

Normal Gait

Heikki Uustal, MD

Medical Director, Prosthetic/Orthotic Team

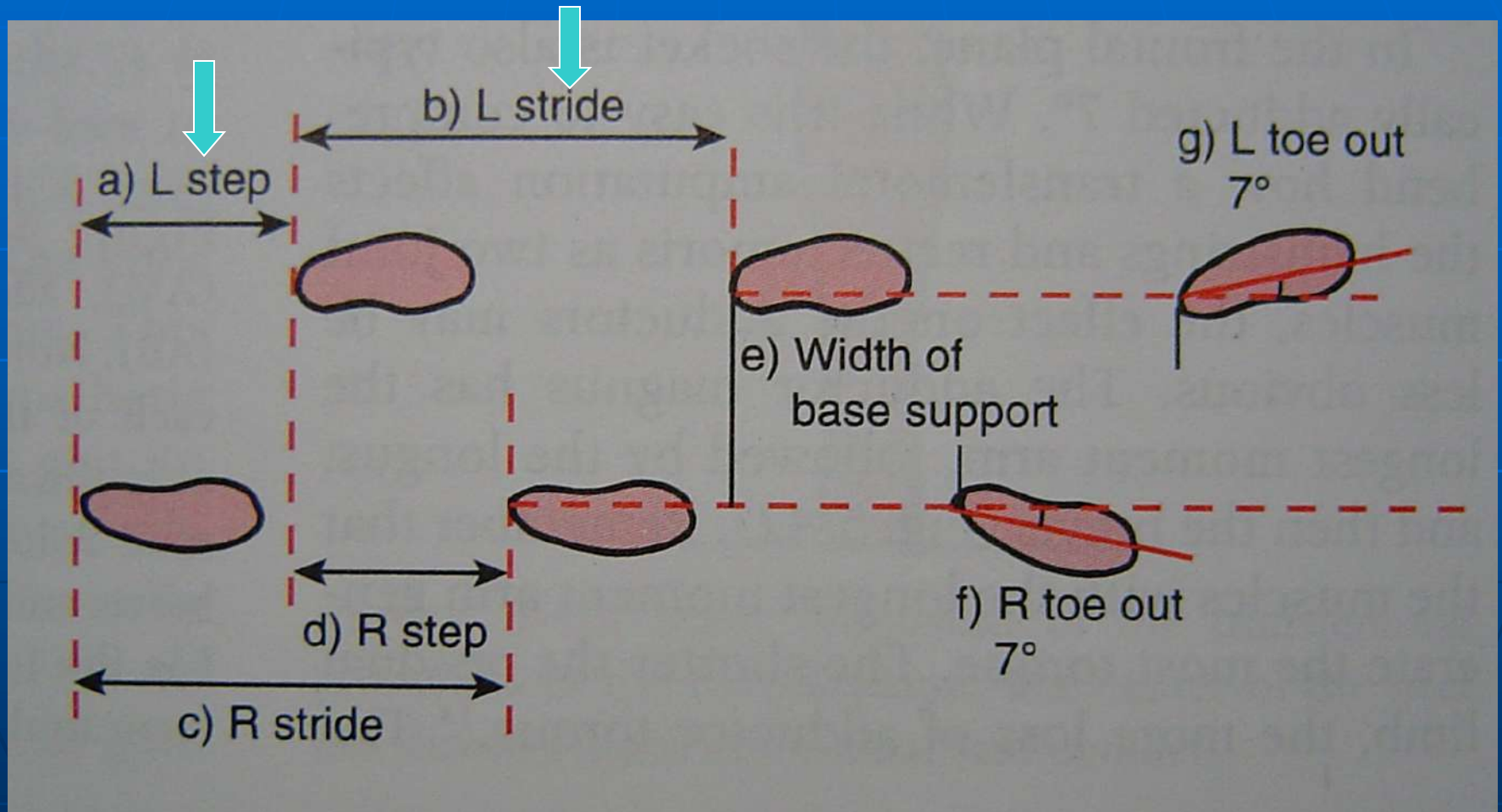
JFK-Johnson Rehab Institute

Edison, NJ

Critical Gait Parameters

- Average walking speed = 2-3 mph (60-80m/min)
- Average cadence = 80-110 steps/min
- Average step length = 60 cm
- Stance/swing = 60/40
- Single/double limb support = 80/20
- Running has no double limb support

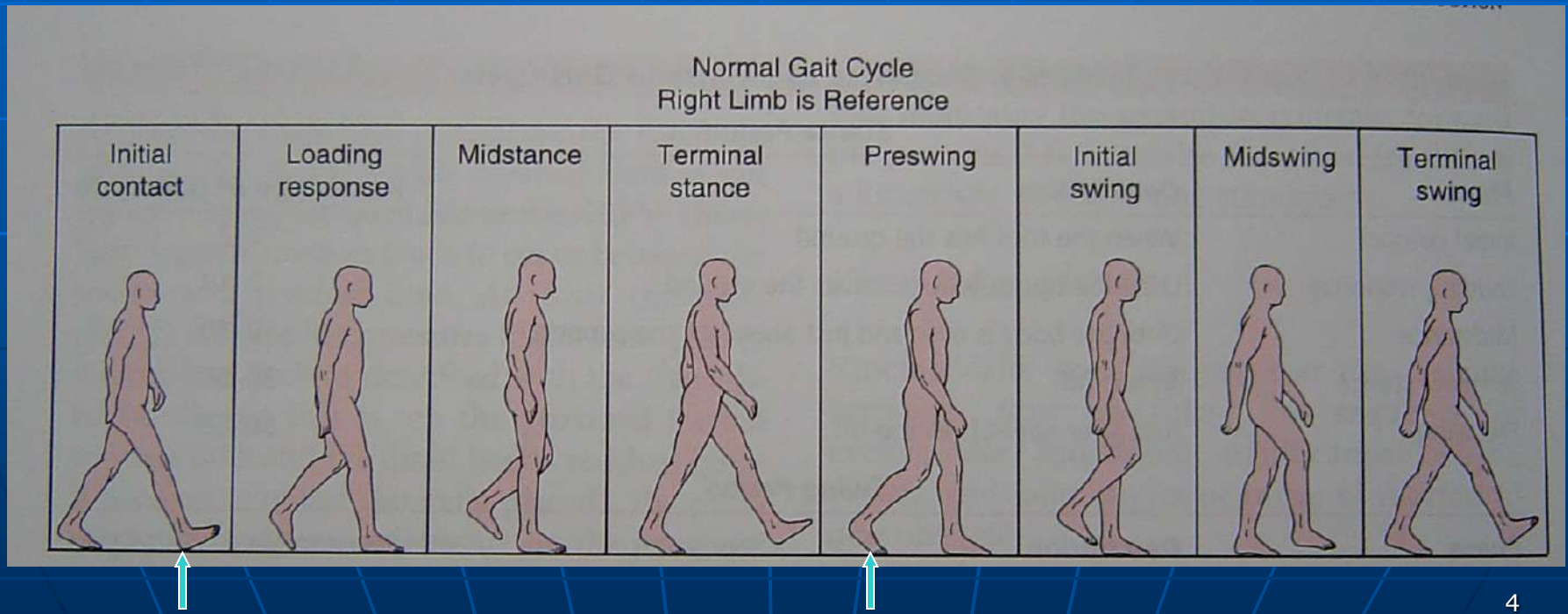
Step or Stride?



Phases of the Gait Cycle

Stance Phase – 60%

Swing Phase – 40%



Comparison of Right Leg to Left Leg Phases

Table 5-2. Summary of Gait Phases

R	0–10% (10%)	10–30% (20%)	30–50% (20%)	50–60% (10%)	60–73% (13%)	73–87% (14%)	87–100% (13%)
R	Initial & loading	Midstance	Terminal stance	Preswing	Initial swing	Midswing	Terminal swing
L	Preswing	Initial swing	Midswing	Terminal swing	Initial & loading	Midstance	Terminal stance
L	0–10% (10%)	10–23% (13%)	23–37% (14%)	37–50% (13%)	50–60% (10%)	60–80% (20%)	80–100% (20%)

Key: Swing Stance

Three Important Gait Factors

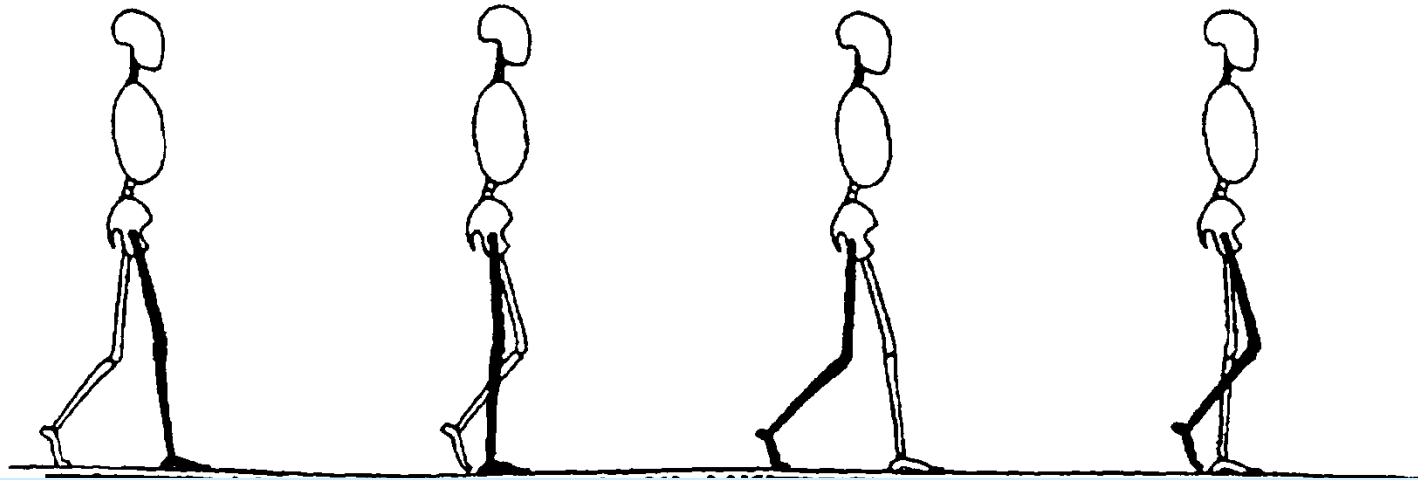
- Forward Progression
- Stance Stability
- Conservation of Energy

Methods of Analyzing Gait

- **Kinematics** is the method of observing or measuring the position of joints and segments through each phase of gait (visual gait analysis)
- **Kinetics** is the method of measuring the Ground Reaction Force at each joint and then calculating the muscle activity or soft tissue resistance present to stabilize the joint

Gait Analysis Basic Training

- Assess only one joint at a time
- Look at early stance, late stance, then swing
- Separate kinetics from kinematics
- **KEEP IT SIMPLE!**



Normal Human Locomotion: Sagittal Plane Gait Kinematics

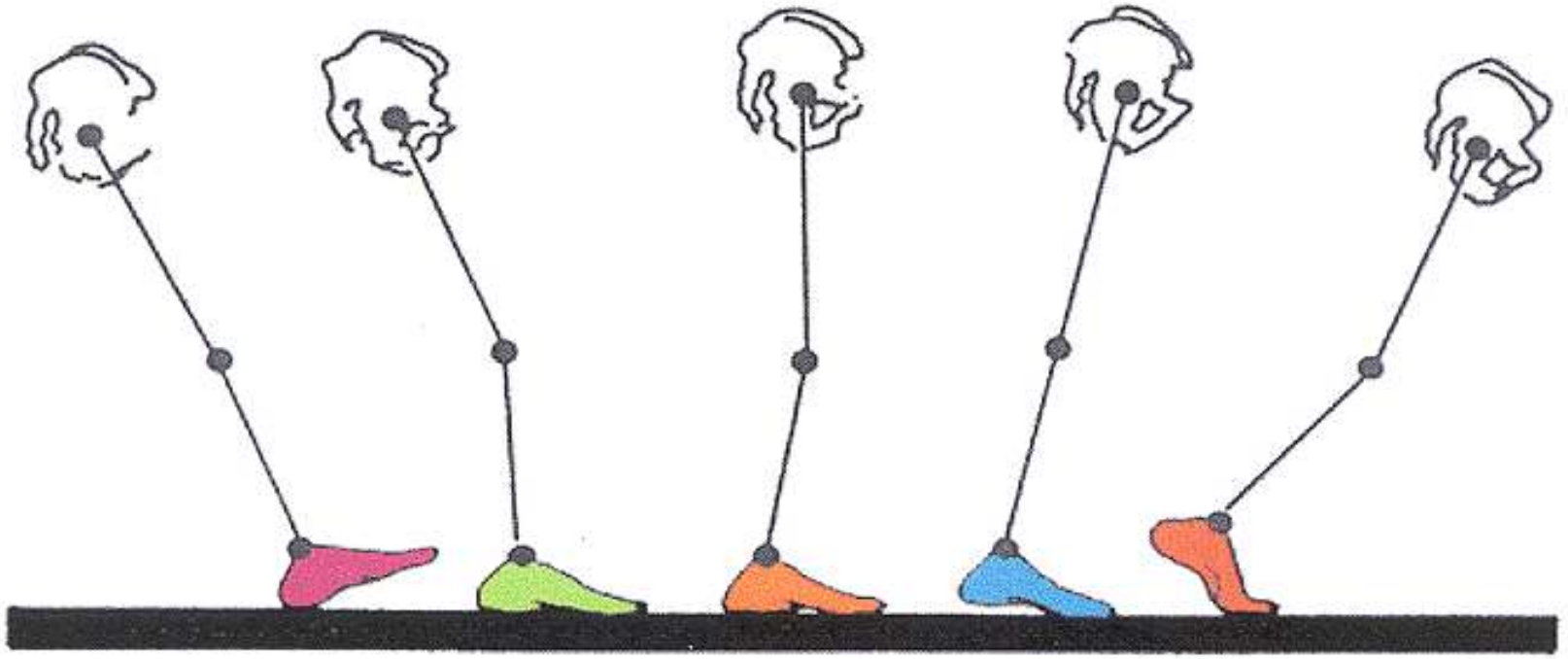
**HEEL
STRIKE**

**LOADING
RESPONSE**

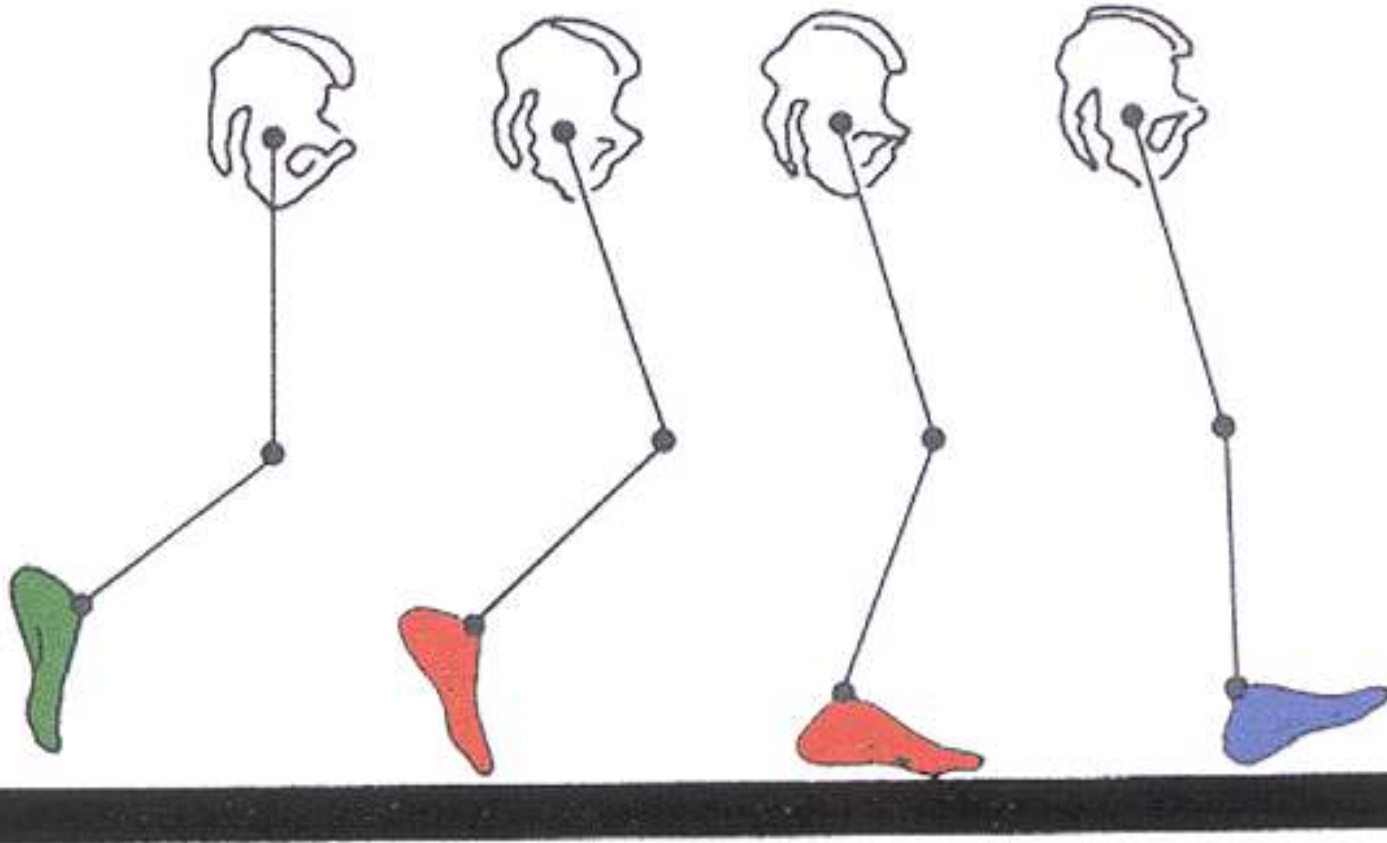
**MID-
STANCE**

**TERMINAL
STANCE**

**PRE-
SWING**



STANCE PHASE



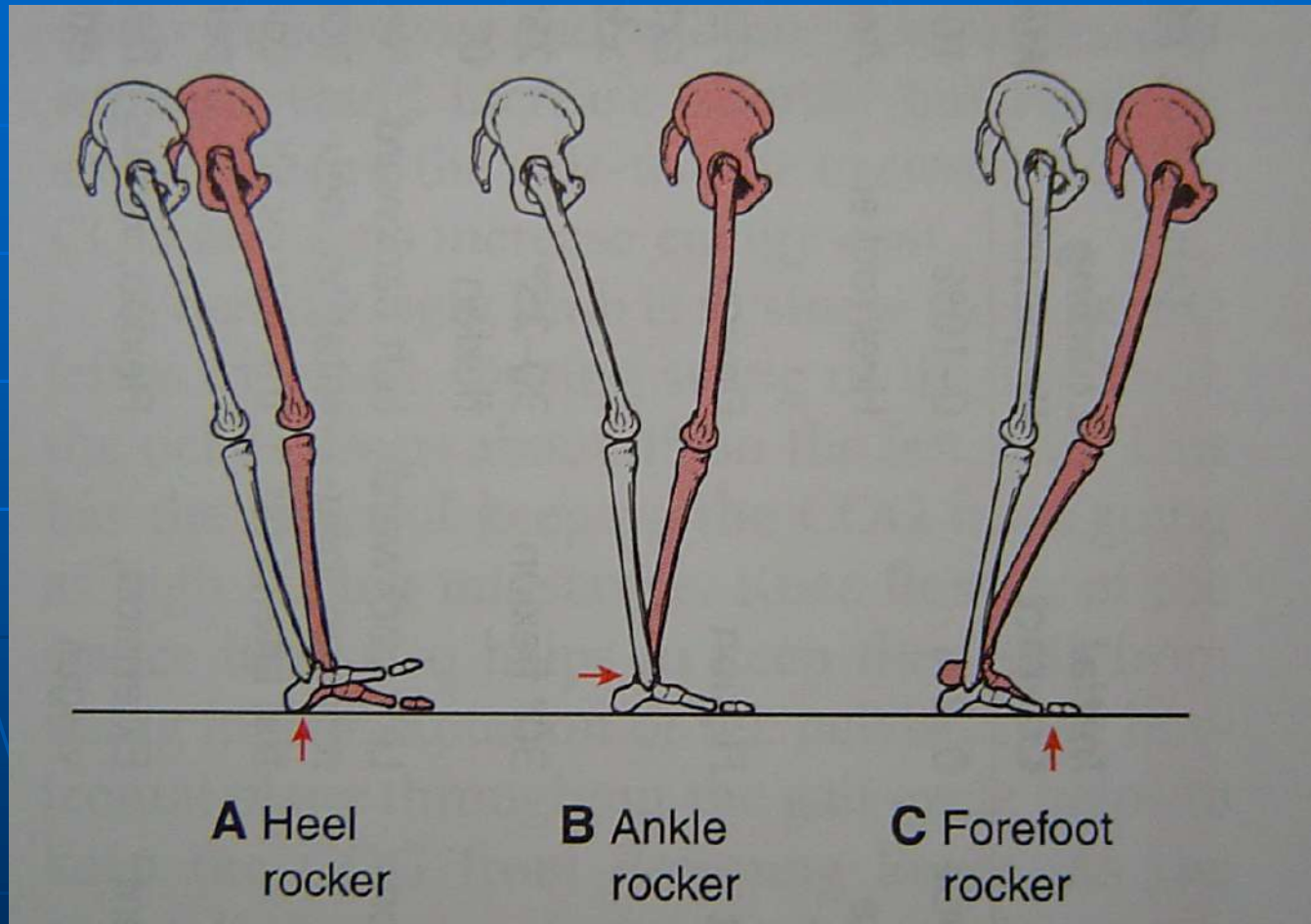
INITIAL SWING

MIDSWING

TERMINAL SWING

SWING PHASE

Rockers or Pivot Points in Stance



Initial Contact:

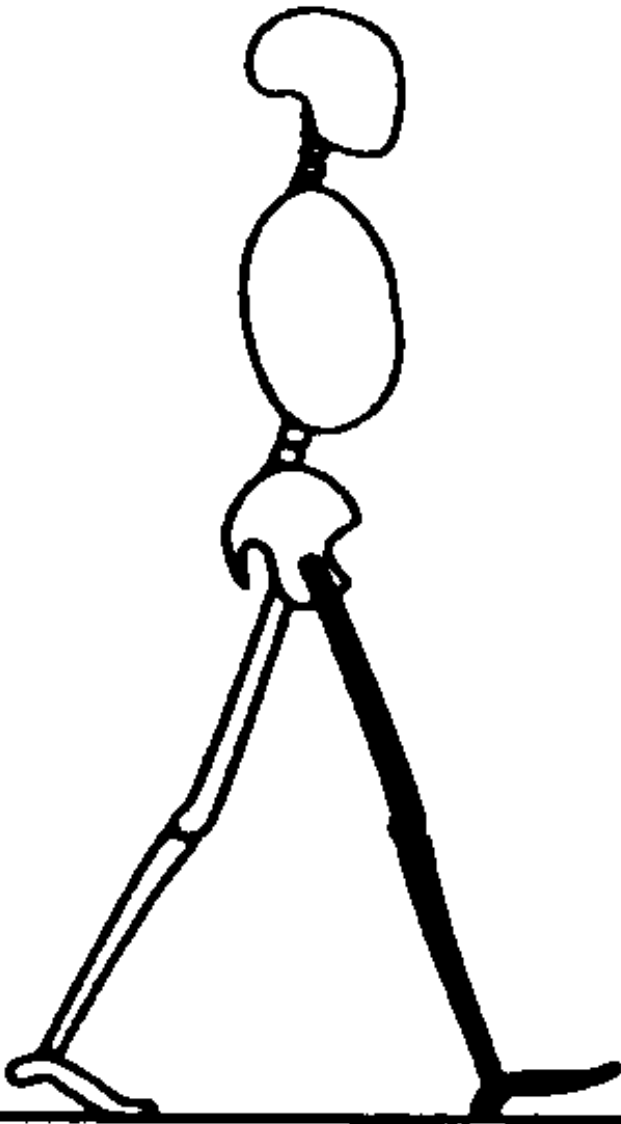
- Double Support

- Hip = Flexed 30*

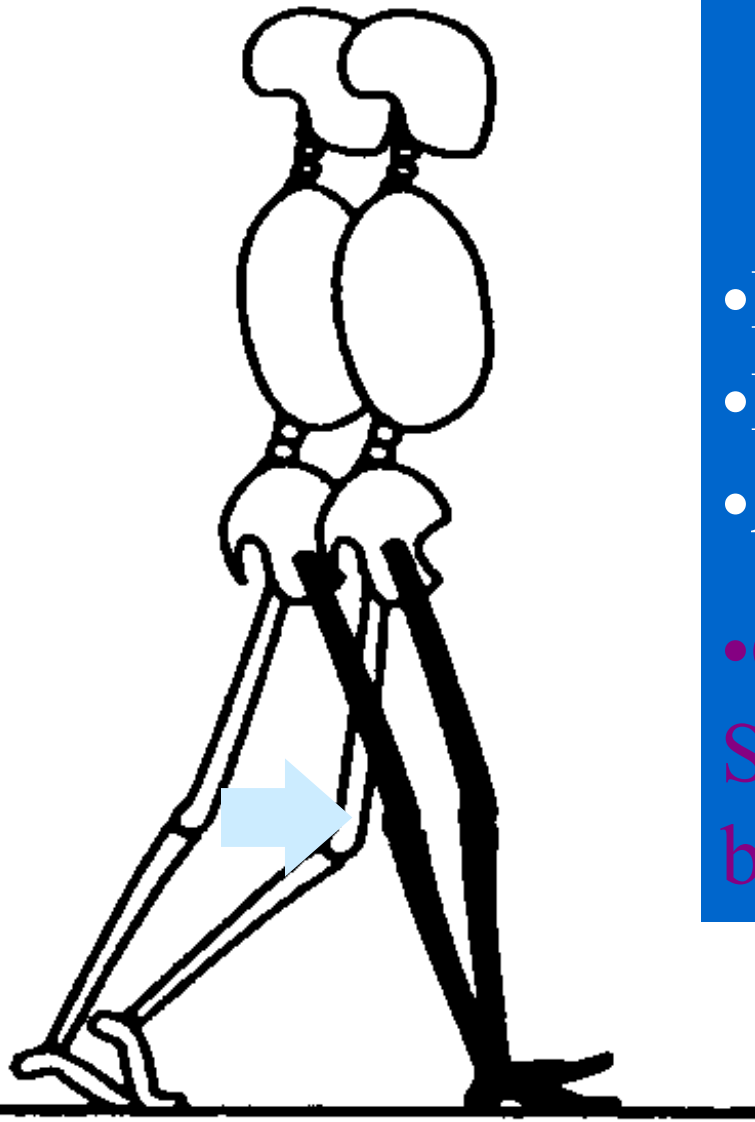
- Knee = Extended

- Ankle = Neutral

- Goal = Begin Stance



Initial Contact



Loading Response

Loading Response:

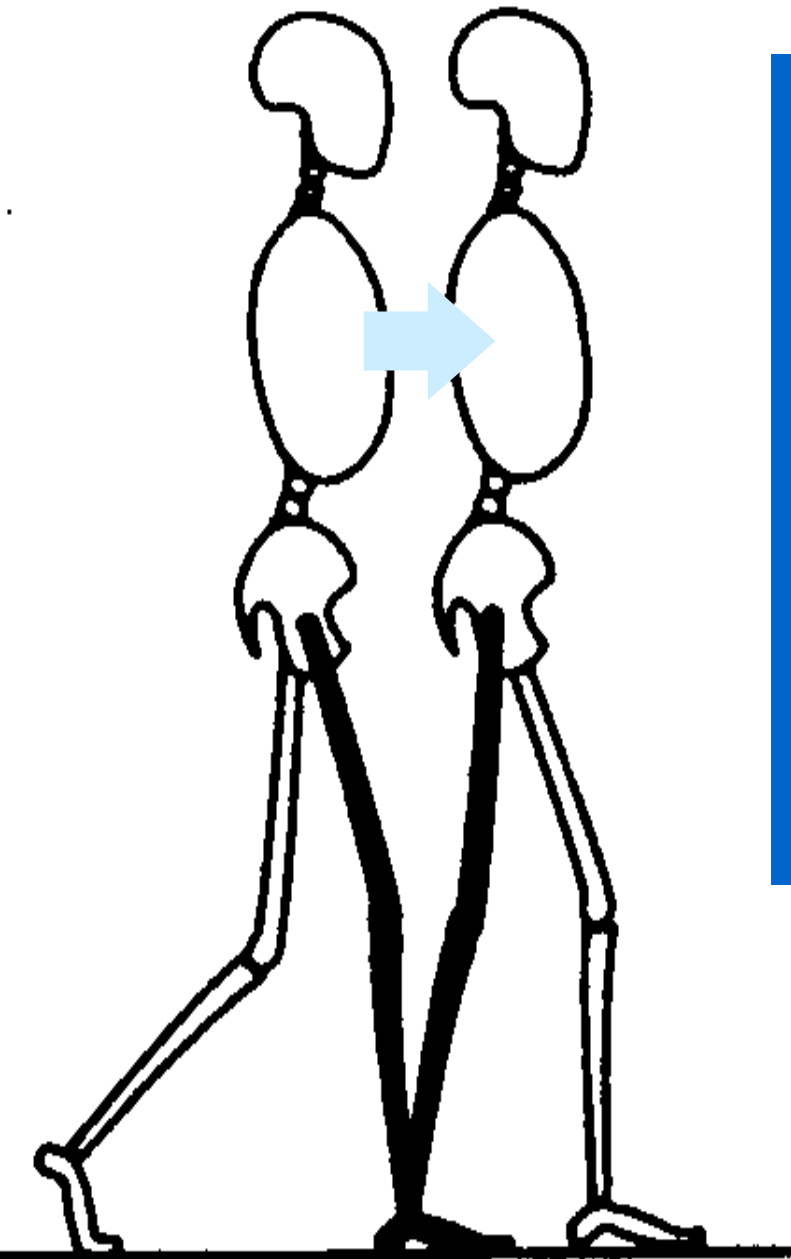
•Double Support

- Hip = Flexed
- Knee = Flexing 5-10*
- Ankle = Plantarflexing to 20*
- Goals = Weight Acceptance, Shock Absorption, Advance body over Heel Rocker

Mid Stance:

• Single Support

- Hip = Extending
- Knee = Extending but not to 0*
- Ankle = Dorsiflexing
- Goal = Advance body over stationary foot, ankle rocker

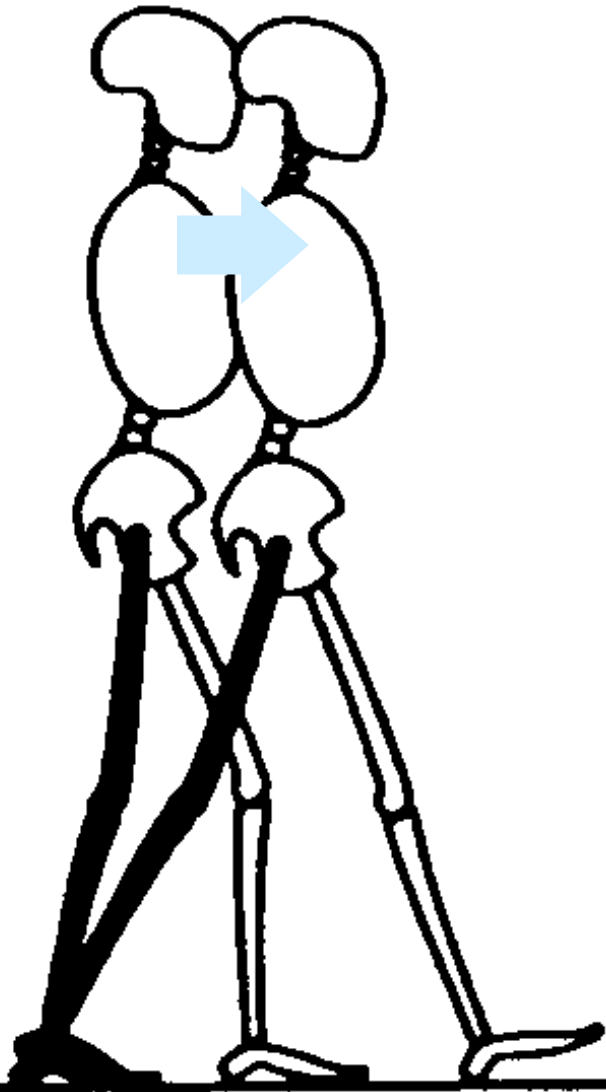


Mid Stance

Terminal Stance:

• Single Support

- Hip = Extending 15-30*
- Knee = Extend, then Flex
- Ankle = 15* DF to Neutral
- Goal = Advance body over forefoot rocker

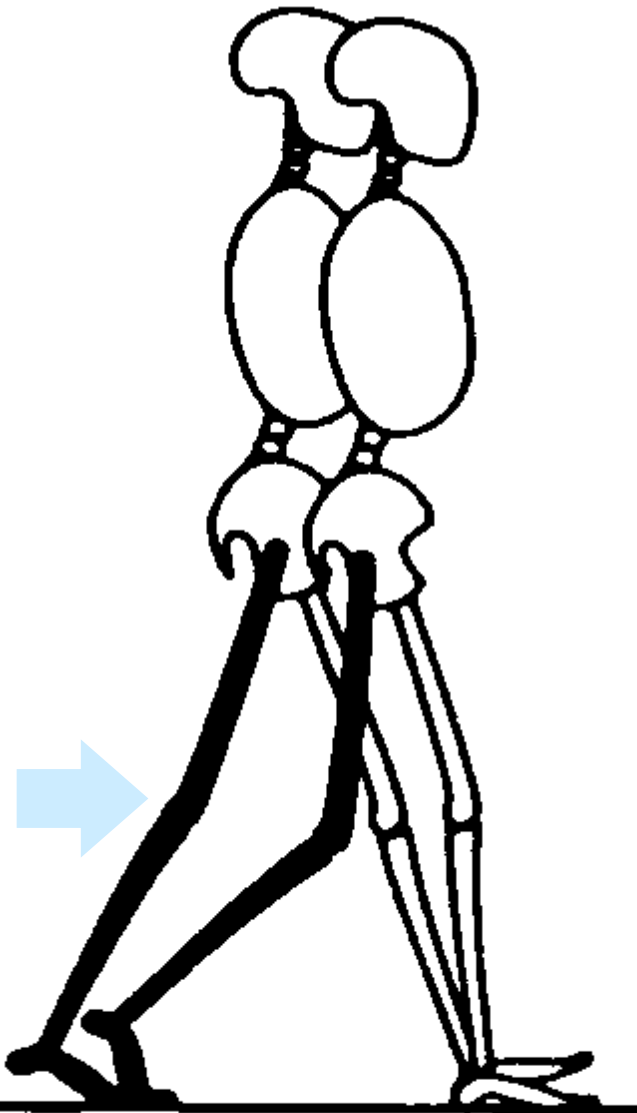


Terminal Stance

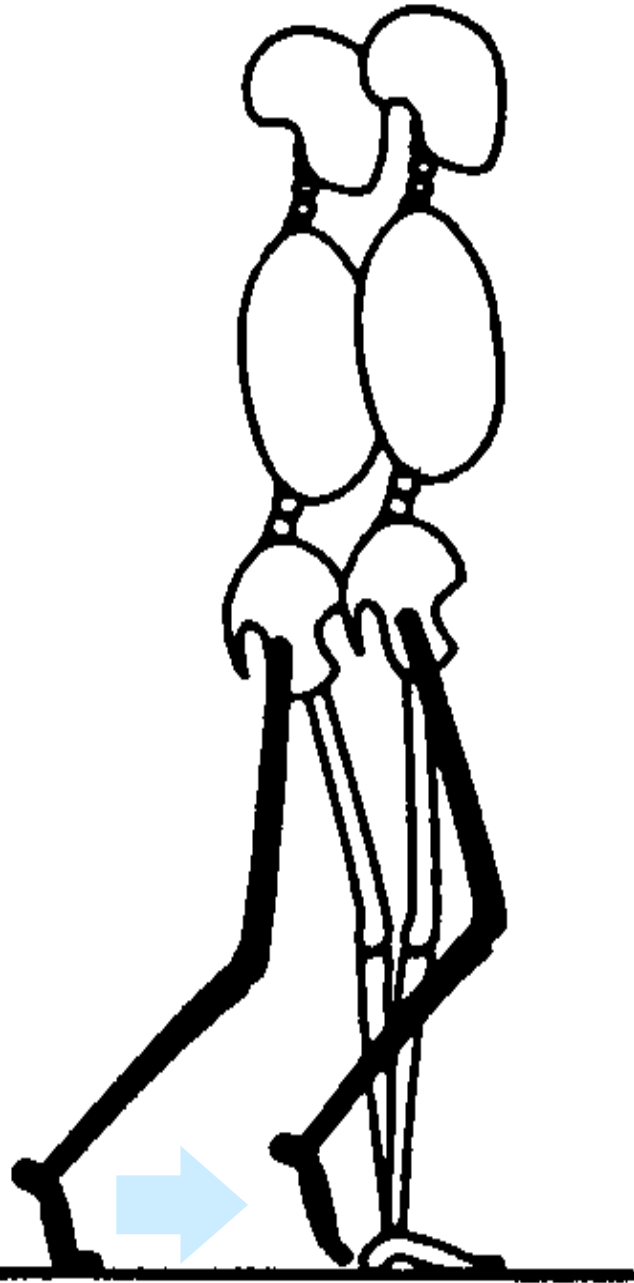
Pre Swing:

•Double Support

- Hip = Flexing
- Knee = Flexing 30-40*
- Ankle = Plantarflexing 20-30*
- Goal = Prepare for Swing, transfer load to other limb



Pre-Swing



Initial Swing

Initial Swing:

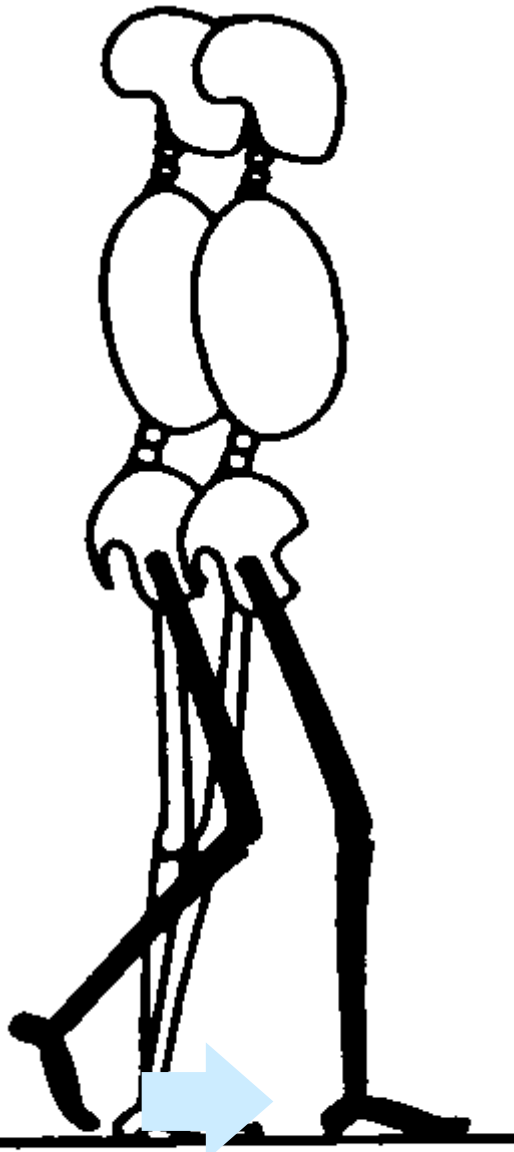
• Single Support

- Hip = Flexing
- Knee = Flexing up to 65*
- Ankle = Dorsiflexing to 0*
- Goal = Clear foot and advance limb

Mid Swing:

• Single Support

- Hip = Flexing to 30*
- Knee = Extending
- Ankle = Dorsiflexing to 0*
- Goal = Advance limb and clear foot

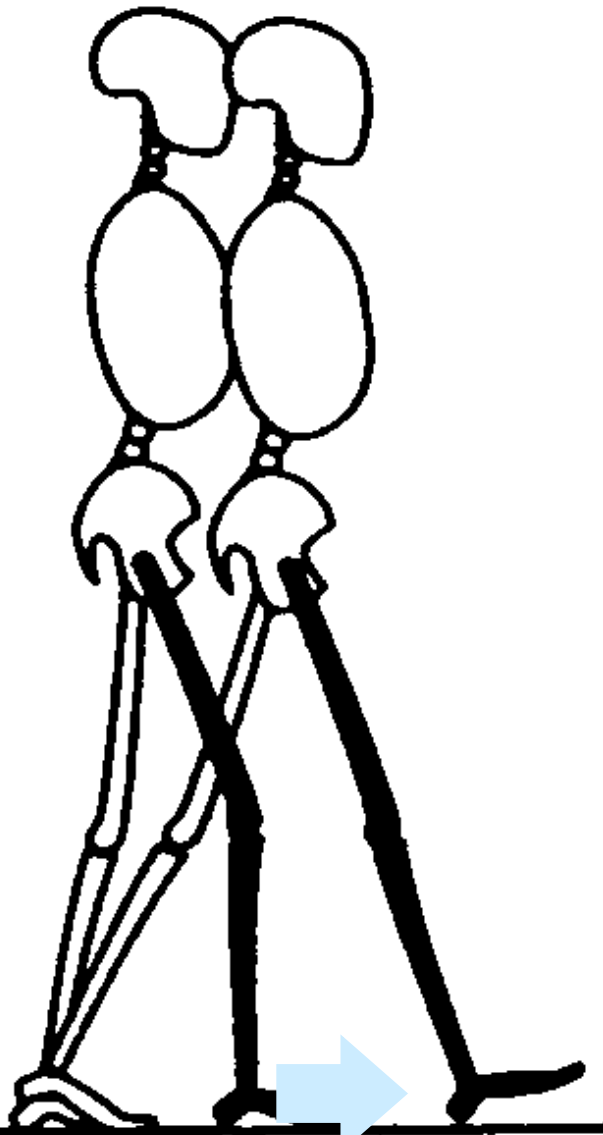


Mid Swing

Terminal Swing:

• Single Support

- Hip = Flexed 30*
- Knee = Extending
- Ankle = Neutral
- Goal = Advance limb



Terminal Swing

Initial Contact:

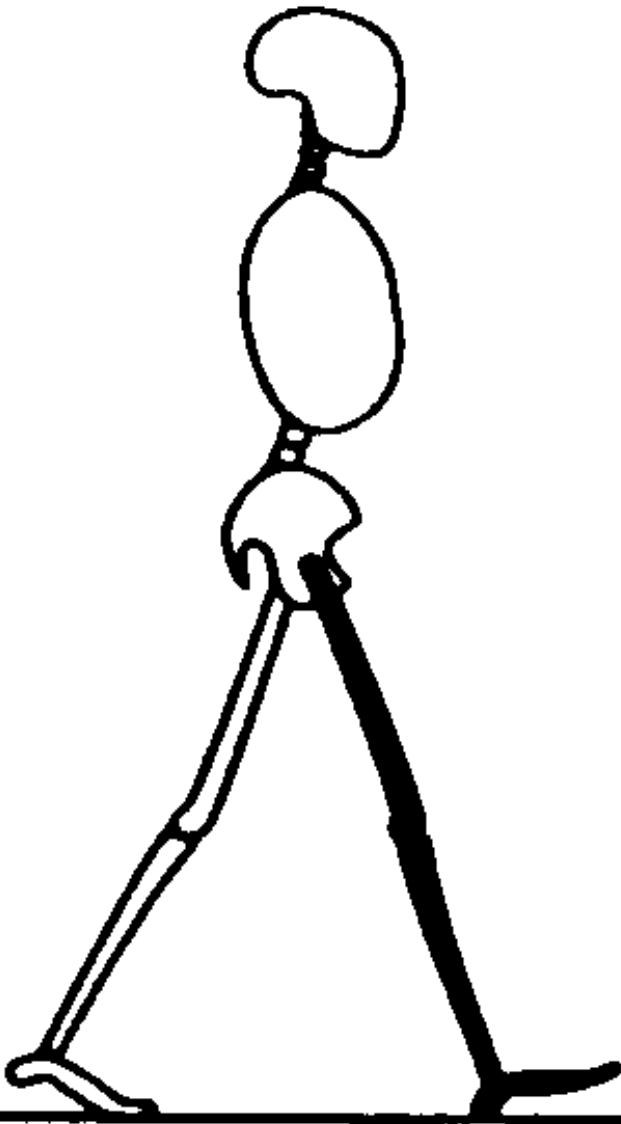
- Double Support

- Hip = Flexed 30*

- Knee = Extended

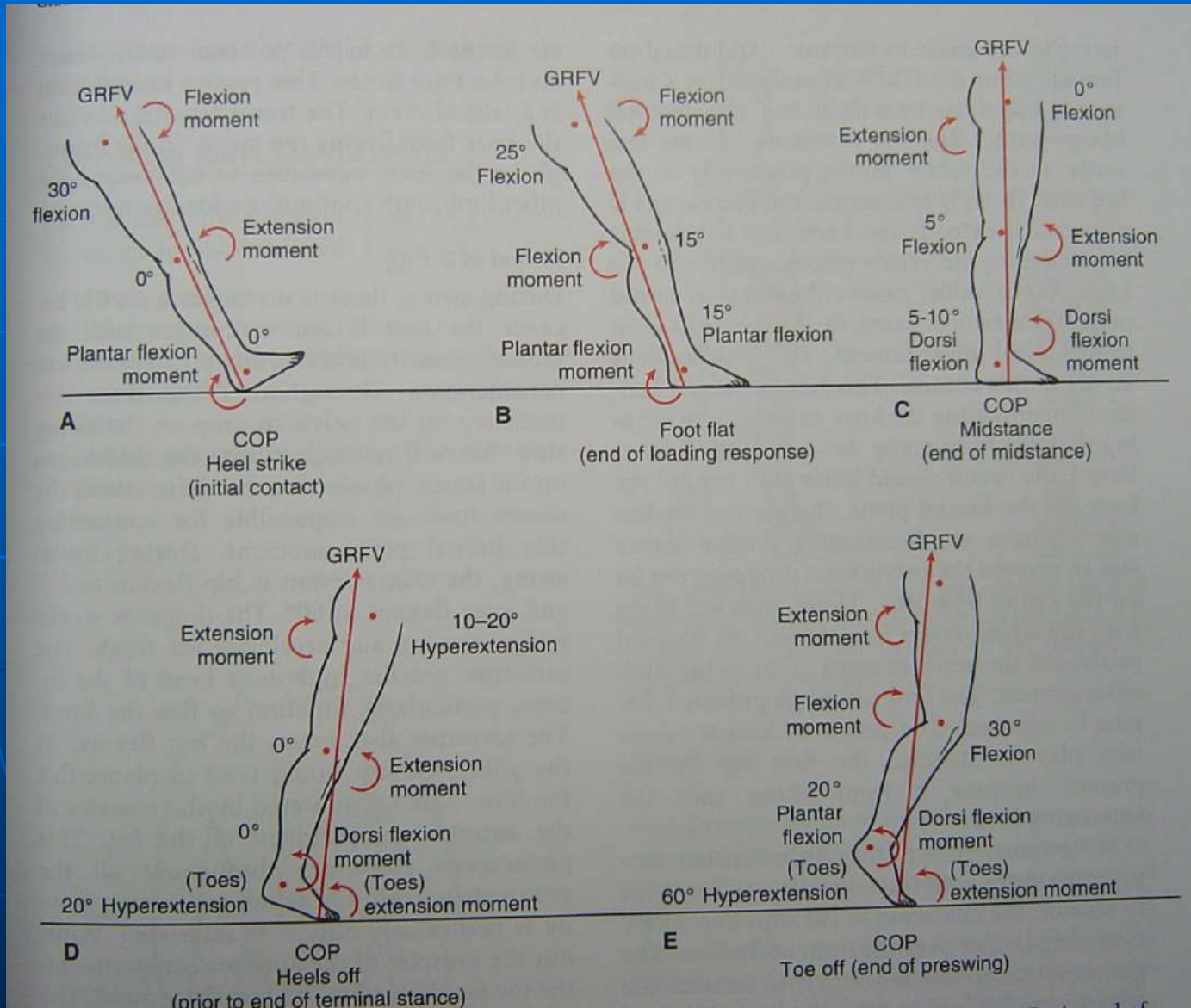
- Ankle = Neutral

- Goal = Begin Stance

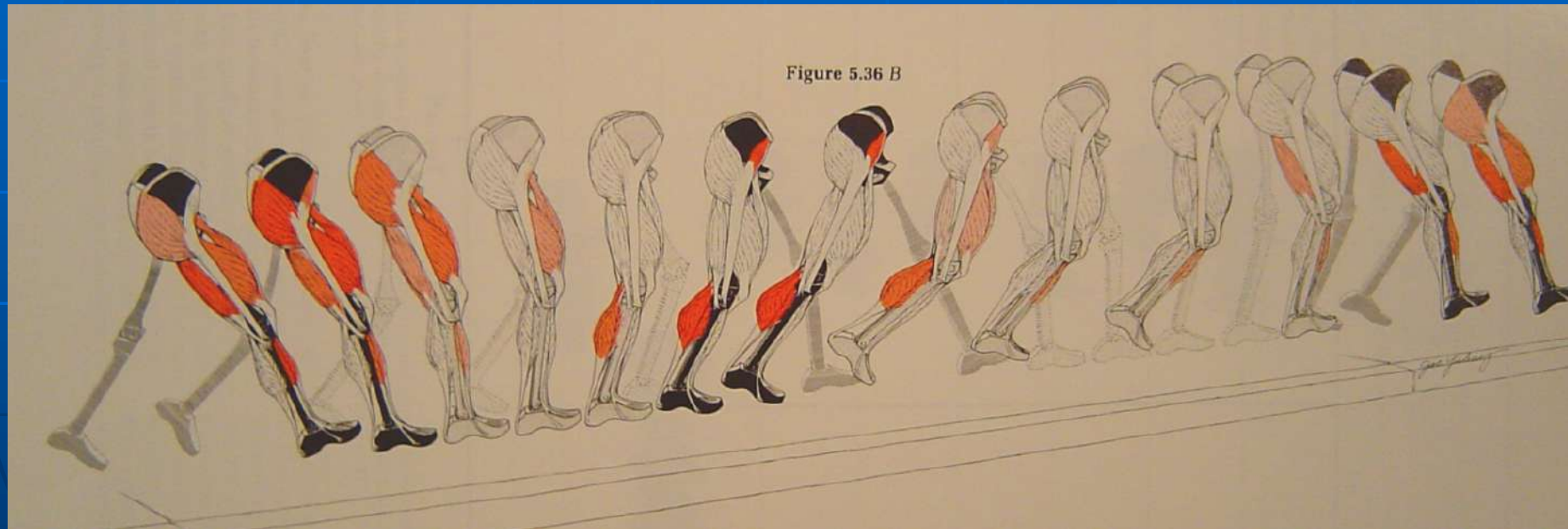


Initial Contact

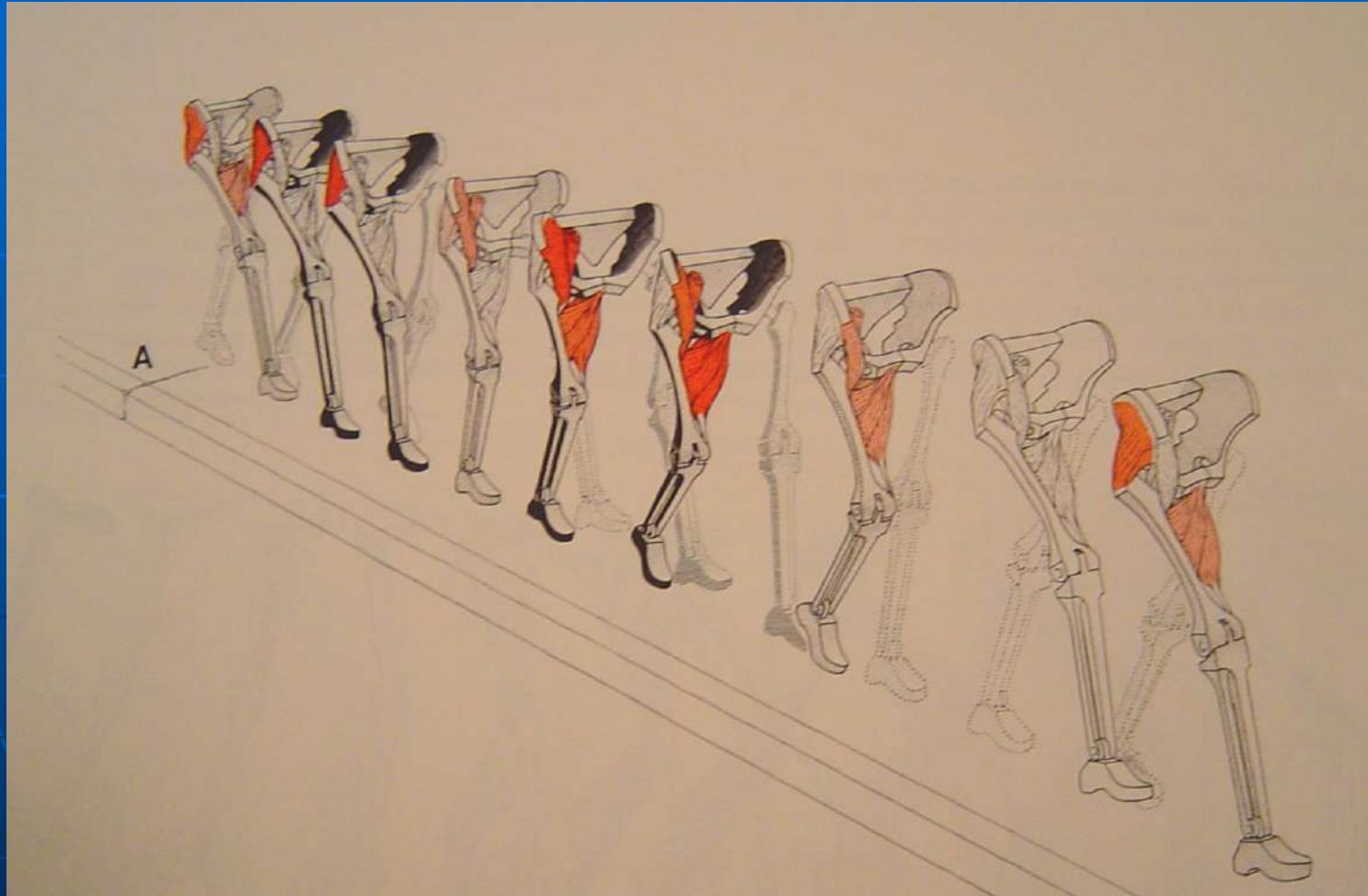
Kinetics of Stance Phase



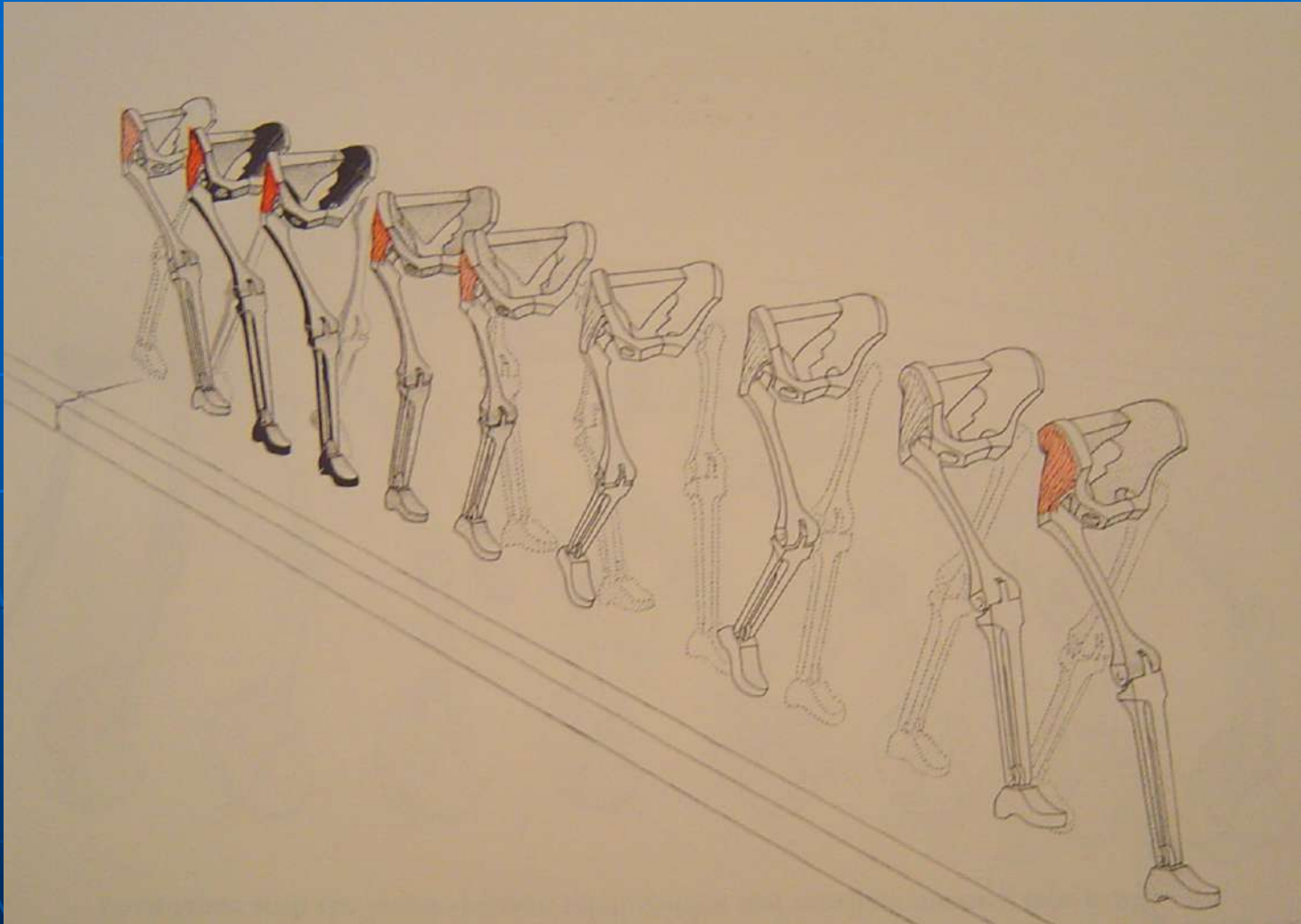
Activity of All Major Muscles



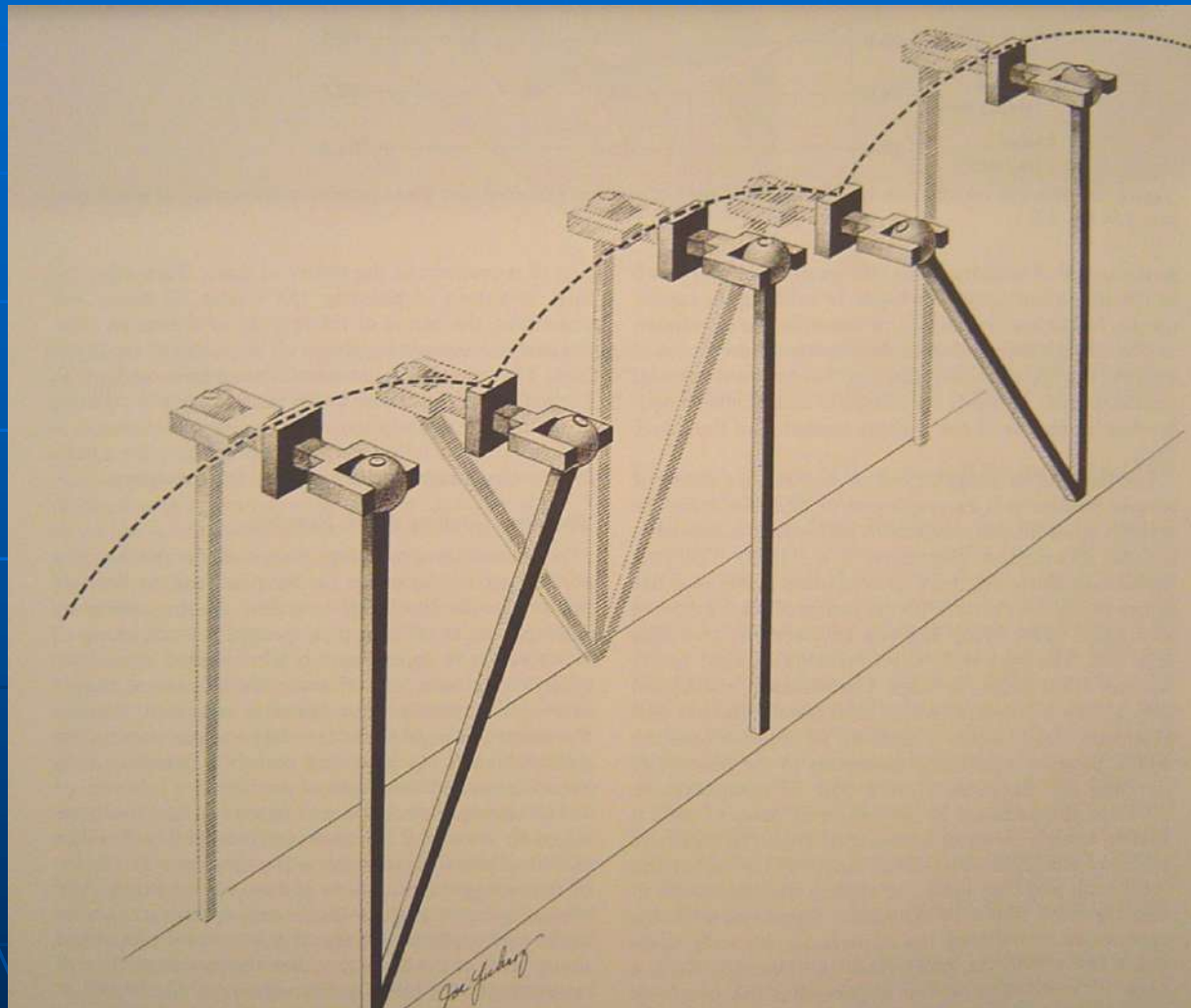
Activity of All Major Muscles



Hip Abductor Activity

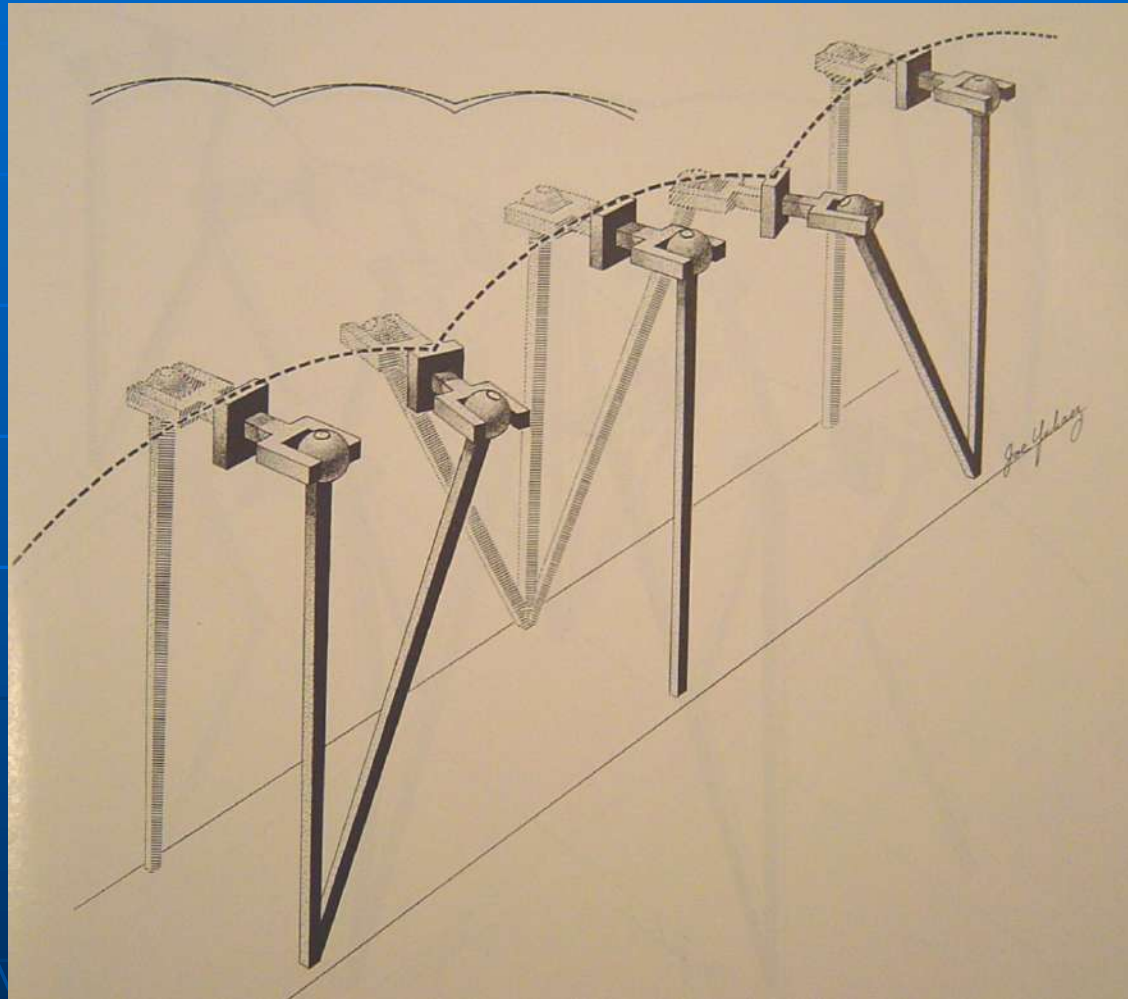


Determinants of Gait Stick Figure Model

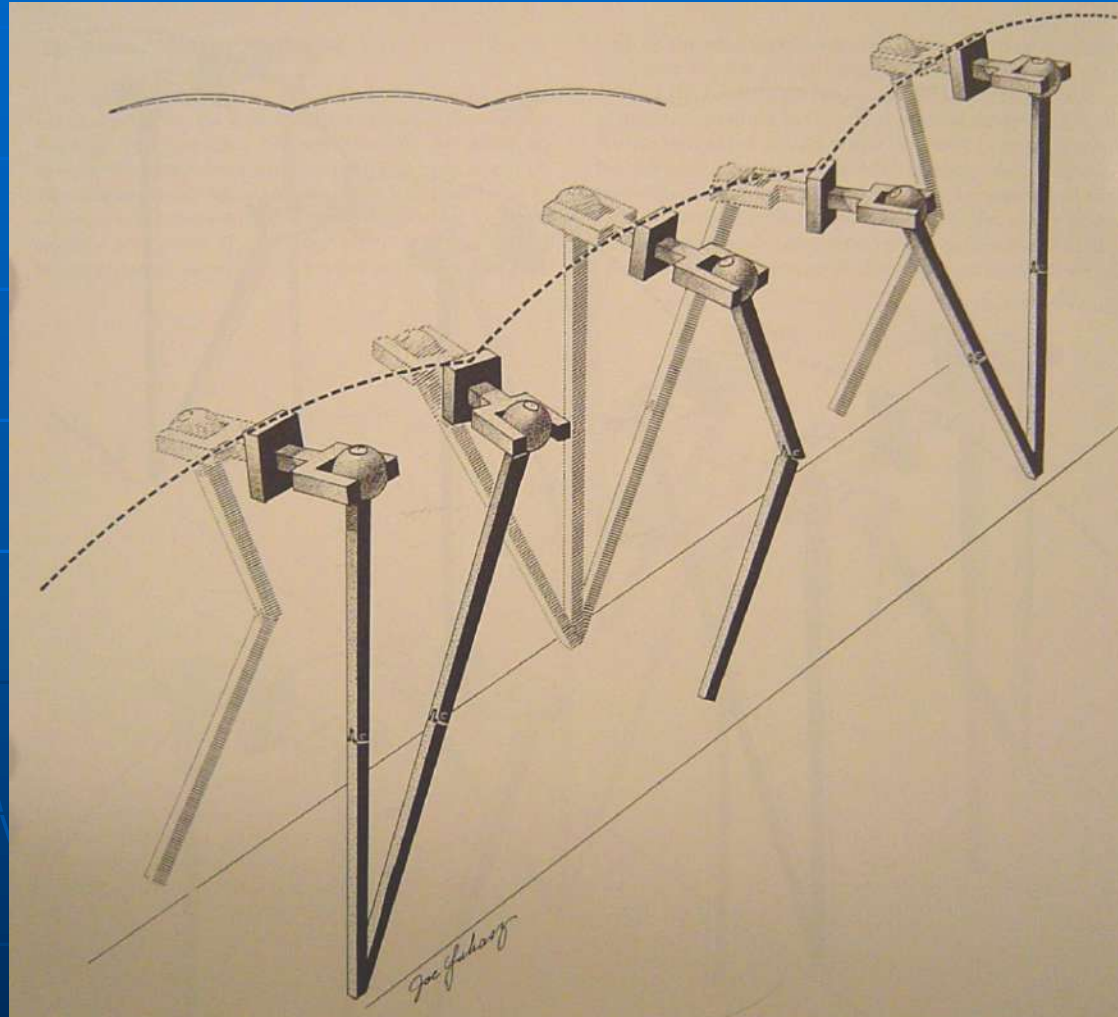


1. Pelvic Rotation

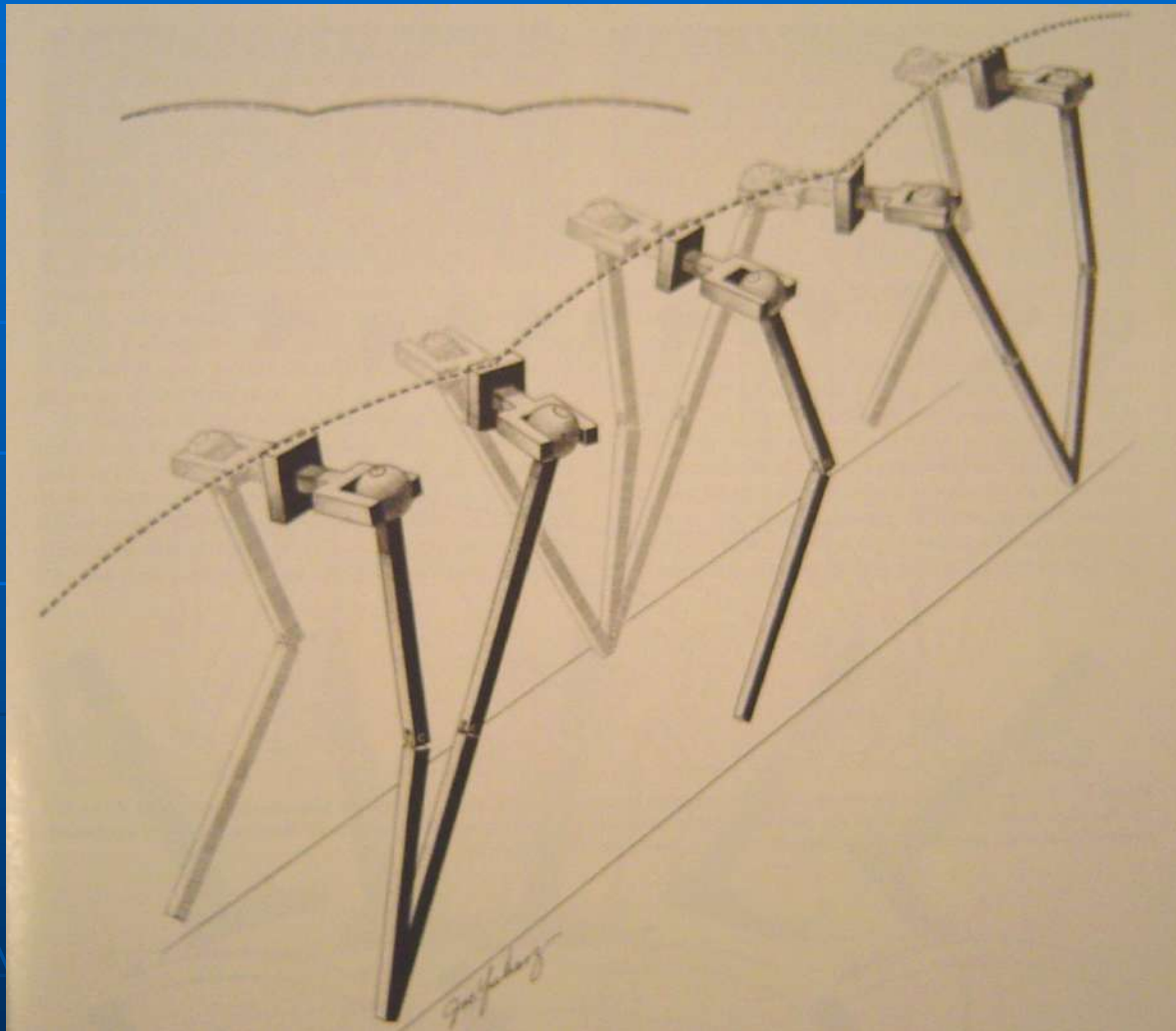
Lengthens Limb at IC and PS



2. Pelvic Tilt Shortens Limb at MS



3. Knee Flexion in Stance Shortens Limb at MS



4&5. Foot and Ankle Motion Lengthens and Shortens Limb

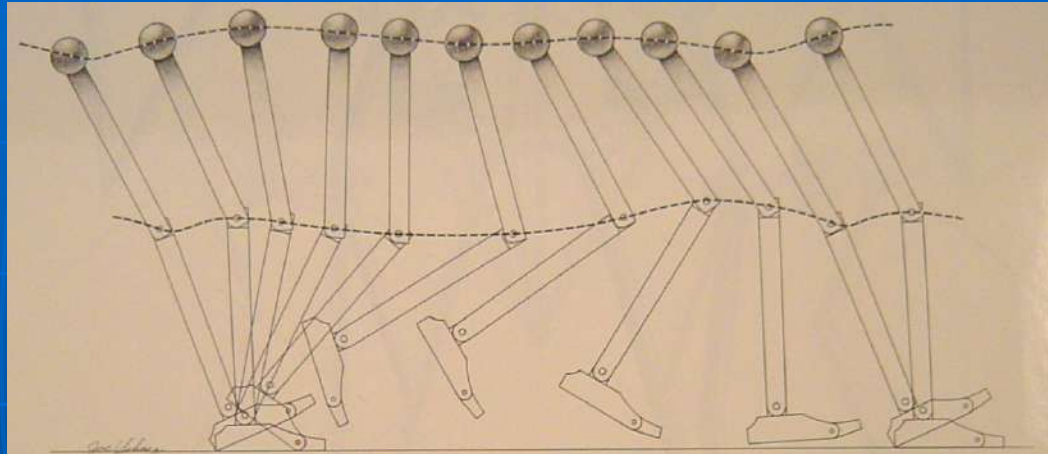


Figure 1.7. Pathway of knee in walking at moderate speed. Note that there is a slight elevation immediately after heel strike, but for the remainder of stance phase the pathway is relatively straight and shows only a slight declination from the horizontal. (Reproduced, with permission, from Saunders et al. *J. Bone Joint Surg.* 35-A:543, 1953.)

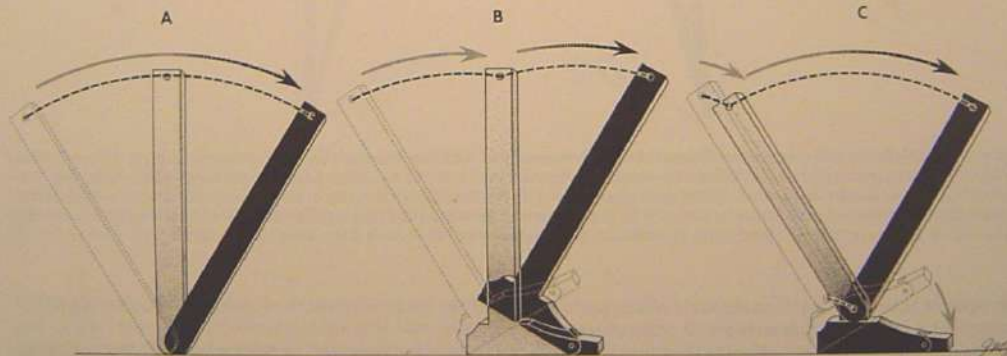
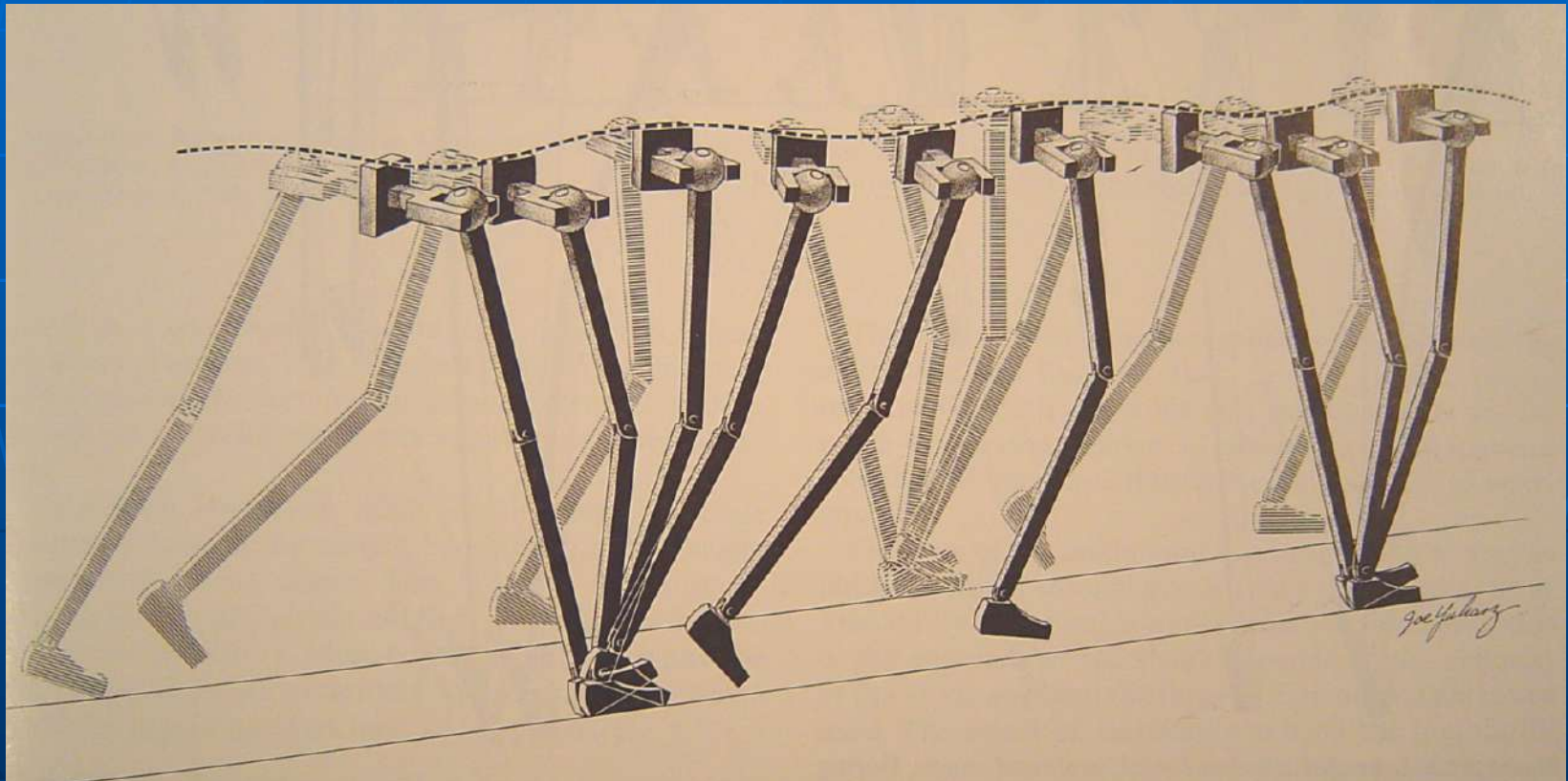
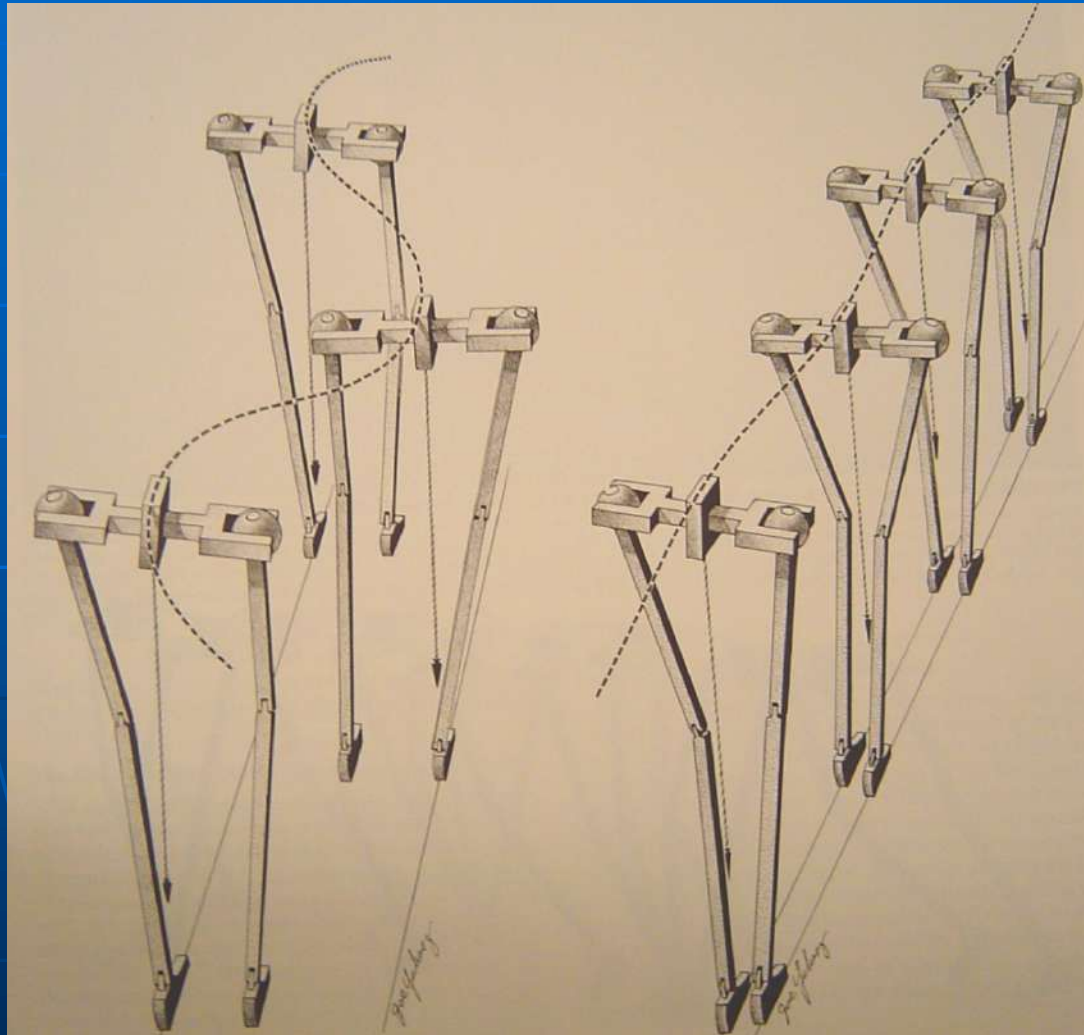


Figure 1.8. Effect of foot on pathway of knee. A, Arc described when there is no foot. B, Effect of foot without ankle. Note that the pathway now comprises two intersecting arcs. However, it does not fall abruptly at the end of stance and begins to resemble the normal pathway. C, Effect of foot with flail ankle. (Reproduced, with permission, from Saunders et al. *J. Bone Joint Surg.* 35-A:543, 1953.)

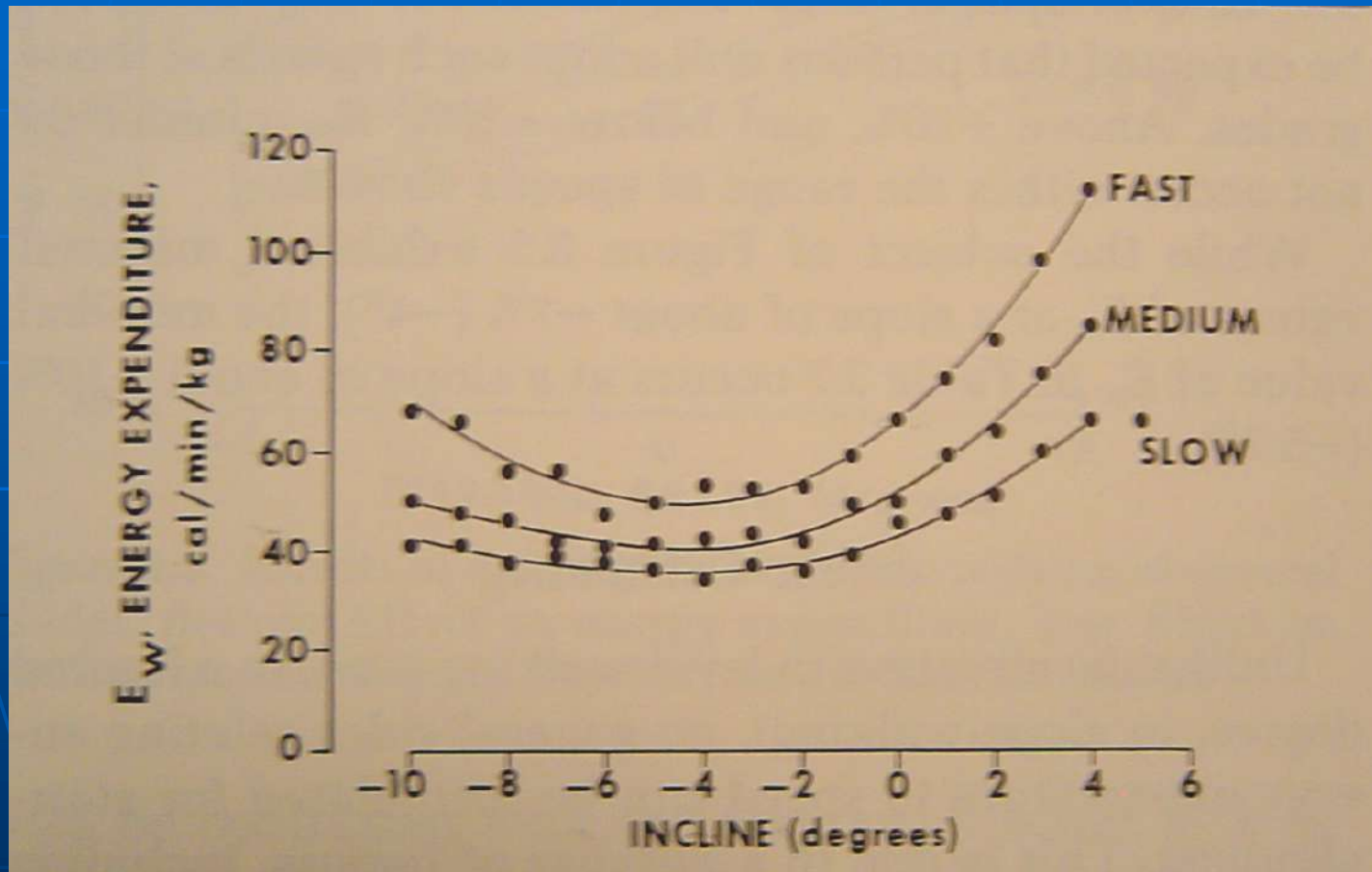
Sinusoidal Motion of the COG



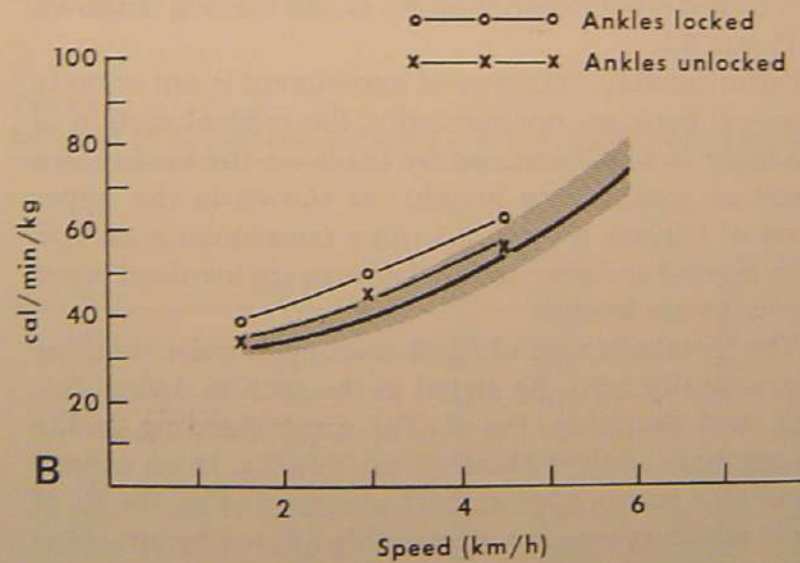
6. Narrow Base of Support to Minimize Horizontal Motion



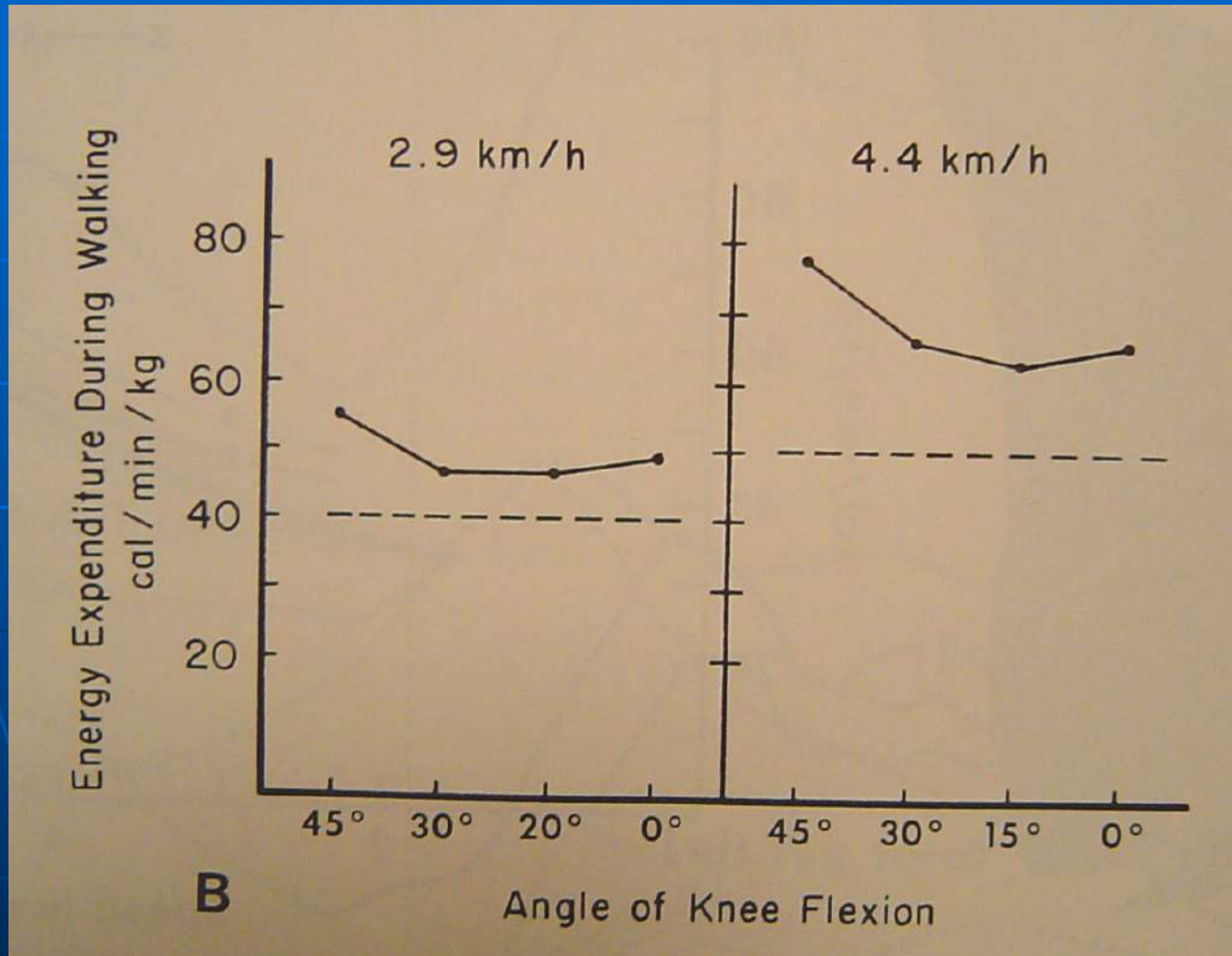
Effect of Incline on Energy



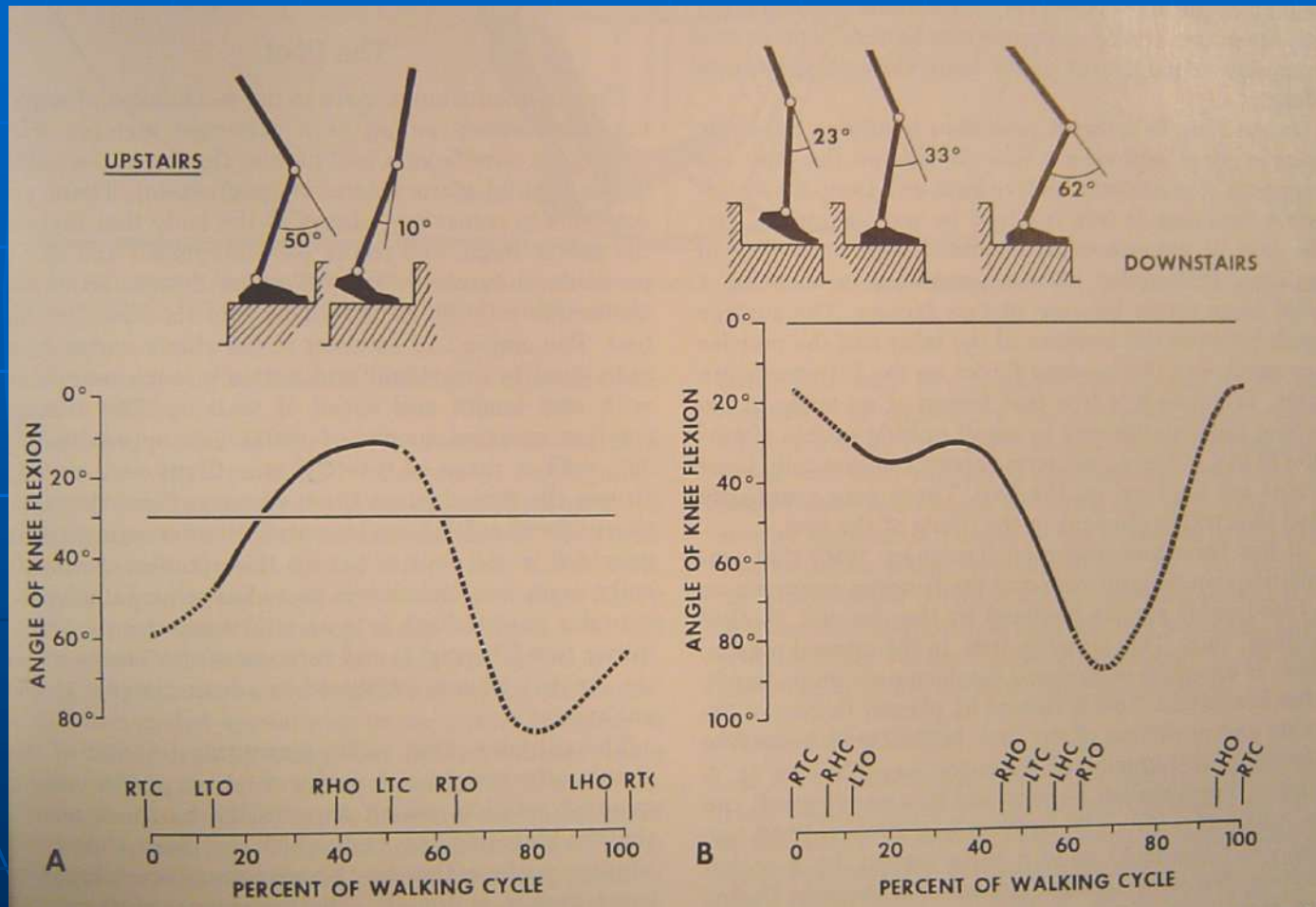
Effect of Ankle Immobilization on Gait



Effect of Knee Immobilization



Up and Down Stairs



Center of Gravity Line

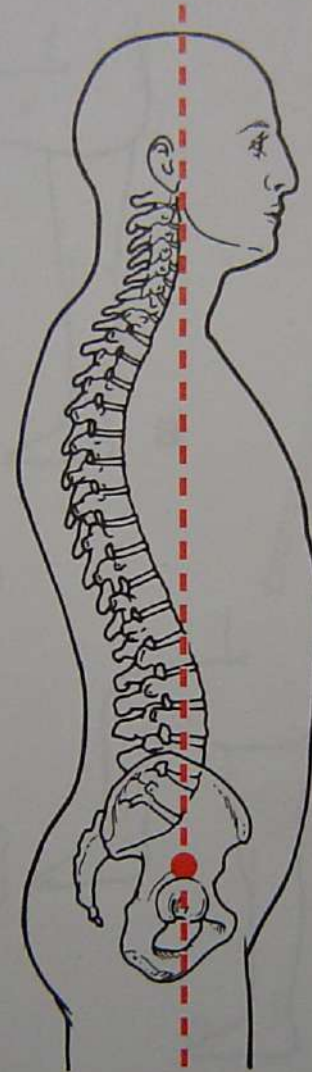


Figure 5-24. Location of the COG. In the average adult, the COG lies anterior to S2.

Base of Support

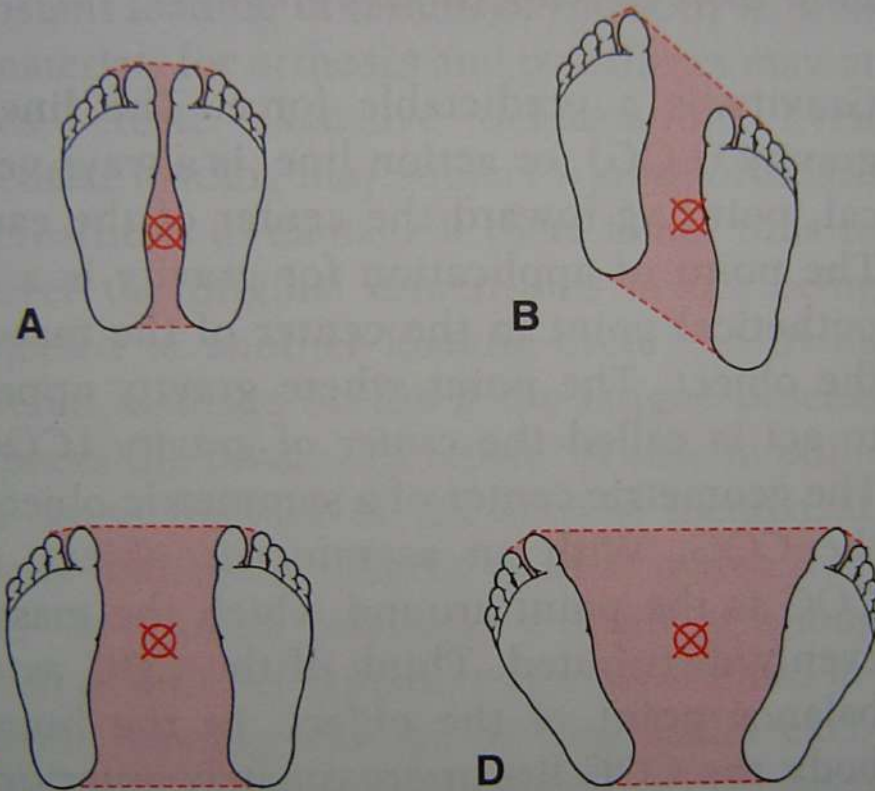


Figure 5-26. Base of support. The size of the base of support varies with a change in foot position.

Base of Support

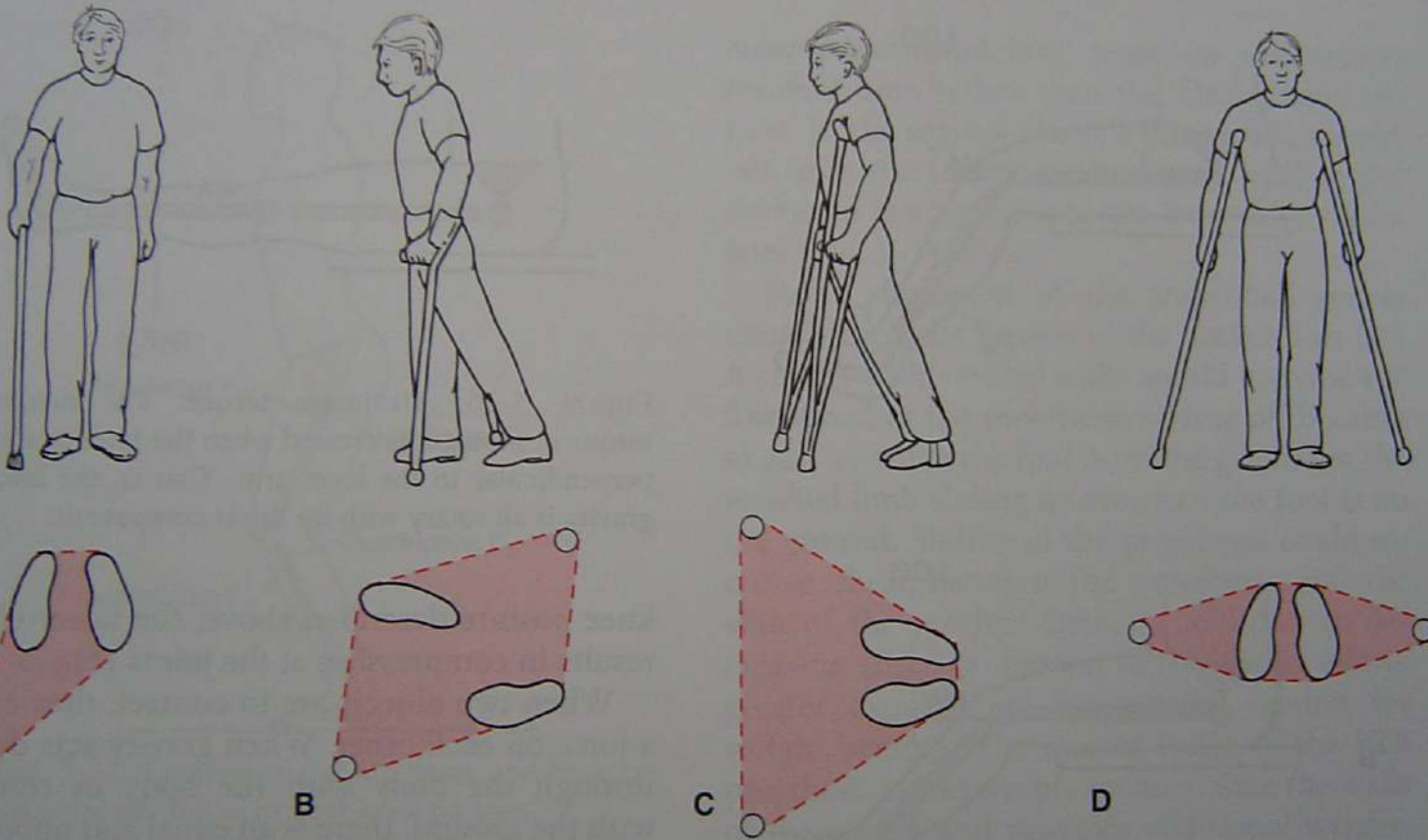


Figure 5-27. Base of support. The size of the base of support varies with the use of a cane or crutches and with placement of the assistive device.

Thank You