Biomechanics of Gait

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Sports Medicine
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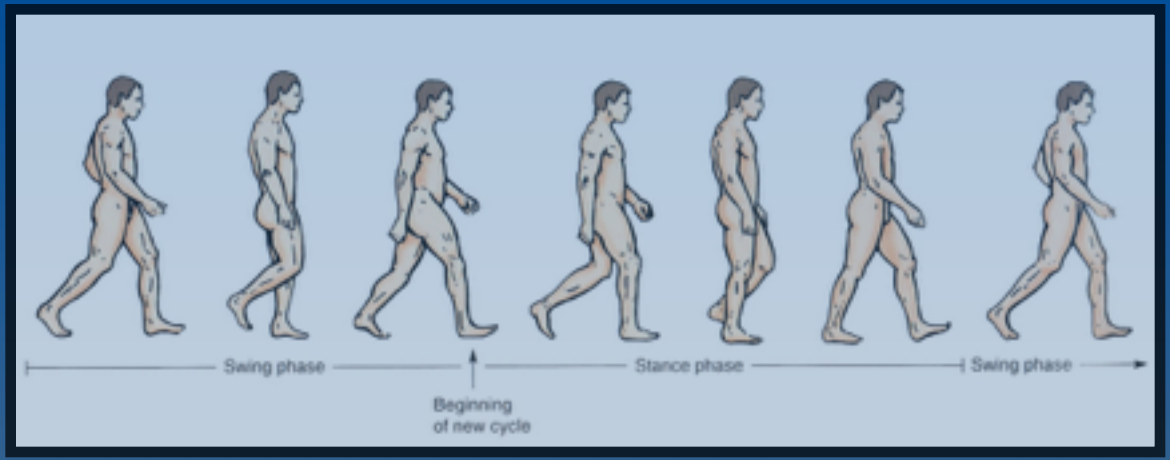
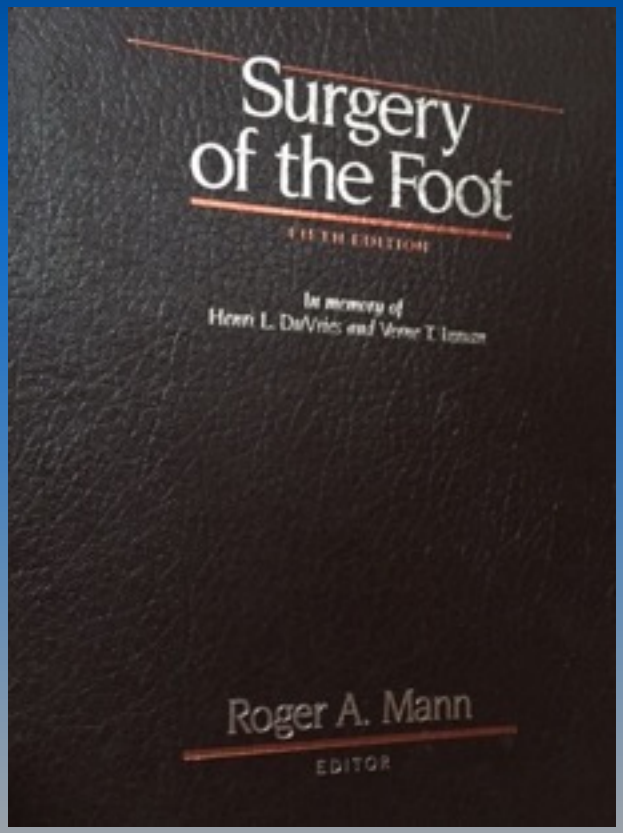


Surgery of the Foot
Roger A Mann Editor
CV Mosby
5th Edition 1986



Biomechanics of the Foot and Ankle by Roger A Mann
Chapter 1

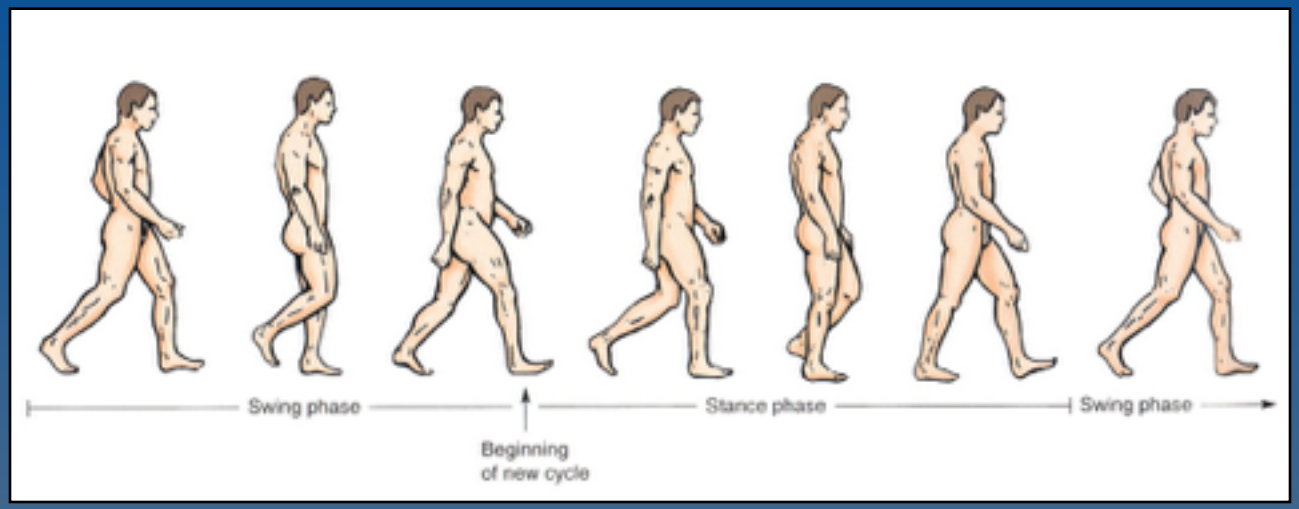
J. W. Thomas Byrd, M.D.

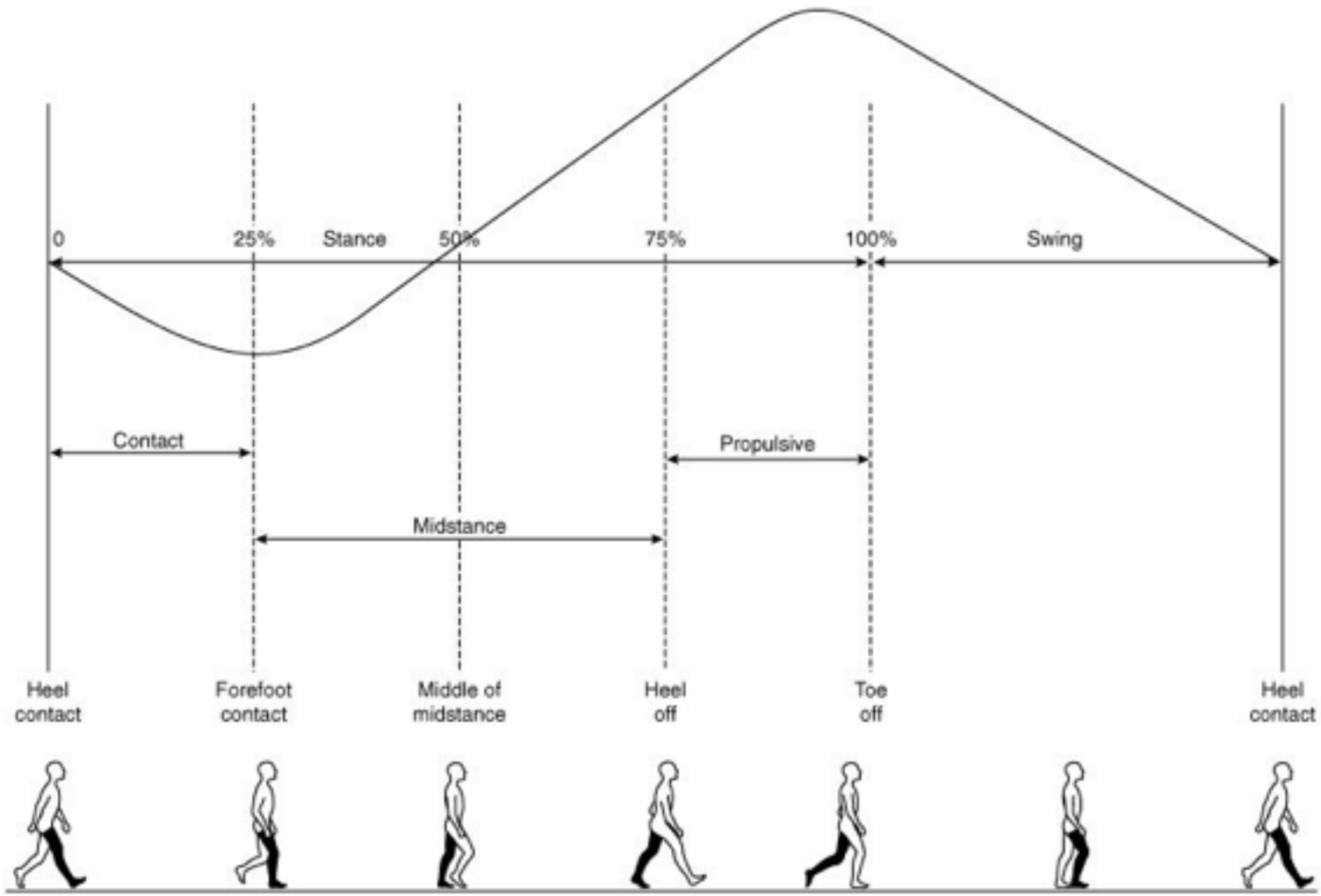
Nashville, Tennessee

Acknowledgement content and narration of video.

Walking Cycle

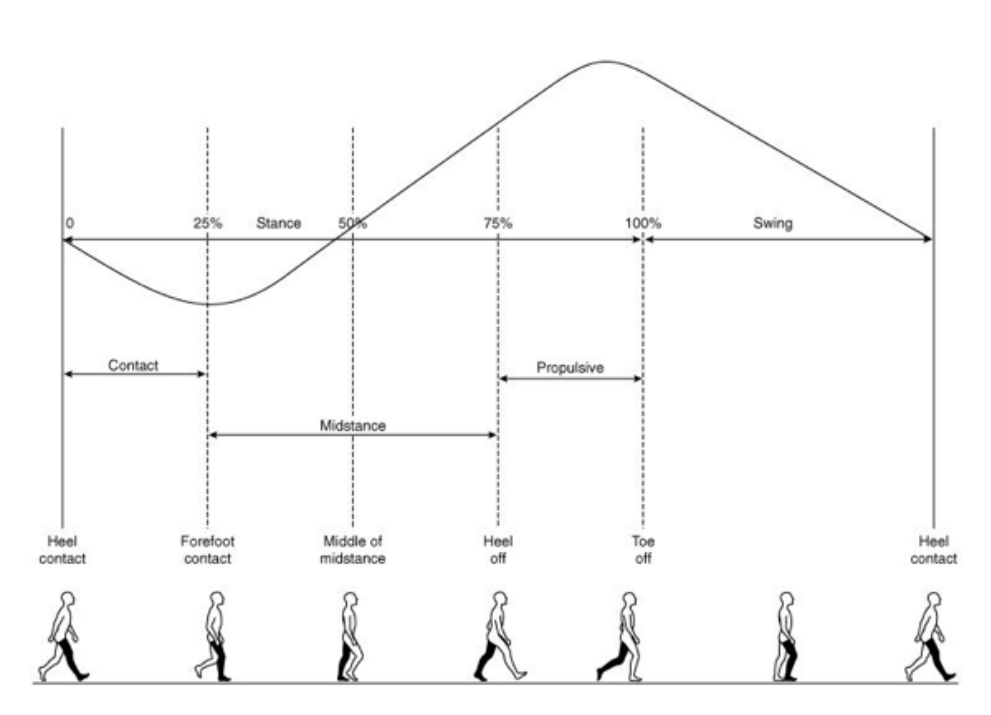
- Stance phase (60%); Swing phase (40%)
- Double limb support (10%): both feet on ground




0
25%
Stance
50%
75%
100%
Swing
Contact
Propulsive
Midstance
Heel contact
Forefoot contact
Middle of midstance
Heel off
Toe off
Heel contact

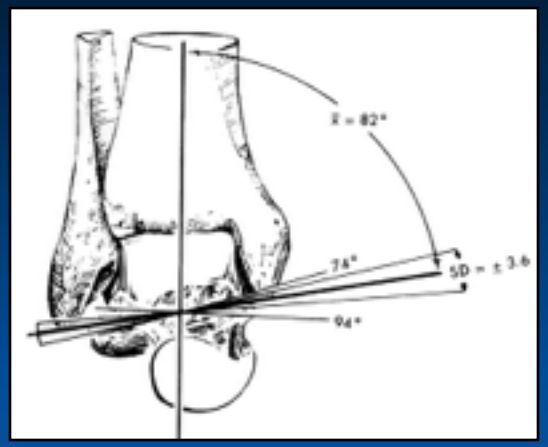
Function

- Propulsion
- Support
- Flexibility
- Rigidity
- Gait mechanics: ankle and foot motions



Ankle Axis: Opposite with foot fixed

- With foot fixed, dorsiflexion / Plantarflexion results in rotation of the leg
  - Dorsiflexion results in internal rotation
  - Plantarflexion results in external rotation



Subtalar Joint

Eversion and inversion of the subtalar joint are directly tied to internal and external rotation of the tibia

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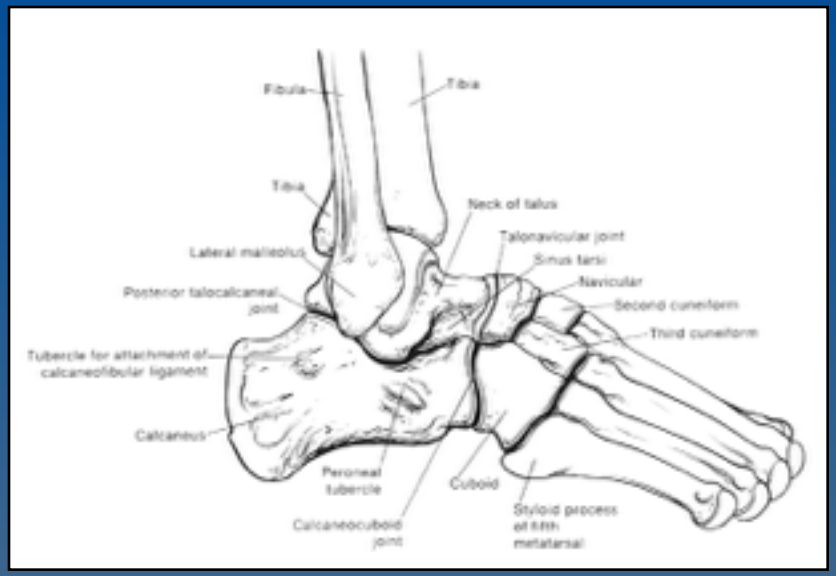
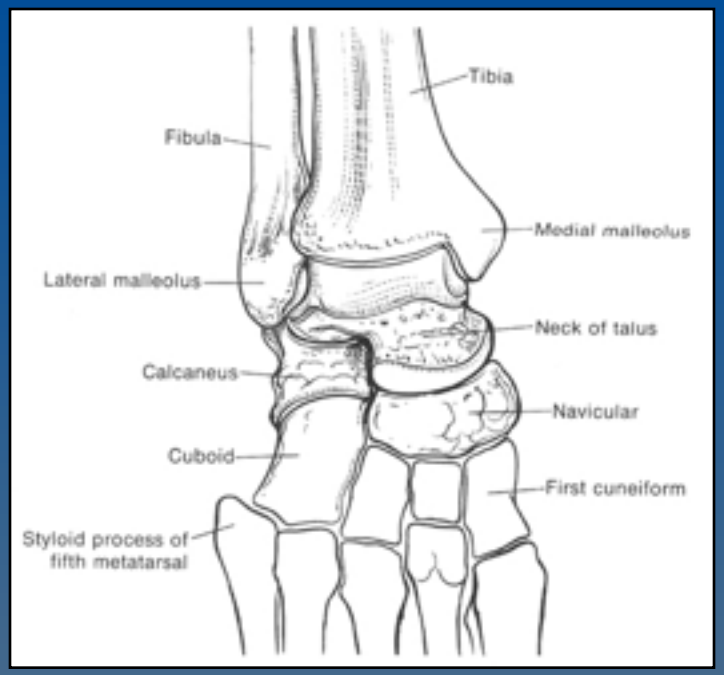
Transverse Tarsal Articulation

- Comprised of Calcaneocuboid & Talonavicular articulations
- Functions as one joint





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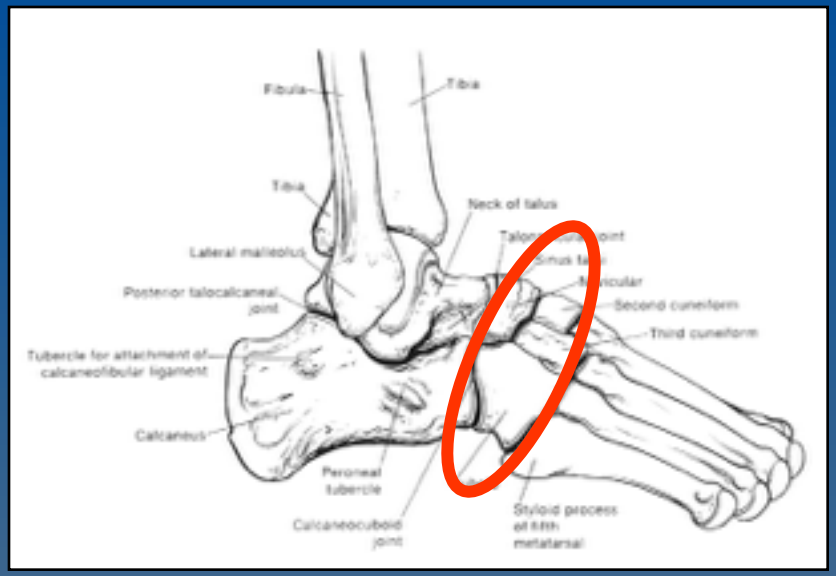
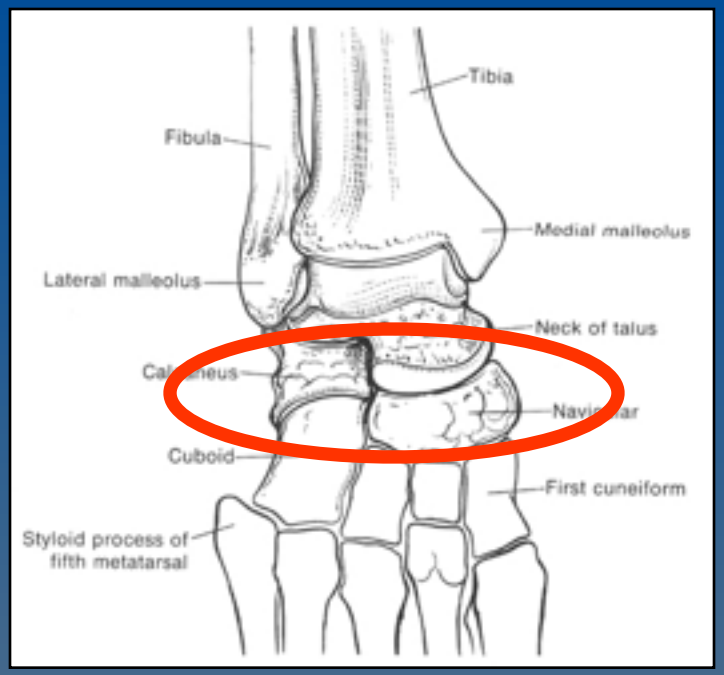
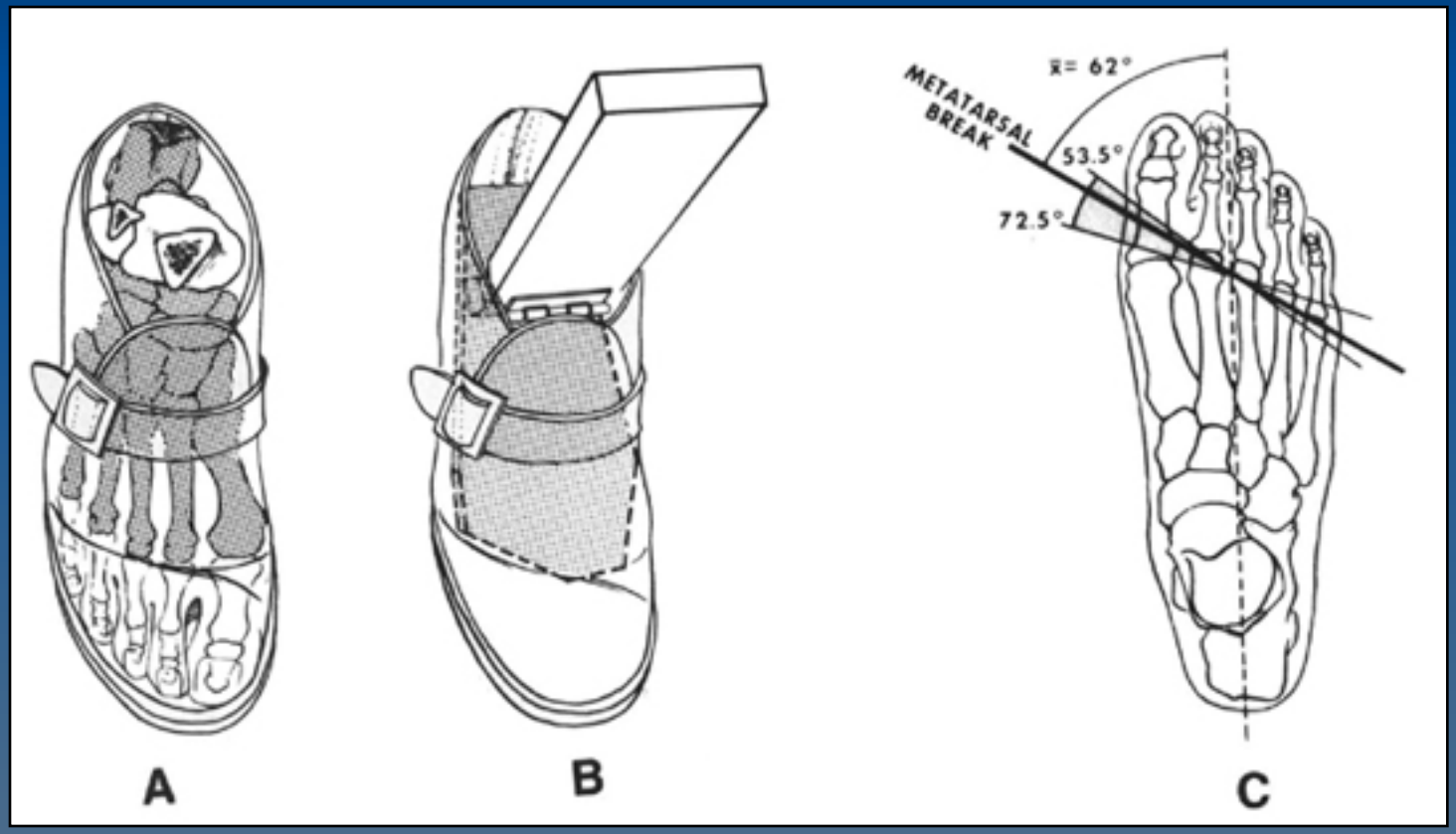




Metatarsophalangeal Break

When the heel is elevated, the weight bearing forces are evenly distributed across the metatarsal heads



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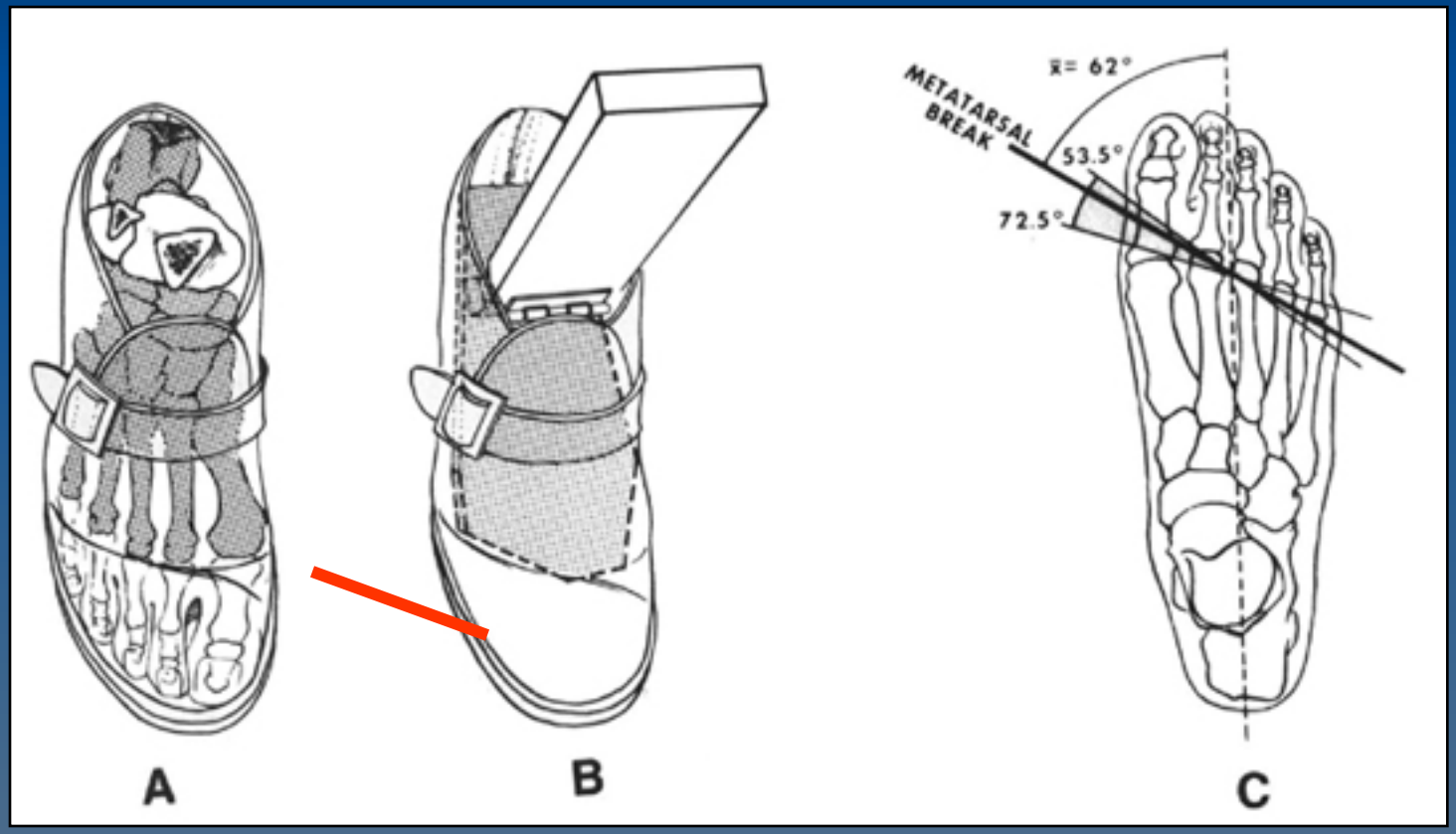

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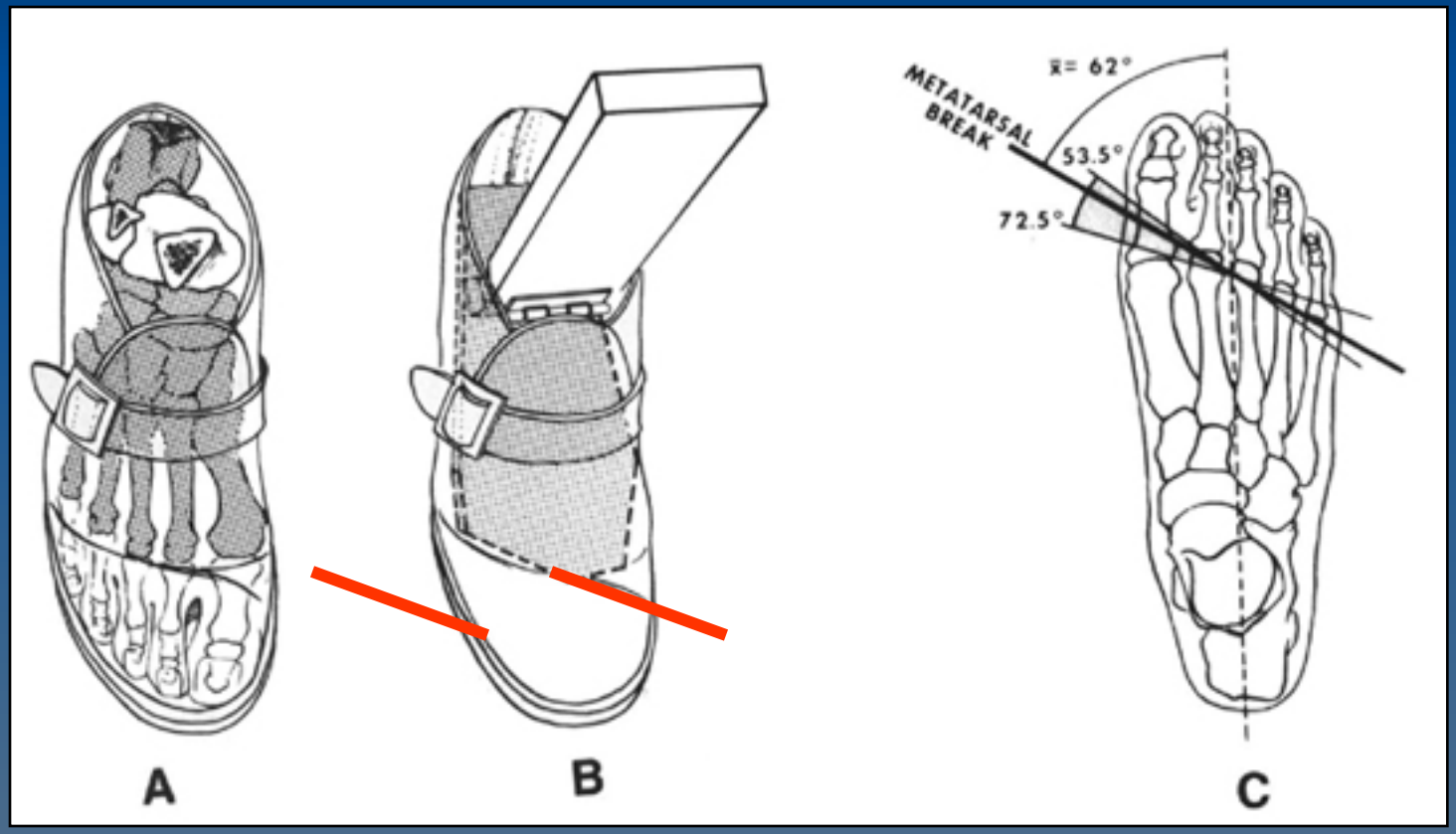

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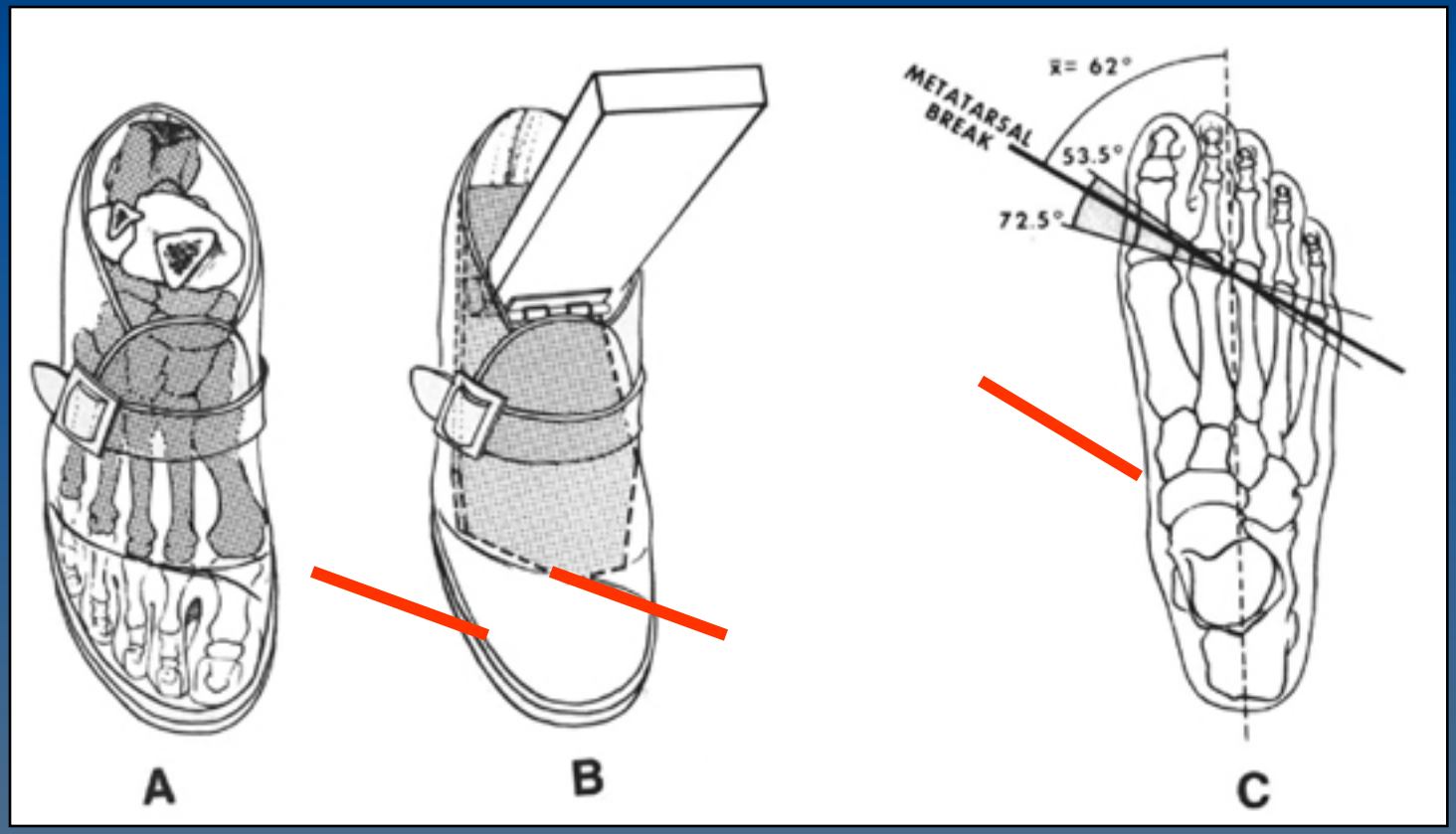


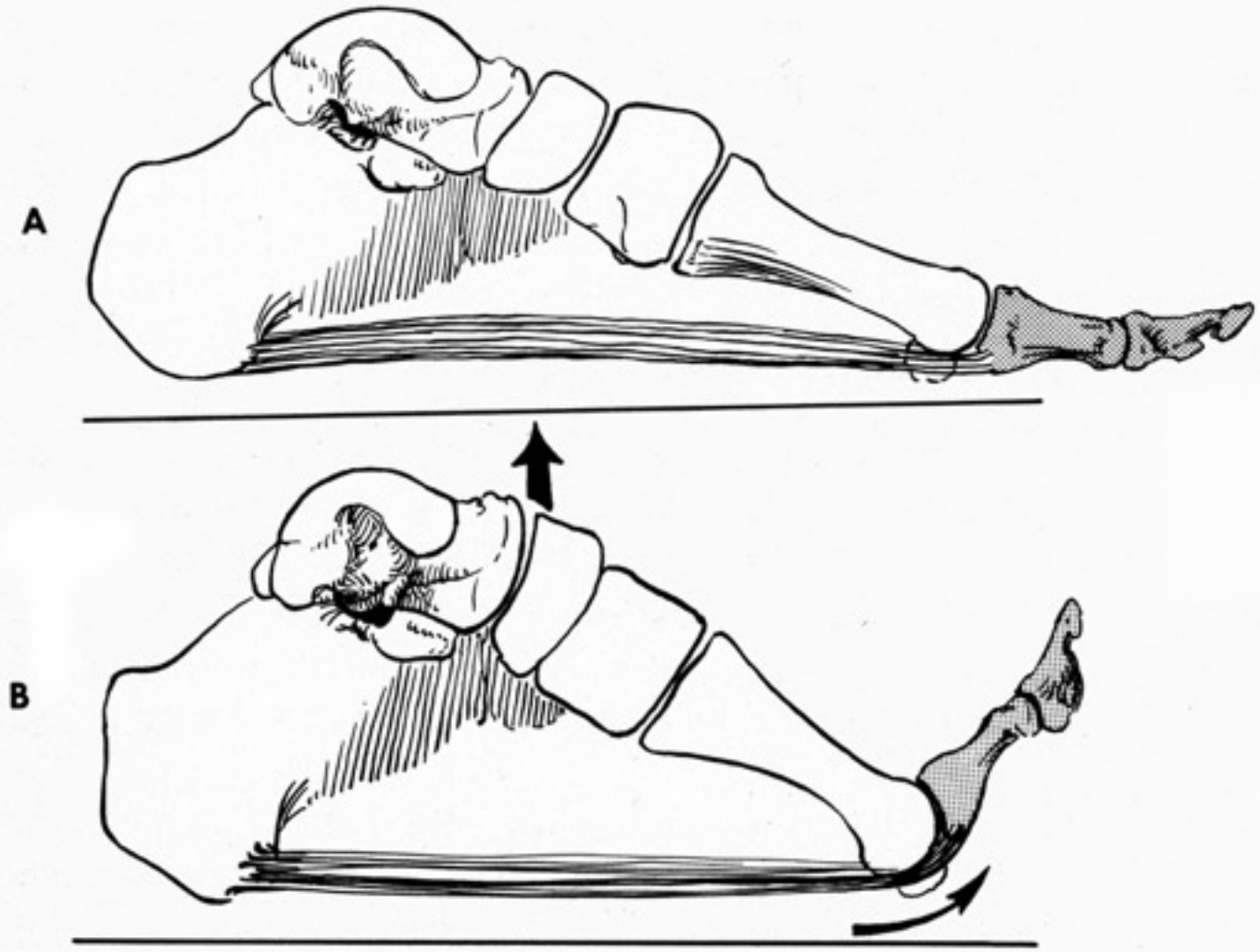


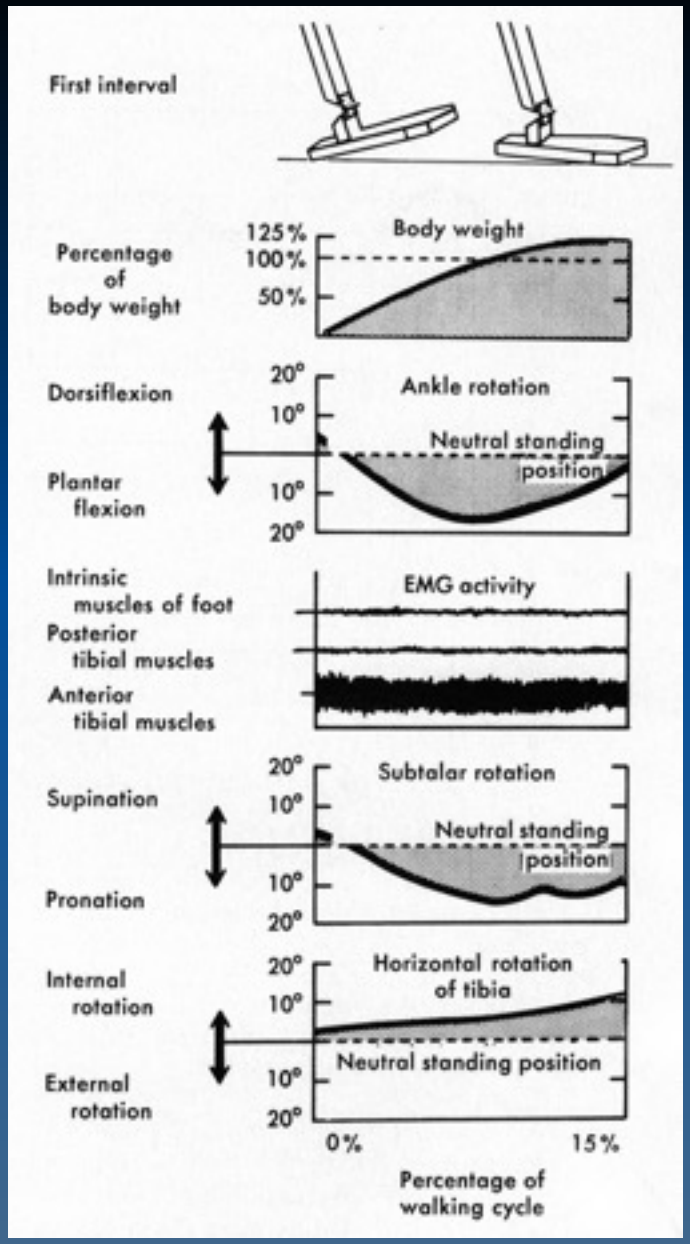
Fig. 1-9. Diagrammatic representation of "windlass action." **A,** Foot flat. **B,** Increased tension of plantar aponeurosis caused by dorsiflexion of the toes with resultant elevation of longitudinal arch.

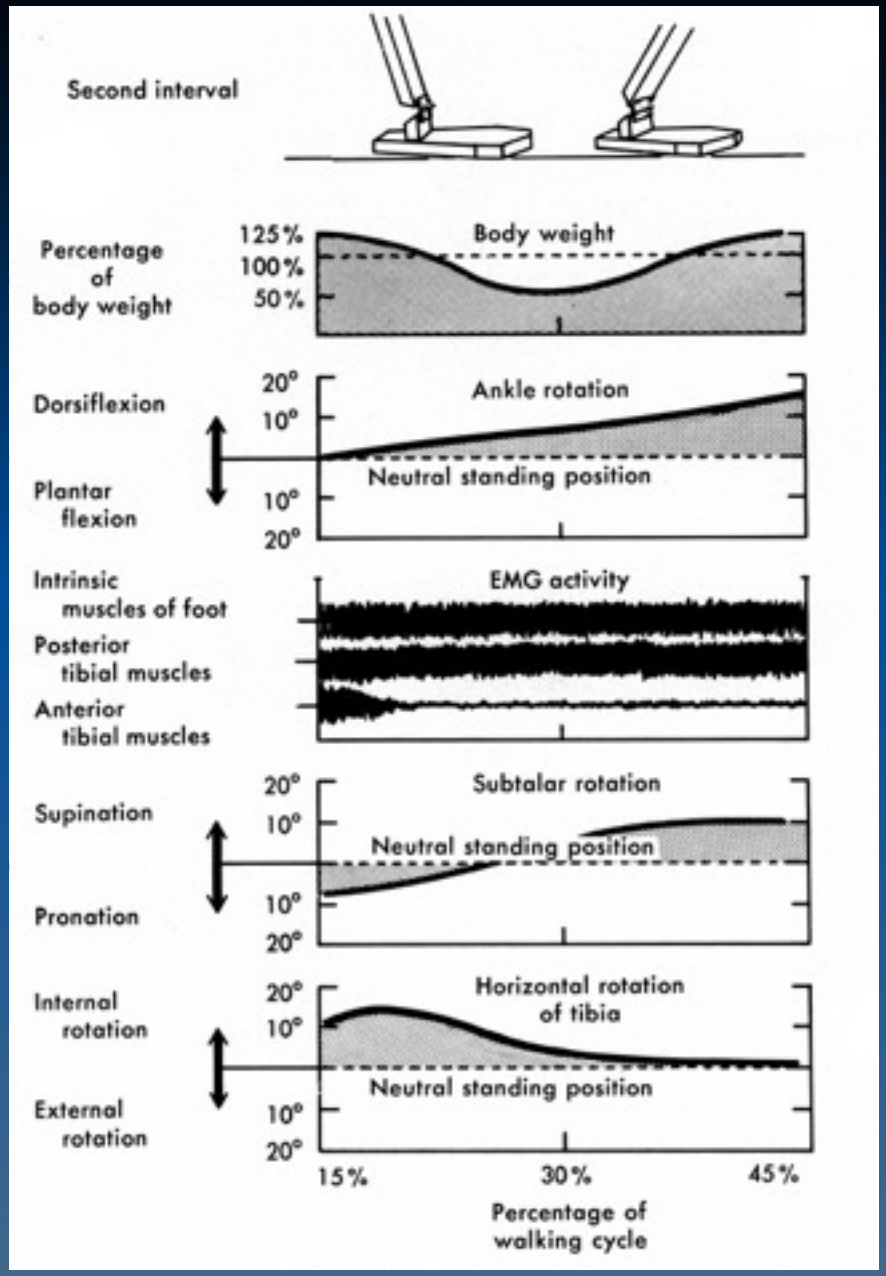
Events of Walking Cycle

- First Interval
  - Deceleration, heel-strike to foot-flat
    - Ankle rapid plantarflexion
    - Foot loaded in pronation – subtalar joint eversion
    - Lower leg internally rotates
    - Eversion unlocks transverse tarsal joint
  - Main thrust force absorption and dissipation

Events of Walking Cycle

- Second Interval
  - Foot-flat to heel-lift
    - Ankle dorsiflexes
    - Subtalar joint inverts
    - Lower limb external rotation
    - Inversion due to ankle oblique axis and plantar aponeurosis and metatarsal break
    - Stability of transverse tarsal joint increased by inversion
  - Mid-foot goes from flexible to rigid


First interval
Percentage of body weight
125%
100%
50%
Body weight
Dorsiflexion
Plantar flexion
20°
10°
10°
20°
Ankle rotation
Neutral standing position
Intrinsic muscles of foot
Posterior tibial muscles
Anterior tibial muscles
EMG activity
Supination
Pronation
Subtalar rotation
Neutral standing position
Internal rotation
External rotation
Horizontal rotation of tibia
Neutral standing position
0%
15%
Percentage of walking cycle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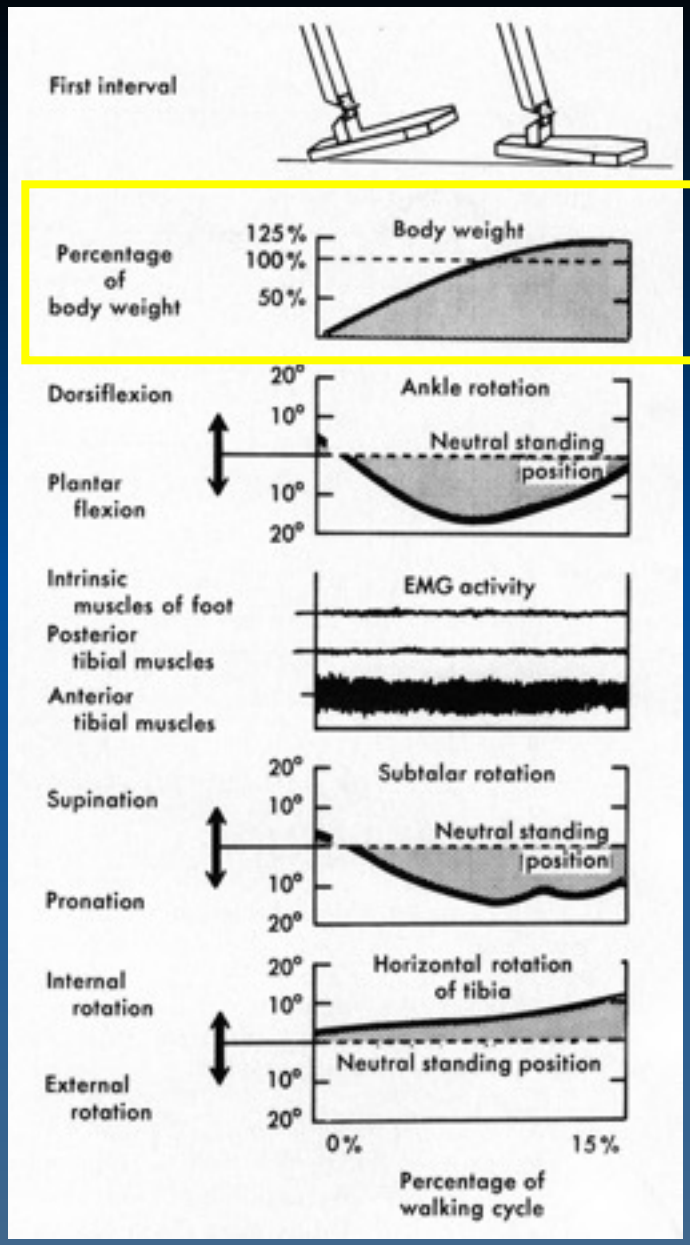
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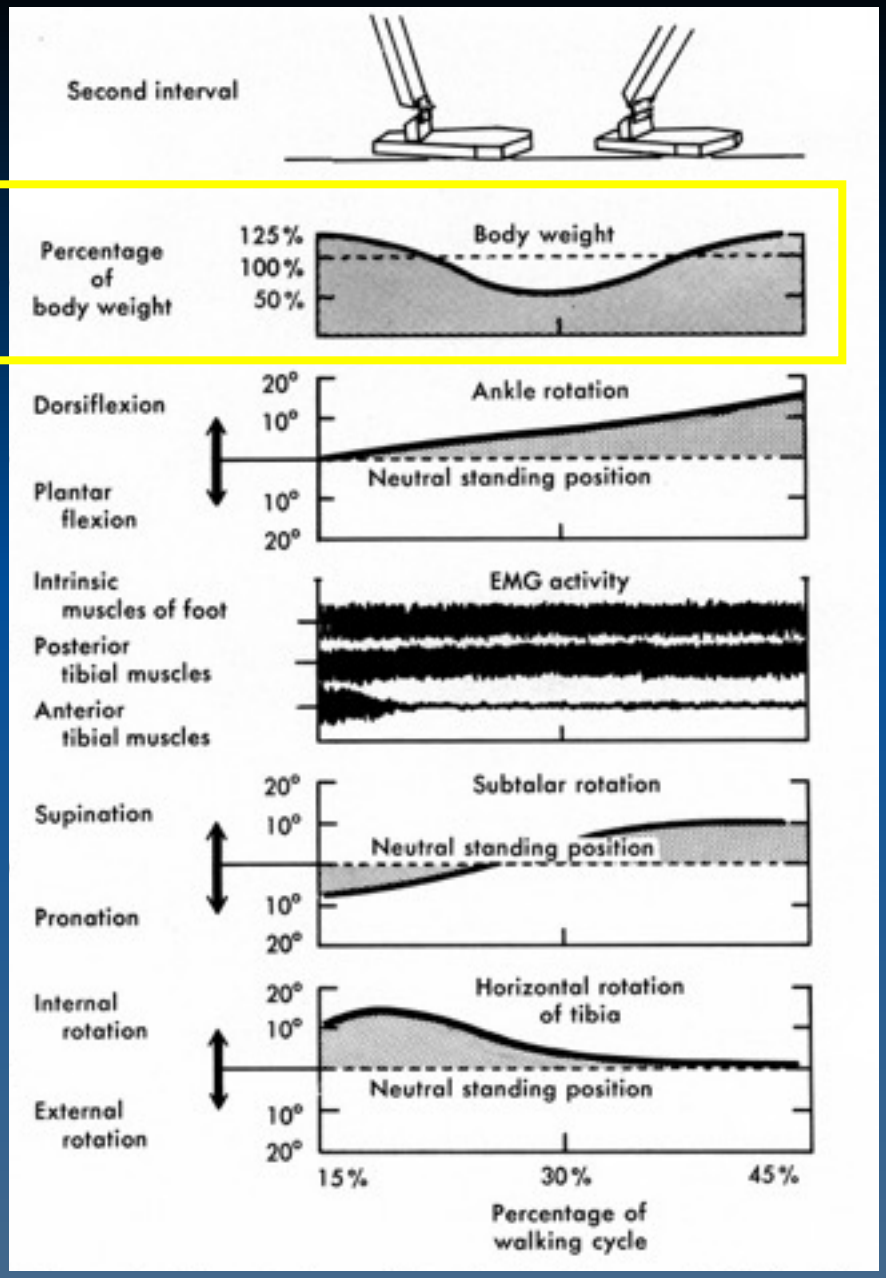
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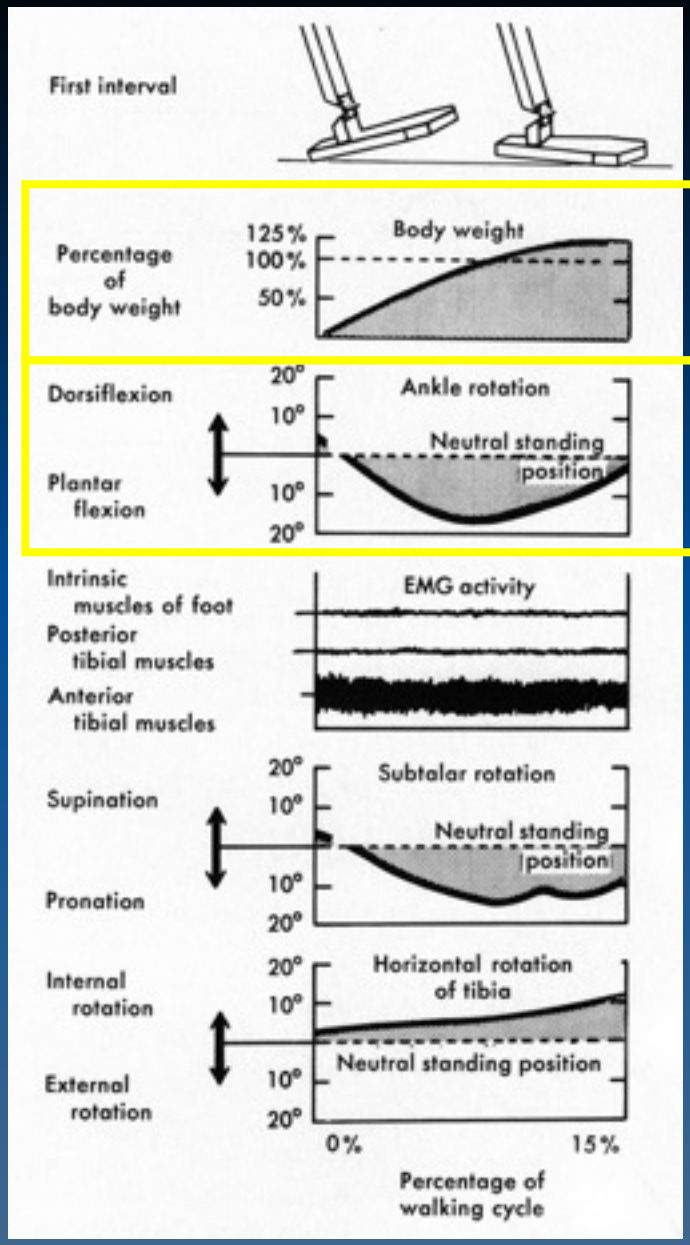
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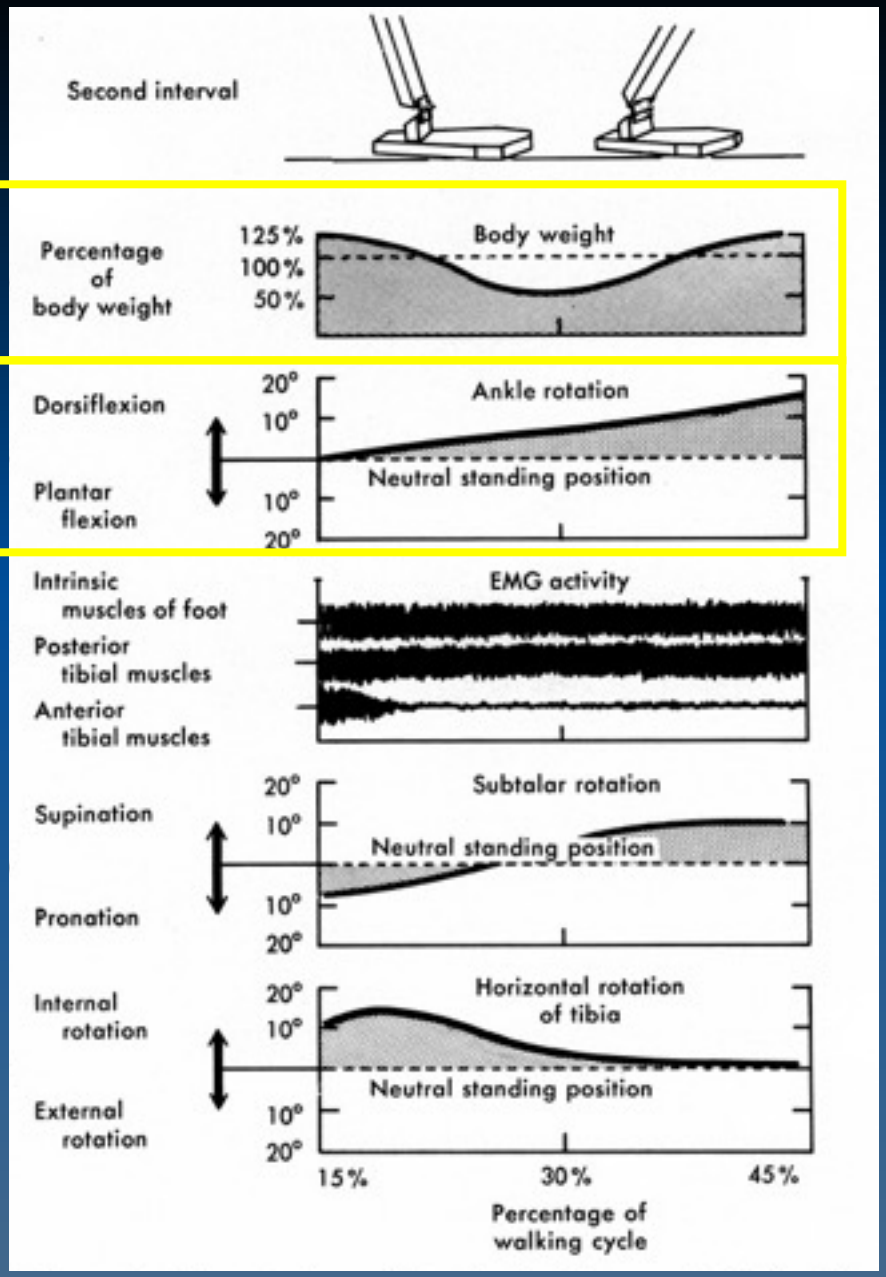
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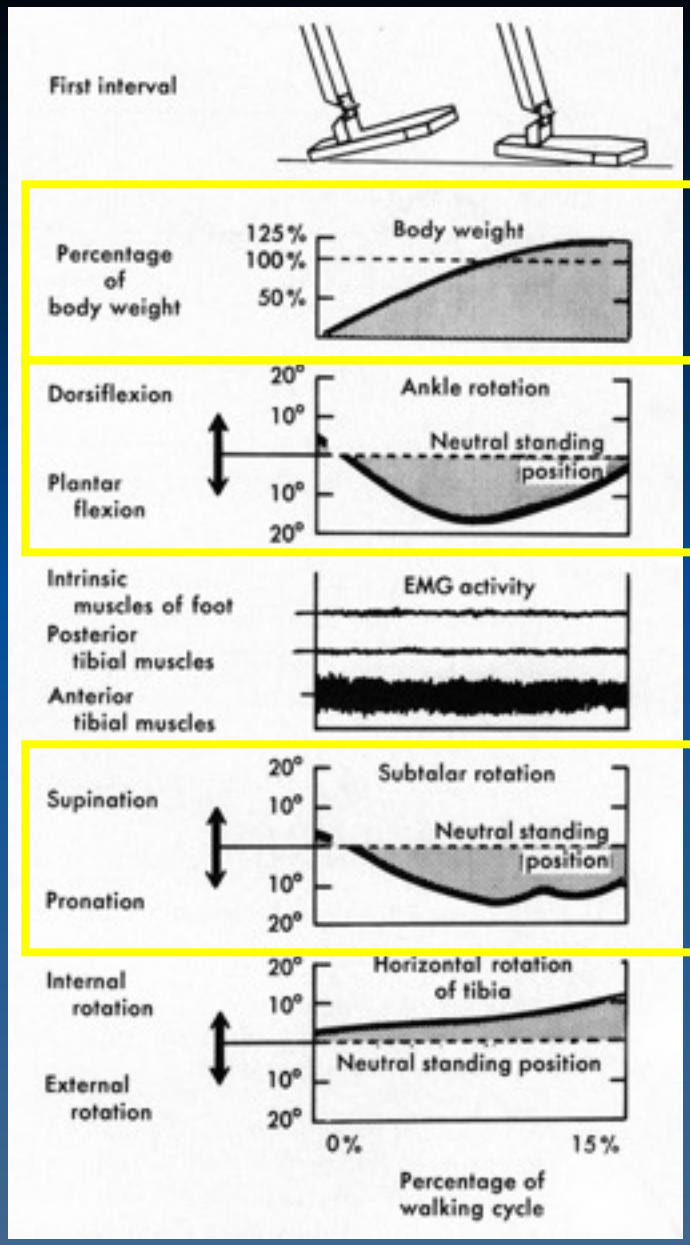
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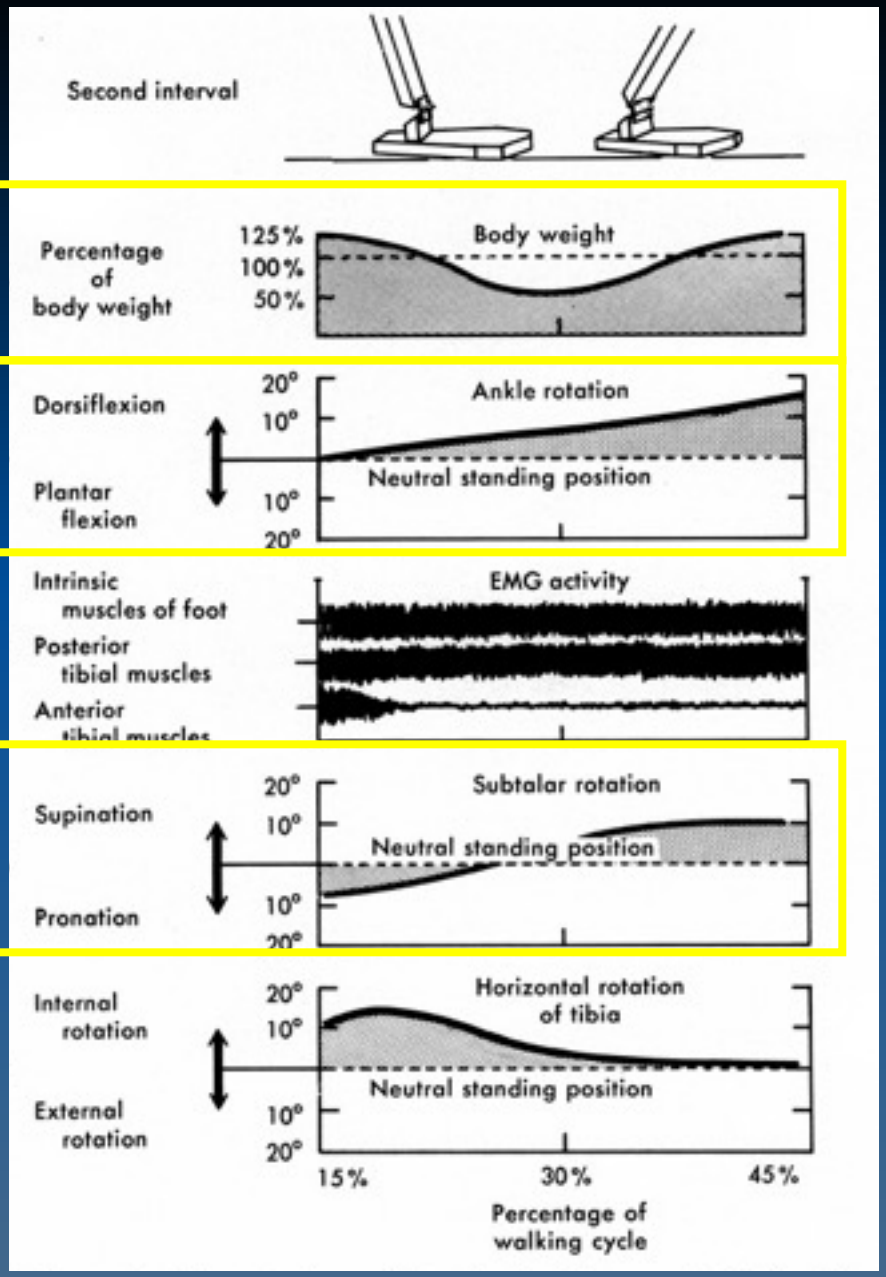
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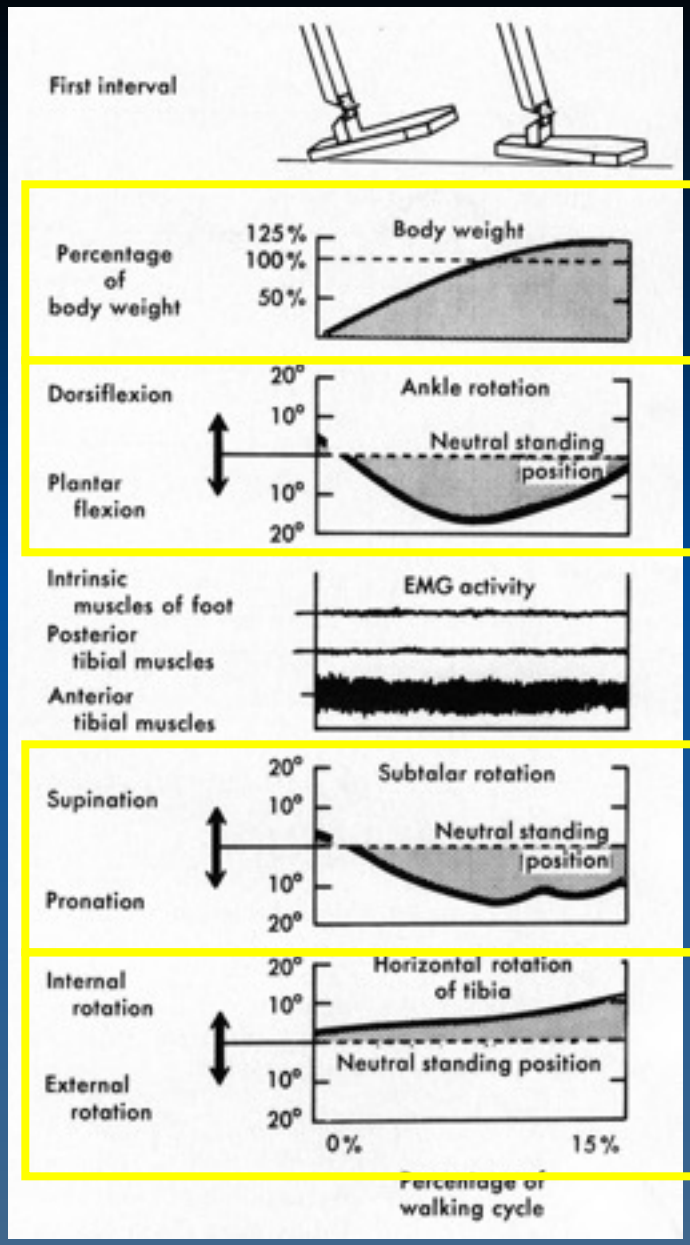
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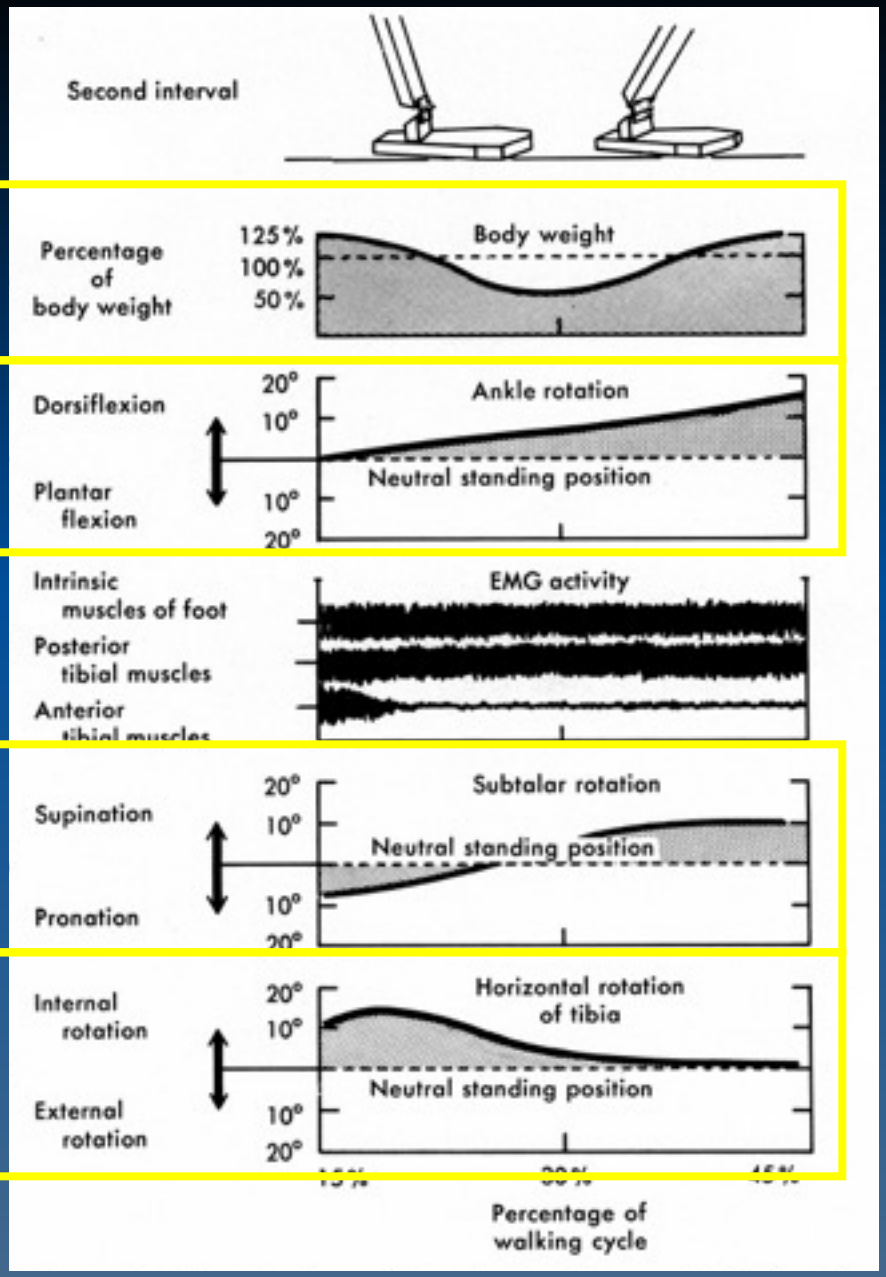
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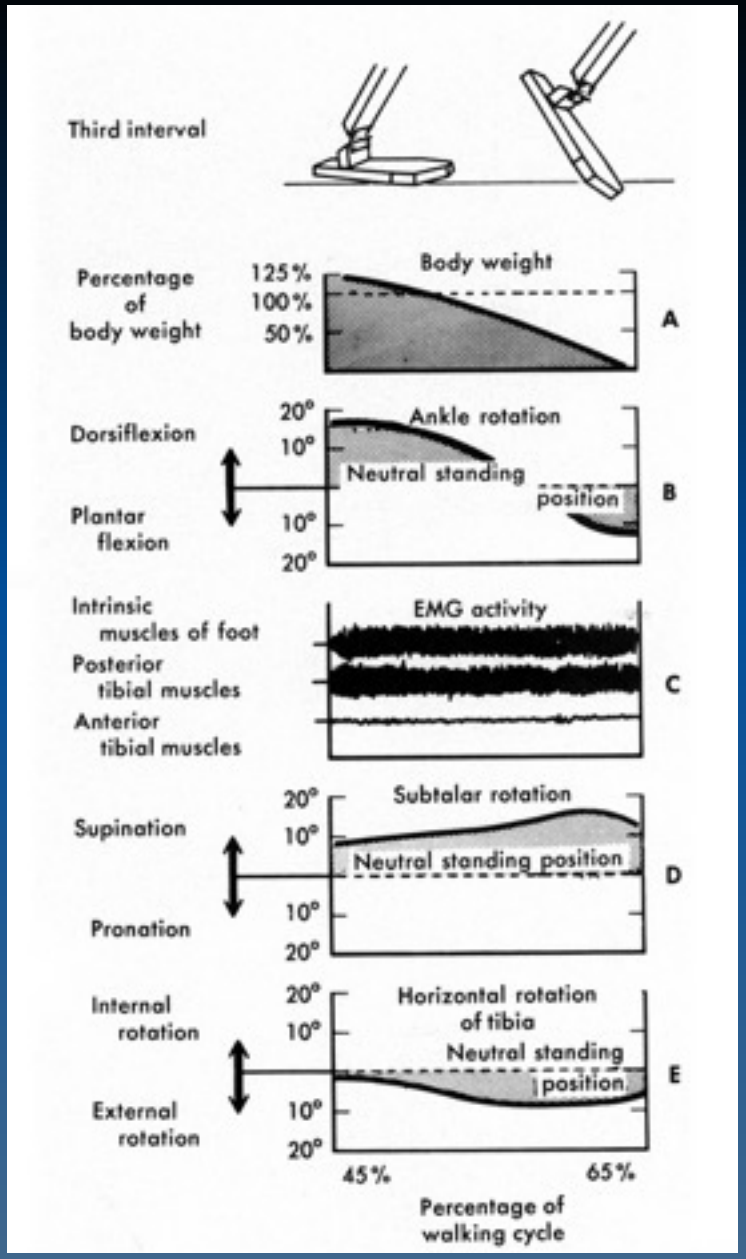
Percentage of walking cycle

Events of Walking Cycle

- Third Interval
  - Heel-lift to Toe-off
    - Ankle rapid plantarflexion
    - Windlass effect of plantar aponeurosis stabilizes longitudinal arch
    - Subtalar joint inverts to maximize rigidity of transverse tarsal joint
  - Body propelled forward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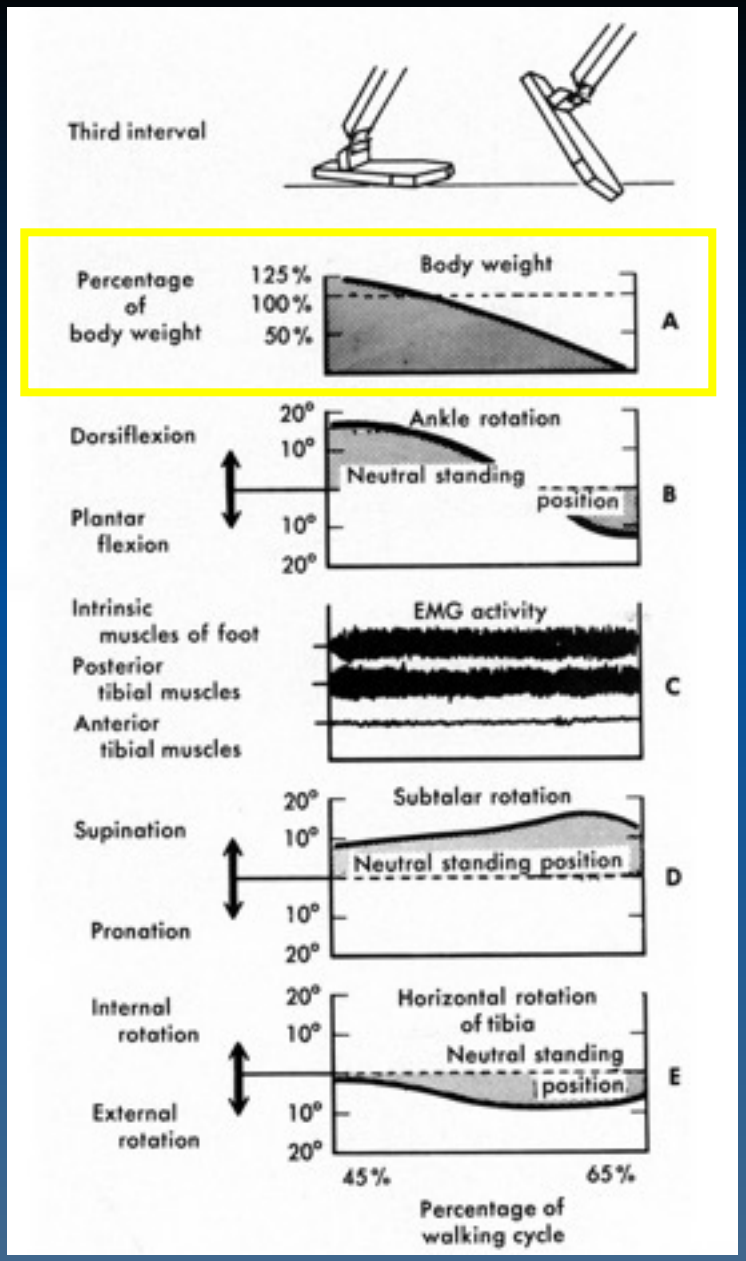
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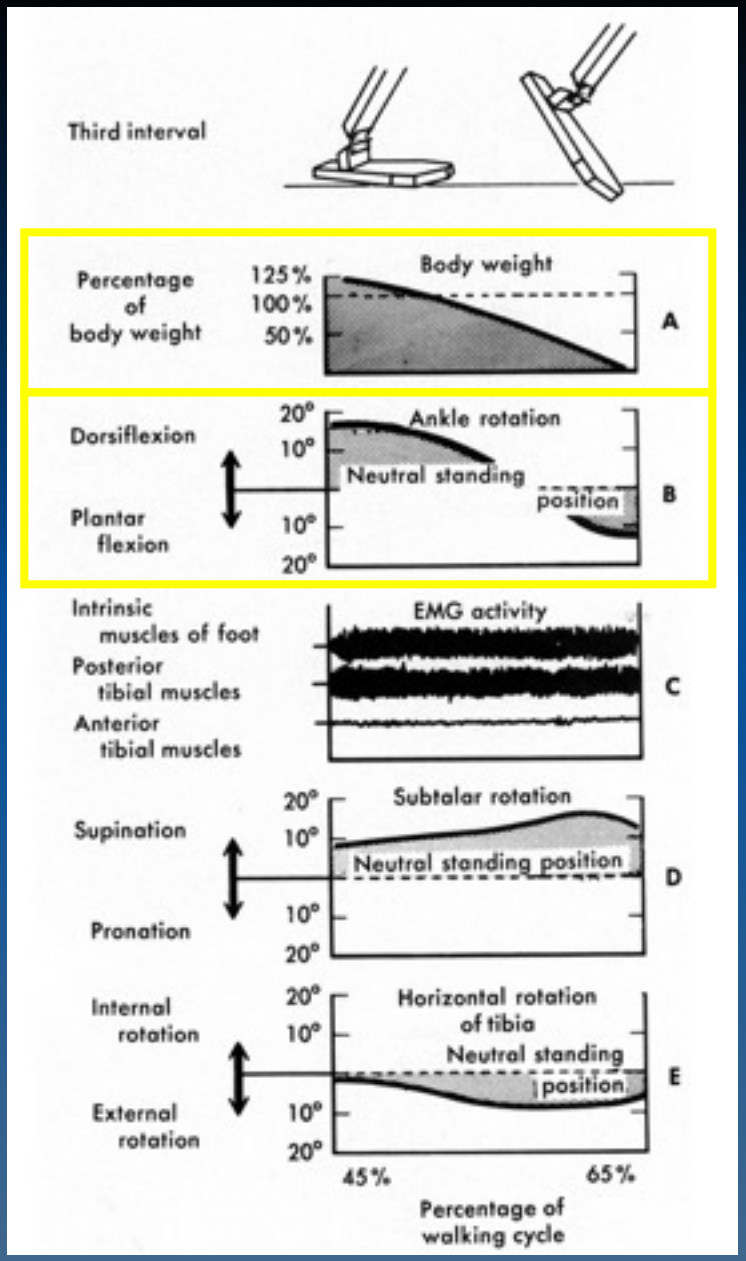
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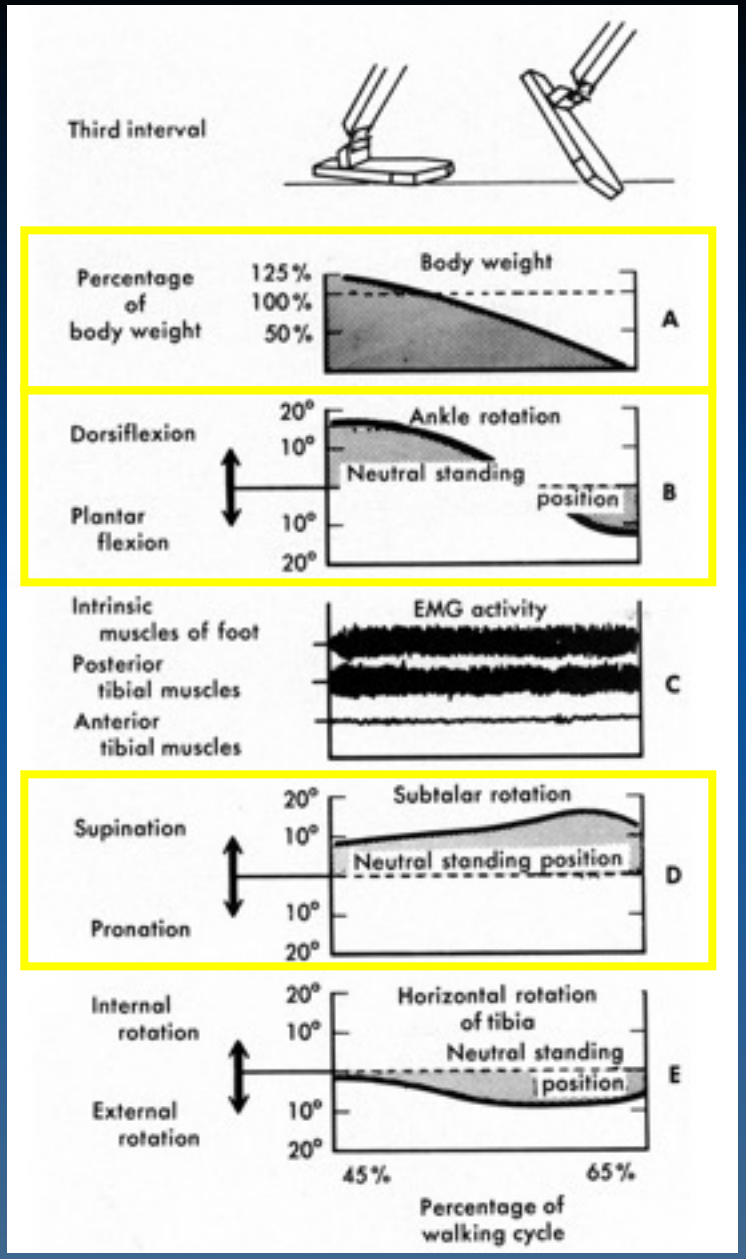
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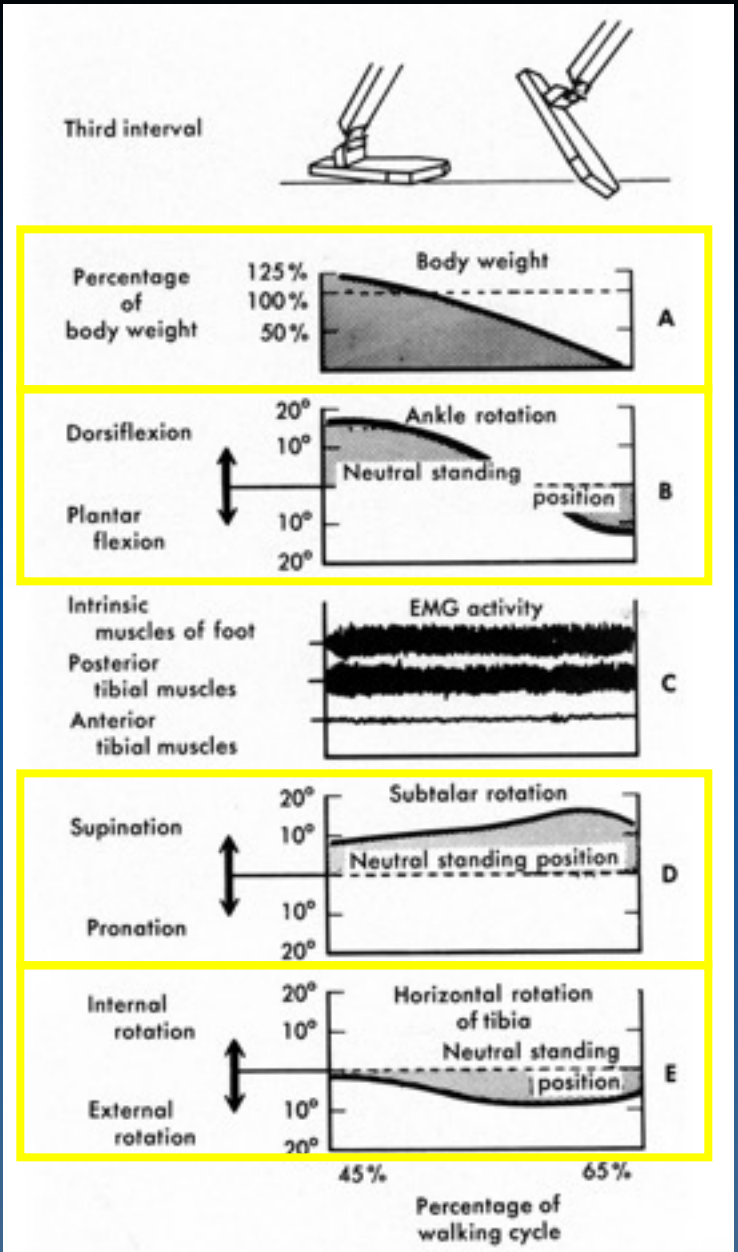
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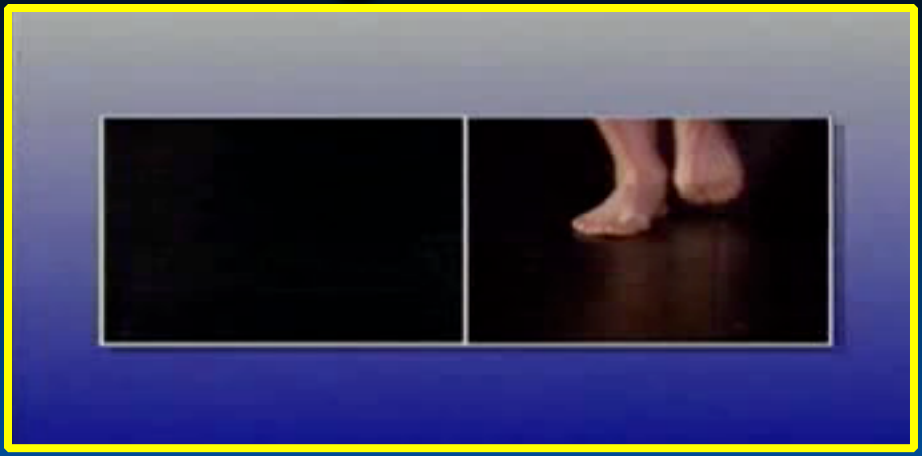
Percentage of walking cycle

Third Interval: create rigid lever for push-off



- Ankle undergoes rapid plantarflexion
- Longitudinal arch stabilized by windlass effect of the plantar aponeurosis as toes are brought into dorsiflexion
- Subtalar joint continues to invert (enhanced by obliquity of the ankle joint) maximizing rigidity of the transverse tarsal joint at toe off

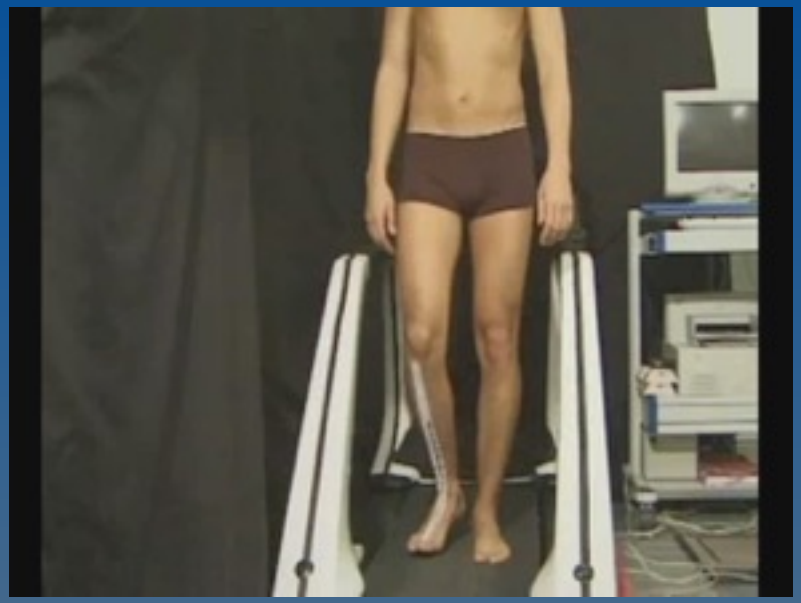
During gait: coupled motion between ankle and subtalar joints

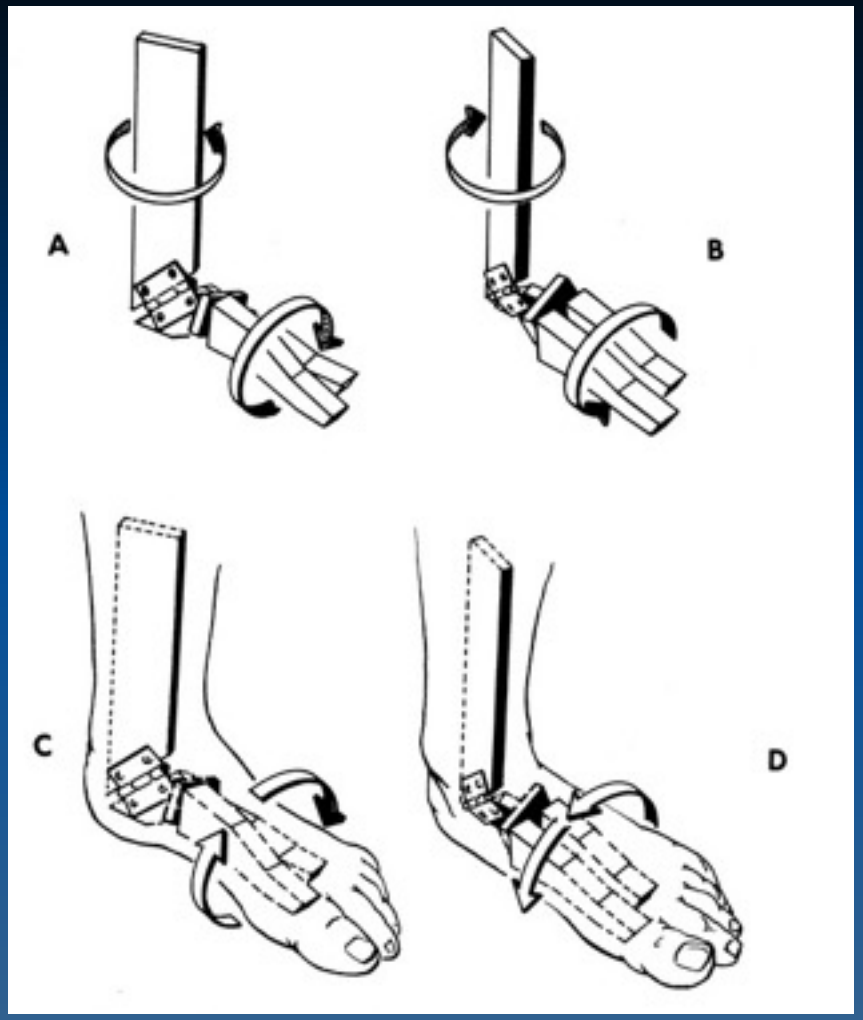
- First
  - Tibial internal rotation
  - Talar eversion
  - Foot pronation
- Third
  - Tibial external rotation
  - Talar inversion
  - Foot supination

Normal Gait is a Controlled Fall
What happens to the Joints with Foot On Ground

Foot	Tibia	Talus	Foot
Dorsiflexion	*Internally Rotates*	*Everts*	*Pronation*
D	*IR*	*E*	*P*
Plantarflexion	*Externally Rotates*	*Inverts*	*Supination*
P	*ER*	*I*	*S*

Gait analysis posterior view




A
B
C
D

Mechanics of Running

- Basic kinematics of the foot and ankle not significantly altered
- Gait cycle shortened
- Stance phase shortened
- Vertical forces during stance phase increase to 2.5 - 3 times body weight
- ROM of joints is increased 50%
- Phasic activity of the lower extremity muscles altered

The End — Thank You!