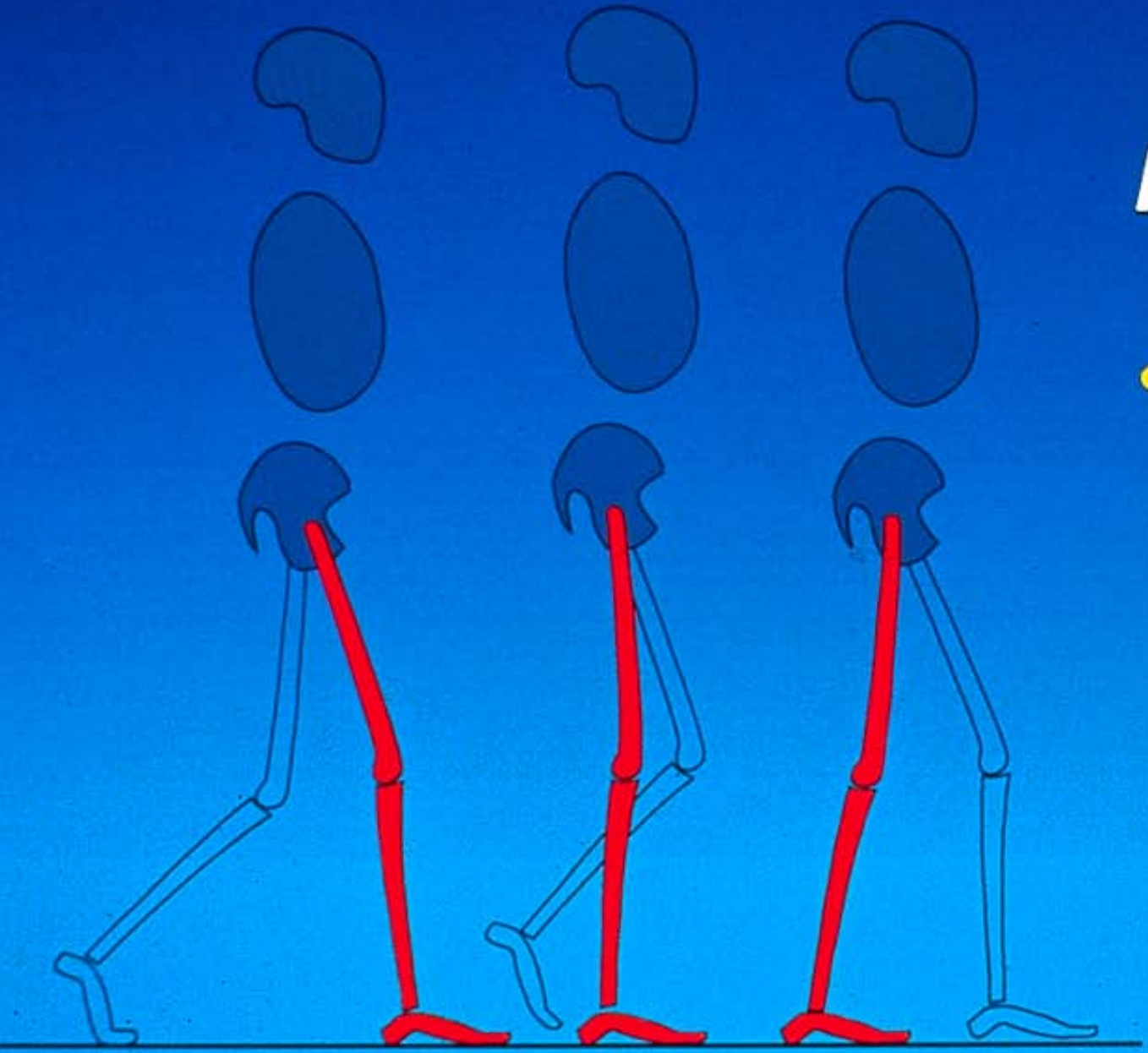


Initial Contact

- Heel First Contact

Toe Walking

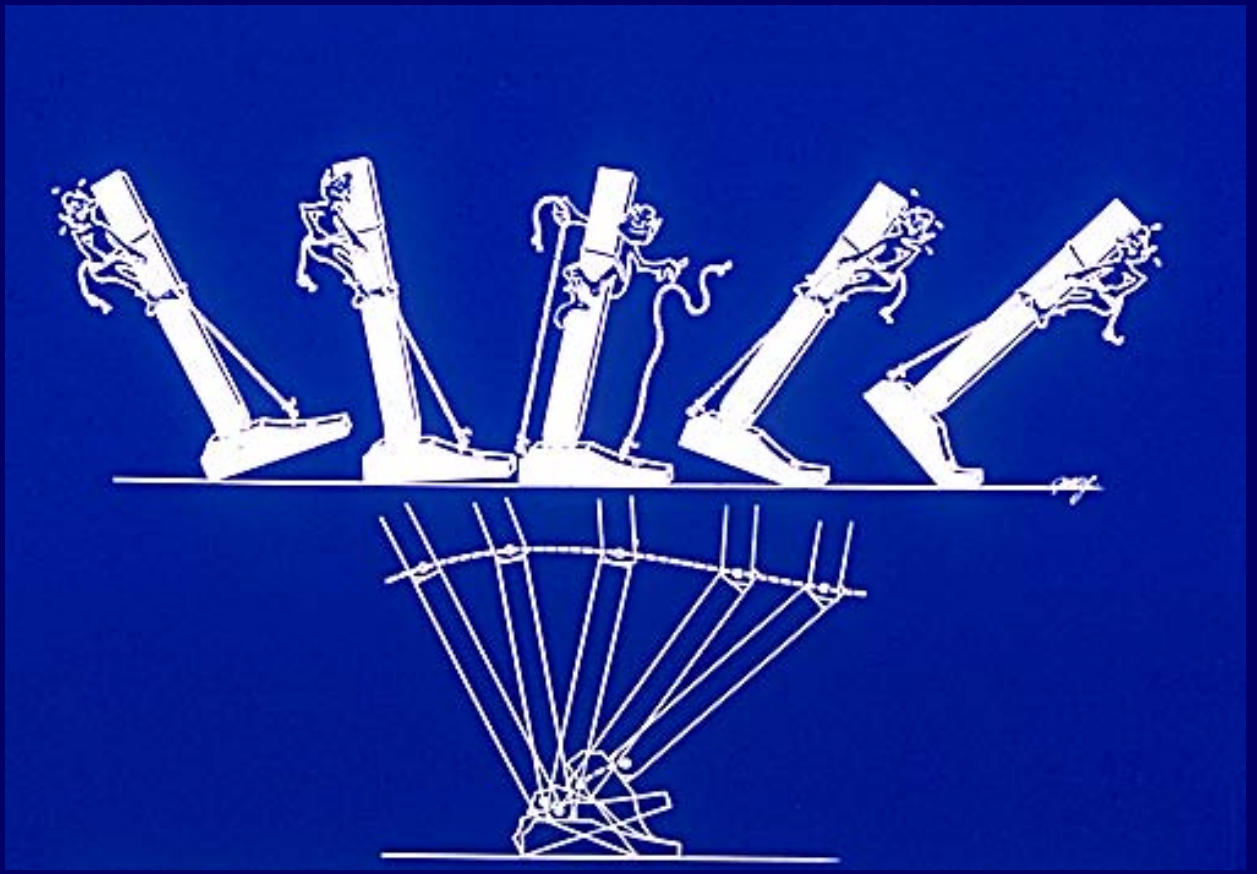
Diplegic Cerebral Palsy



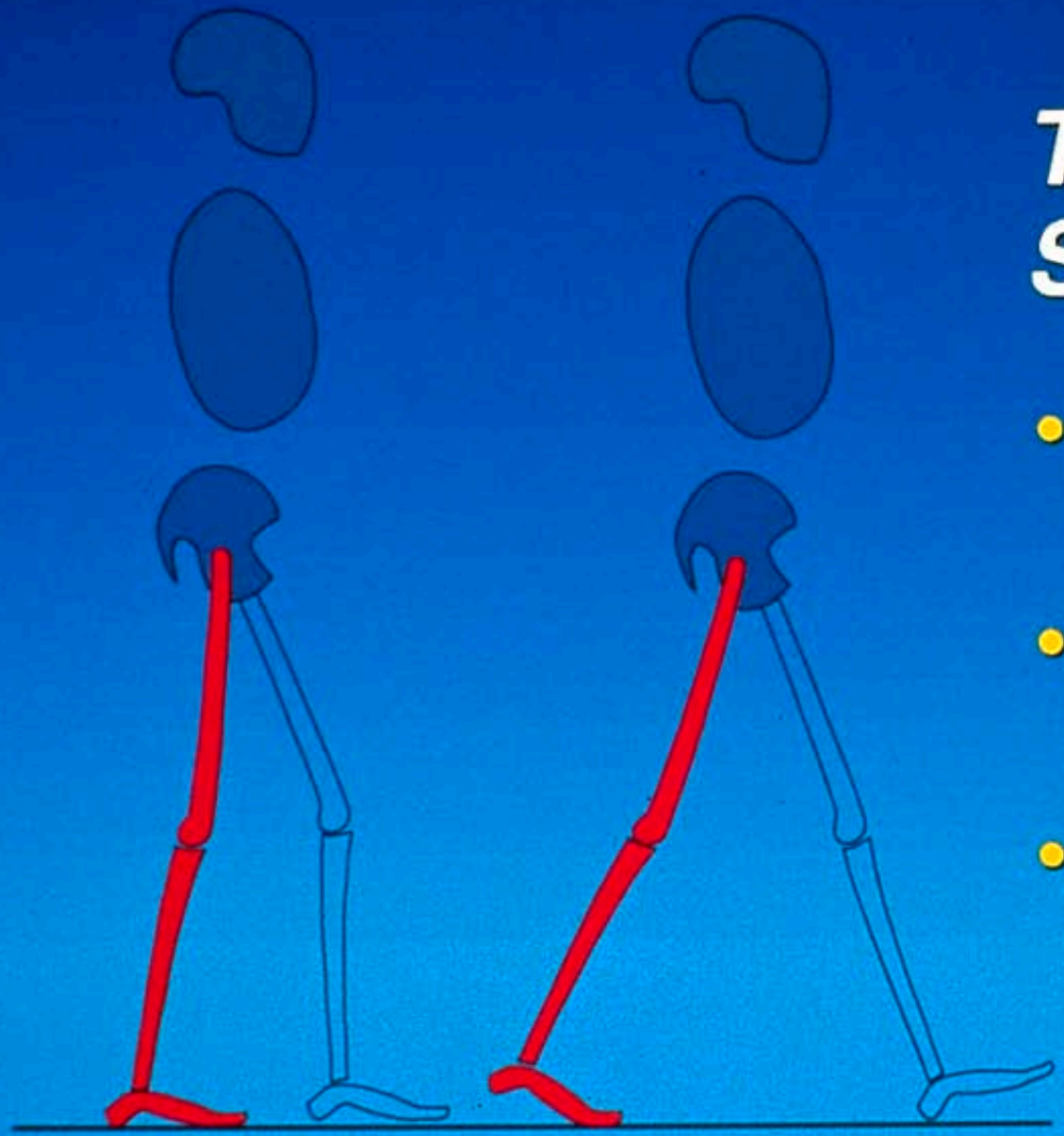
Mid-Stance

- Controlled Tibial Advancement

3 Foot & Ankle Rockers



Rose J & Gamble JG, Editors. Human Walking 3rd Ed, 2006



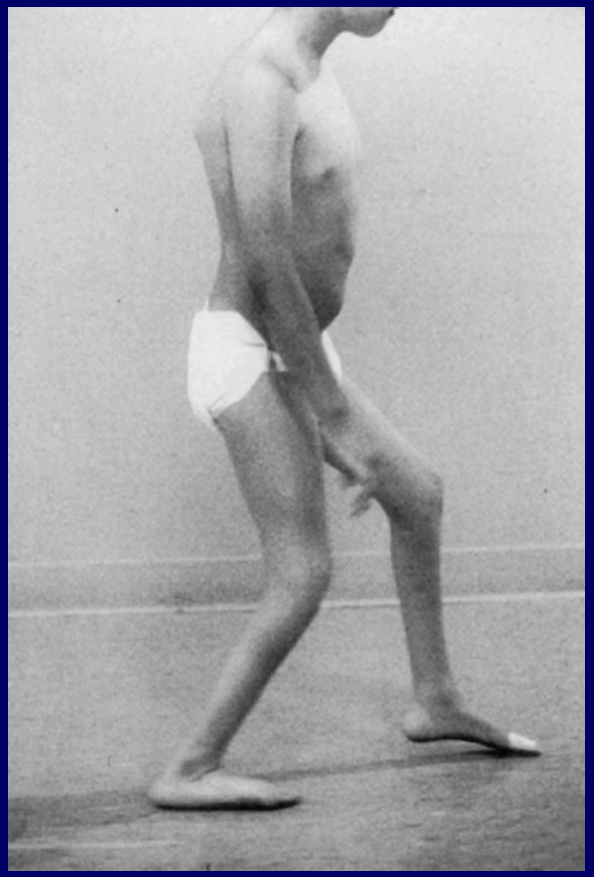
Terminal Stance

- Locked Ankle
- Heel Rise
- Trailing Limb

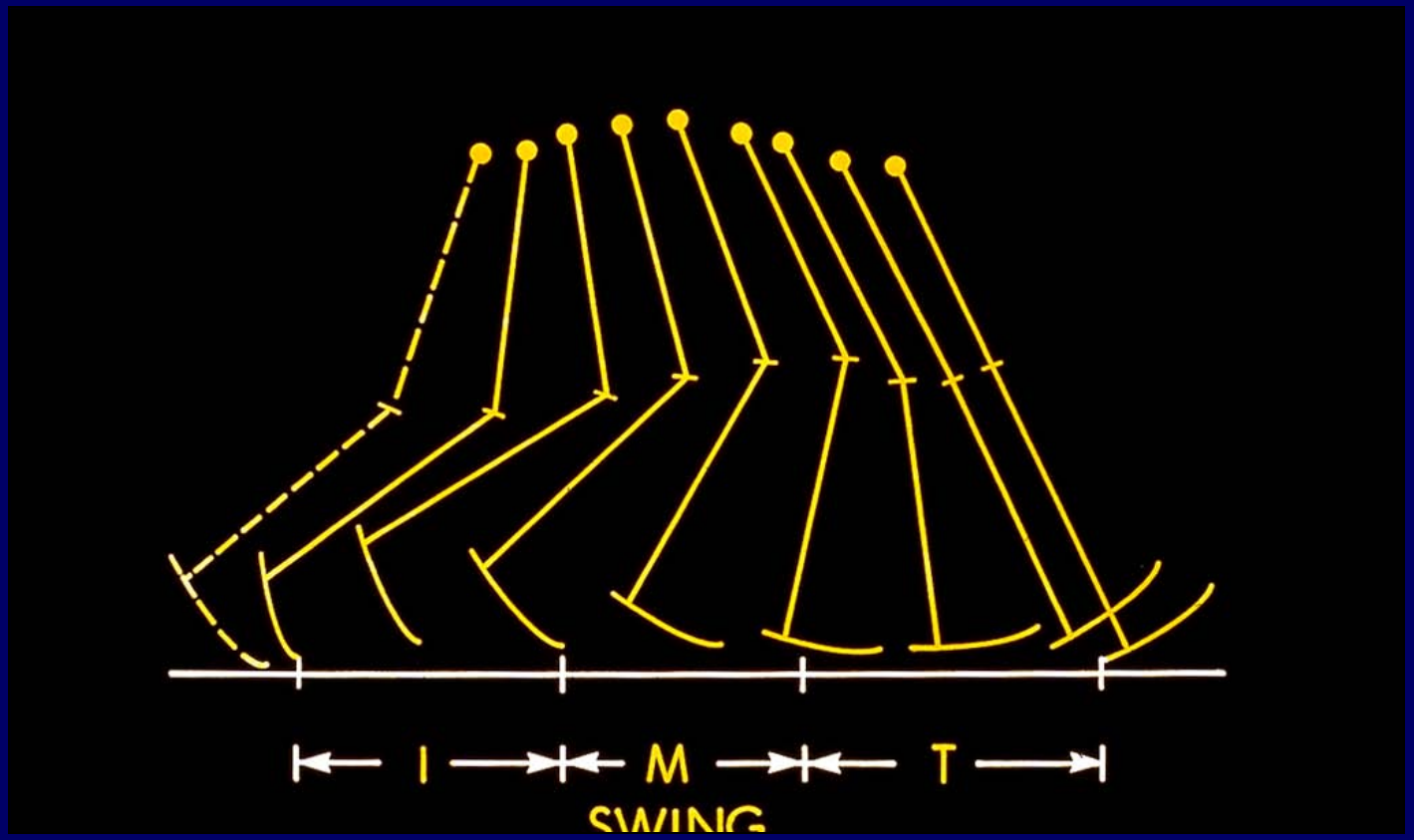
Calf Muscle Weakness

No Fixed Ankle or Heel Rise

Spastic Cerebral Palsy



Swing Phase



- Peak knee flexion in initial swing
- Ankle dorsiflexion to achieve foot clearance

Gait Analysis

- Video
- Kinematics and Kinetics
- Dynamic EMG
- Postural Balance
- Energy Expenditure

Diplegic Cerebral Palsy

Kinematics & Kinetics

- Kinematics: 3-D Joint Motion

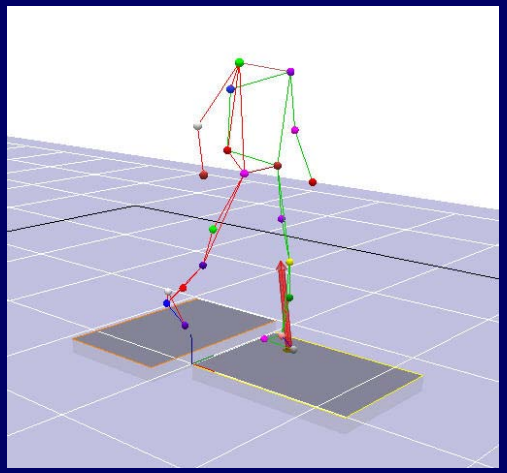
  8 Digital Motion Capture Cameras Record

  Position of Light Reflective Markers

- Kinetics: Forces Passing through Joints

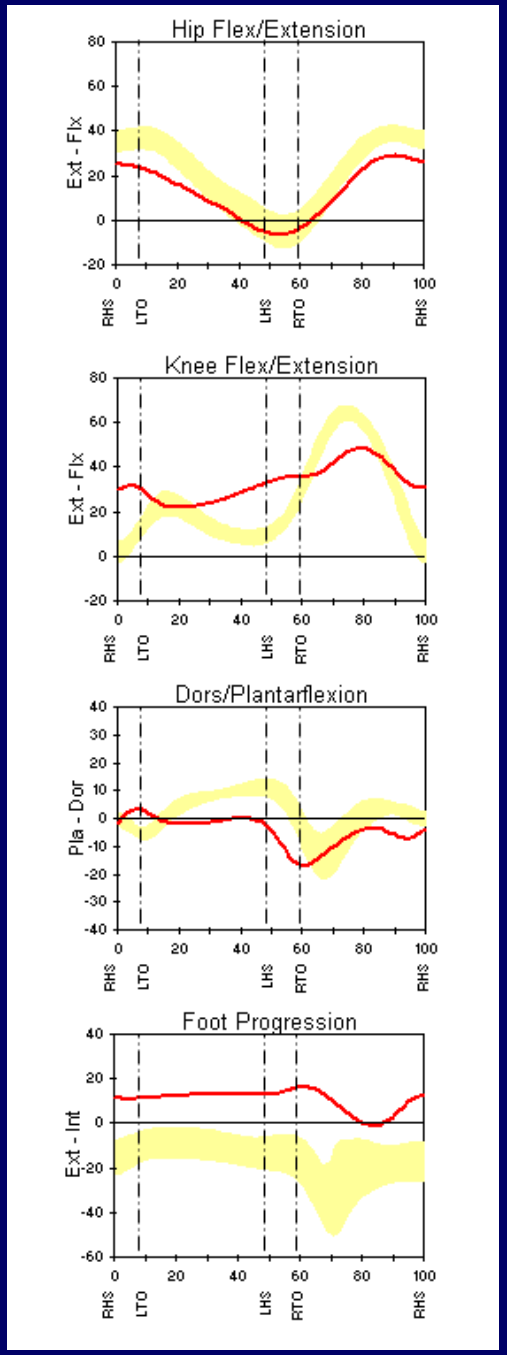
  Force Plate Embedded in Floor Records

  Ground Reaction Force Vectors

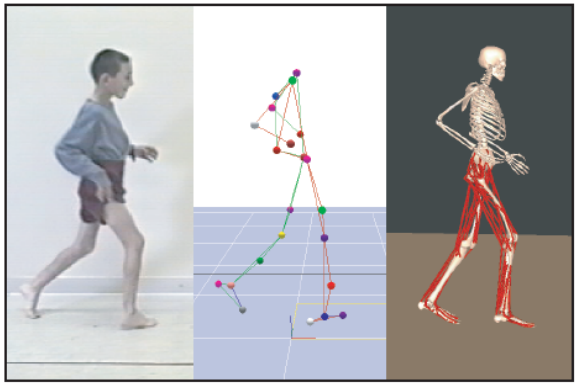


Kinematics

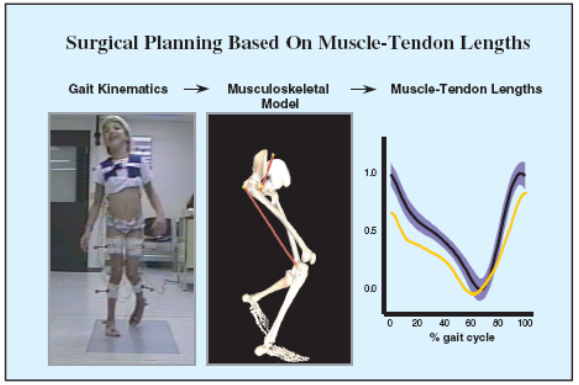
- Nearly normal hip motion
- Increased knee flexion at IC and stance
- Reduced peak knee flexion in swing
- Increased plantar flexion in terminal stance
- Internally rotated foot progression



Musculoskeletal Computer Models of Gait

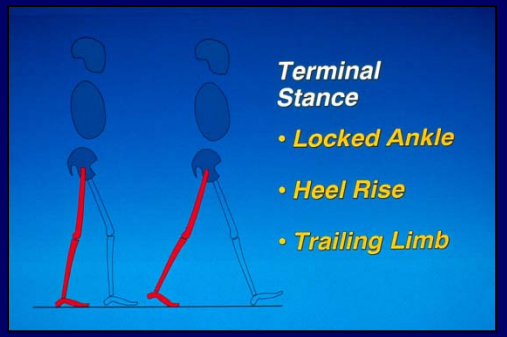


Computer models are generated from gait kinematics (joint motion) and kinetics (joint forces) and reveal the biomechanical features that influence gait.

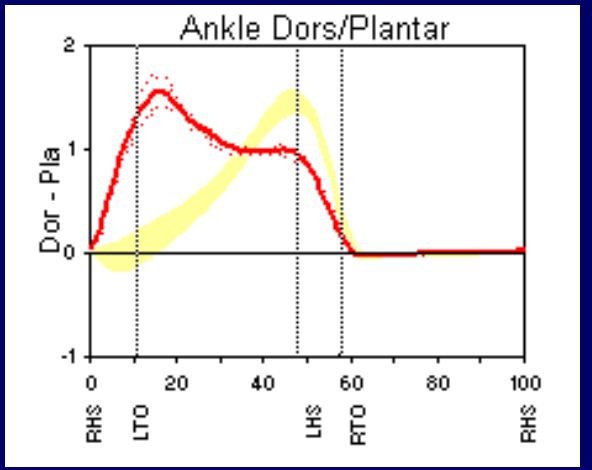


The changing muscle lengths during gait are calculated using the computer model. Muscles that are too short and limit gait can be identified and selected for treatment.

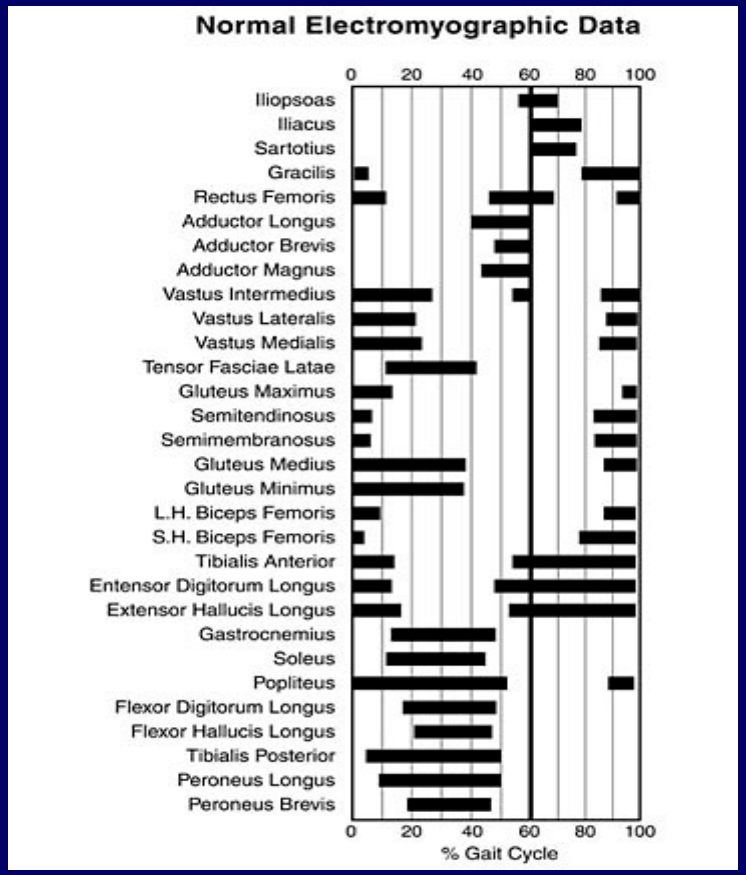
Kinetics



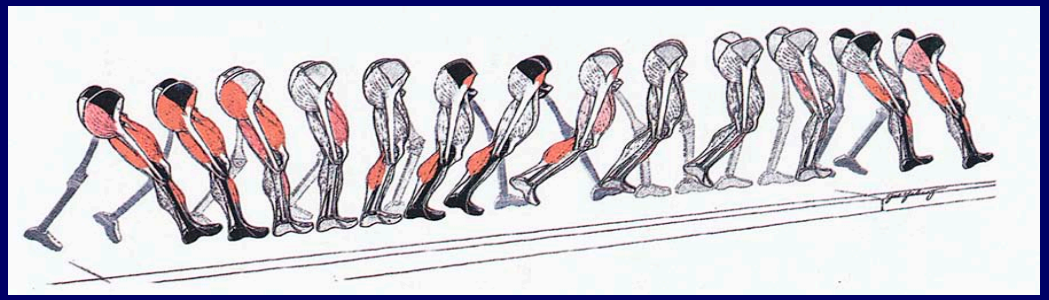
- Normal ankle plantarflexor moment peaks in terminal stance
- Increased plantar flexor moment in loading “double bump” with increased plantar flexion at IC
- Decreased plantar flexor moment in terminal stance with loss of forefoot rocker



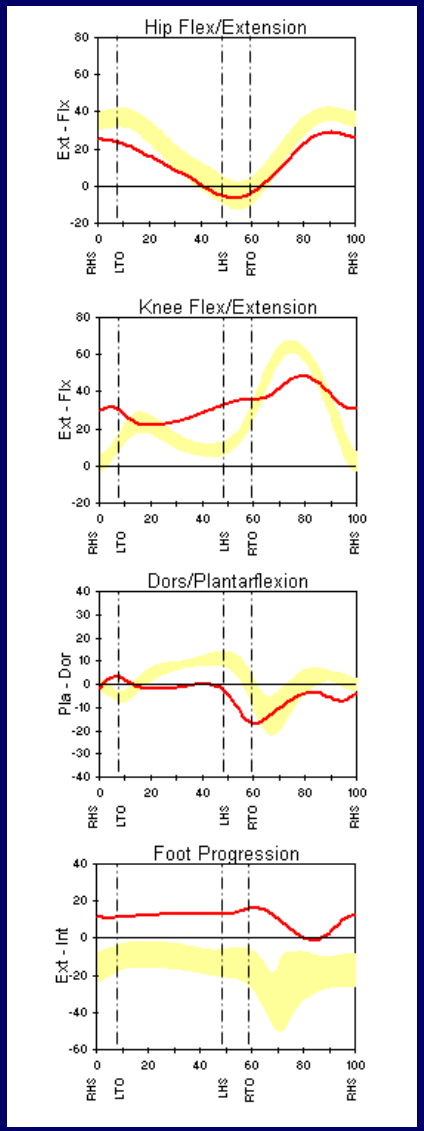
Dynamic EMG During Gait

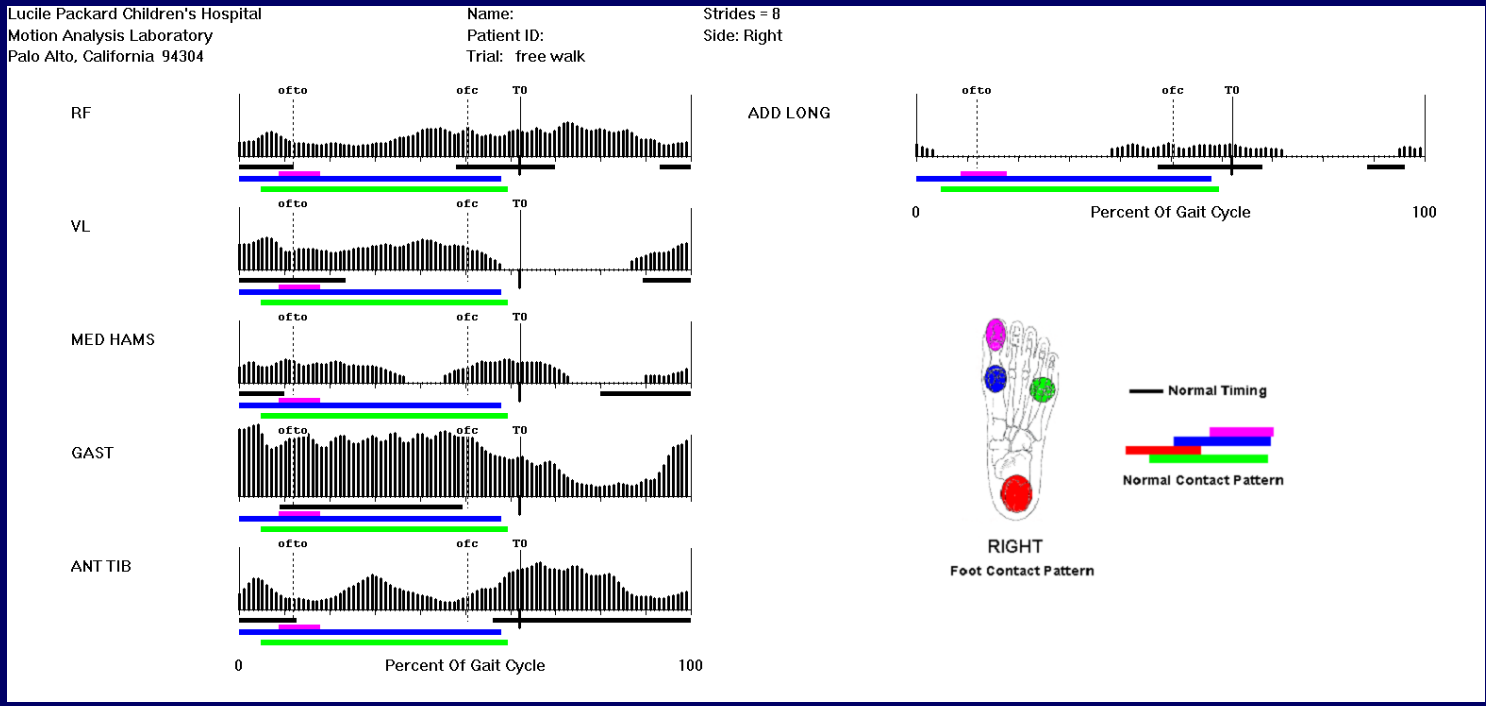


- Footswitch or Markers
- Electrodes
  - Surface
  - Fine Wire
- Interpretation



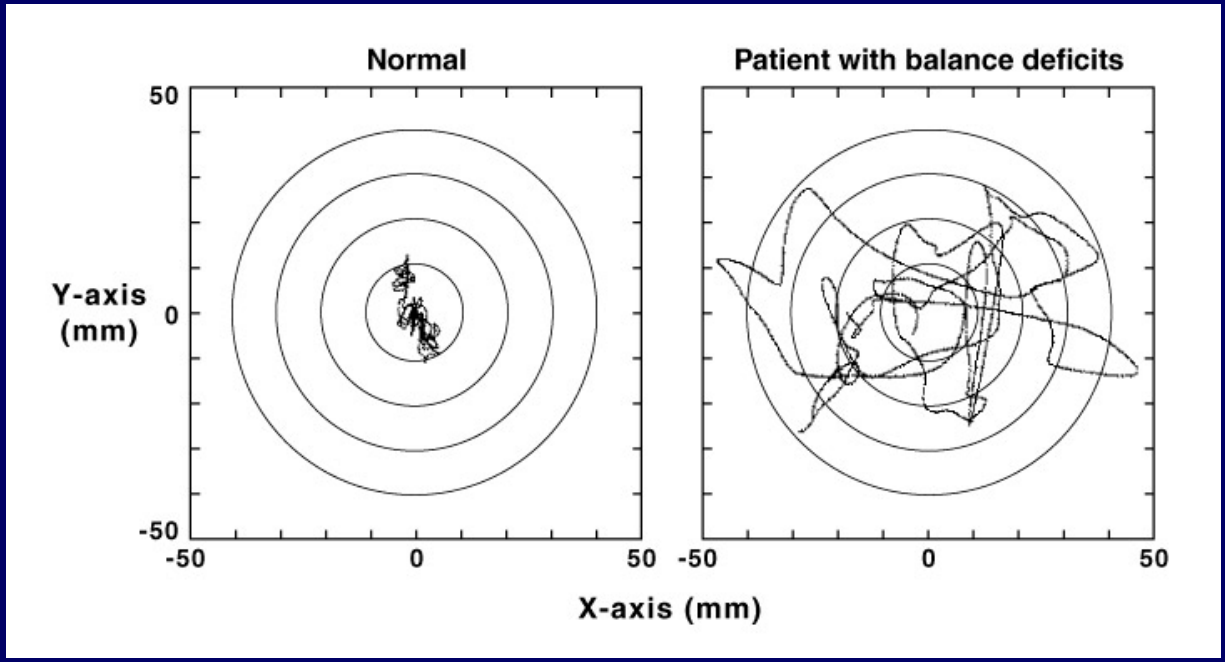
Dynamic EMG & Kinematics





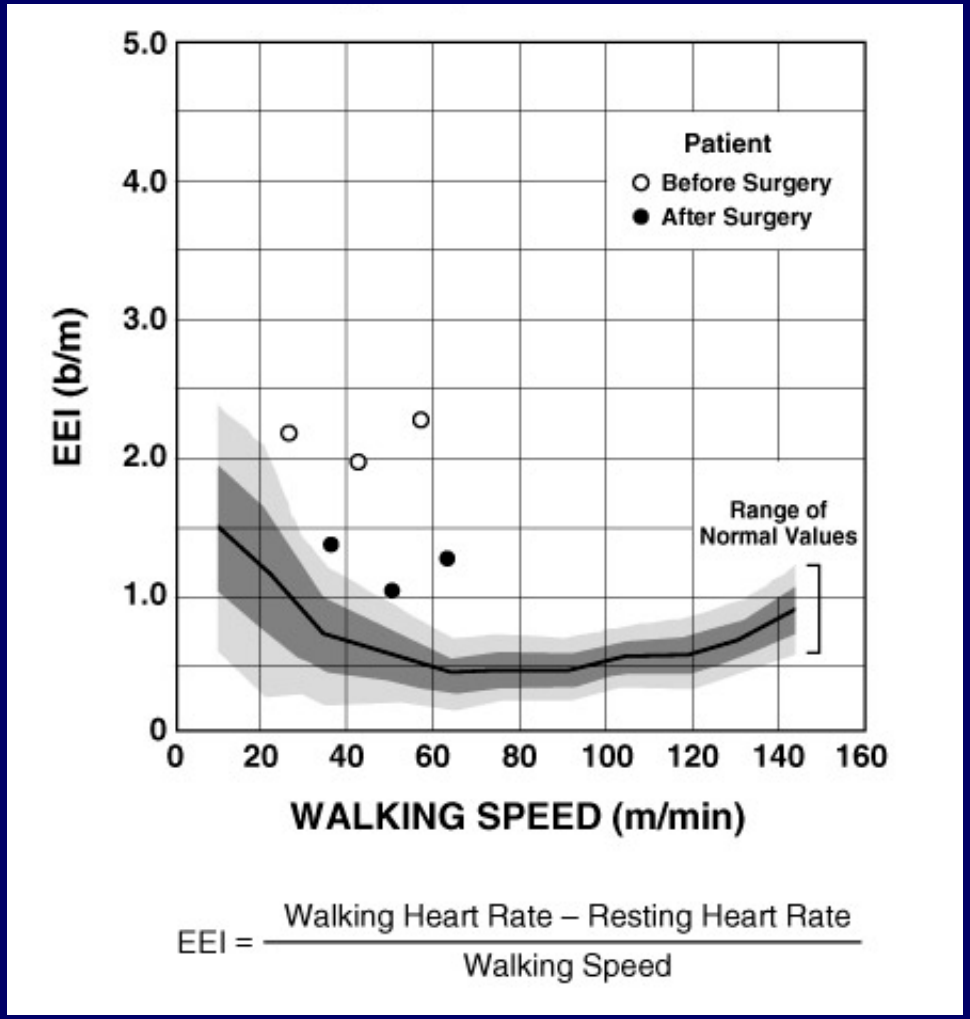
Postural Balance

- Force Plate Center of Pressure
- Postural Sway with Eyes Open / Closed



Energy Expenditure

Energy Expenditure Index



$$EEI = \frac{\text{Walking Heart Rate} - \text{Resting Heart Rate}}{\text{Walking Speed}}$$

Pathologic Gait

Neuromuscular Conditions

- Equinus
- Equinovarus
- Pseudo equinus (knees bent, ankles at neutral, forefoot contact)
- Jumped (knees bent, ankles true equinus)
- Crouch (knees bent, ankles dorsiflexed)
- Stiff–knee gait

Pathologic Gait

Musculoskeletal Conditions

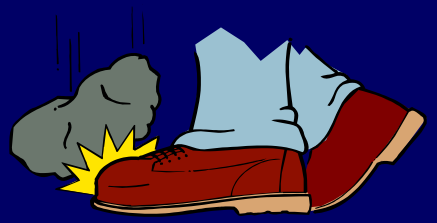
Polio, Dislocation, Arthritis, Muscular Dystrophy

- Pain
- Muscle weakness
- Structural abnormalities (joint instability, short limb)
- Loss of motion
- *Combinations of above*

Antalgic Gait

Painful Gait

- Any gait that reduces loading on an affected extremity by decreasing stance phase time or joint forces



- Examples
  - "stone in your shoe"
  - Painful hip, knee, foot, etc

Thank You