

GAIT ANALYSIS - Normal Gait

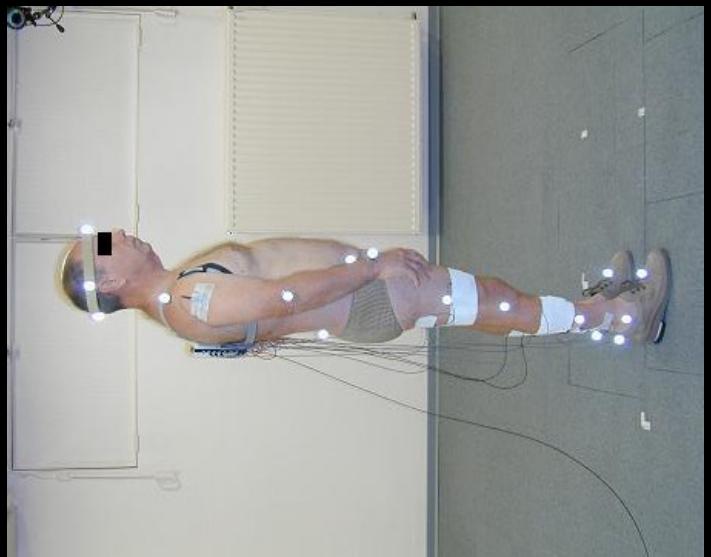
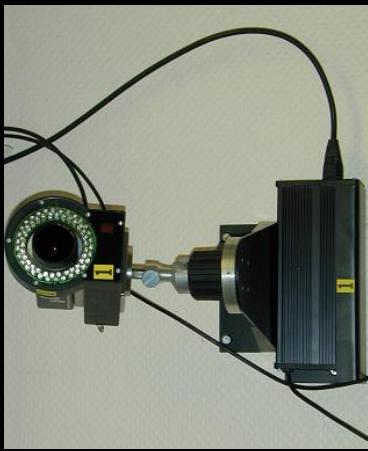
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Types of analysis

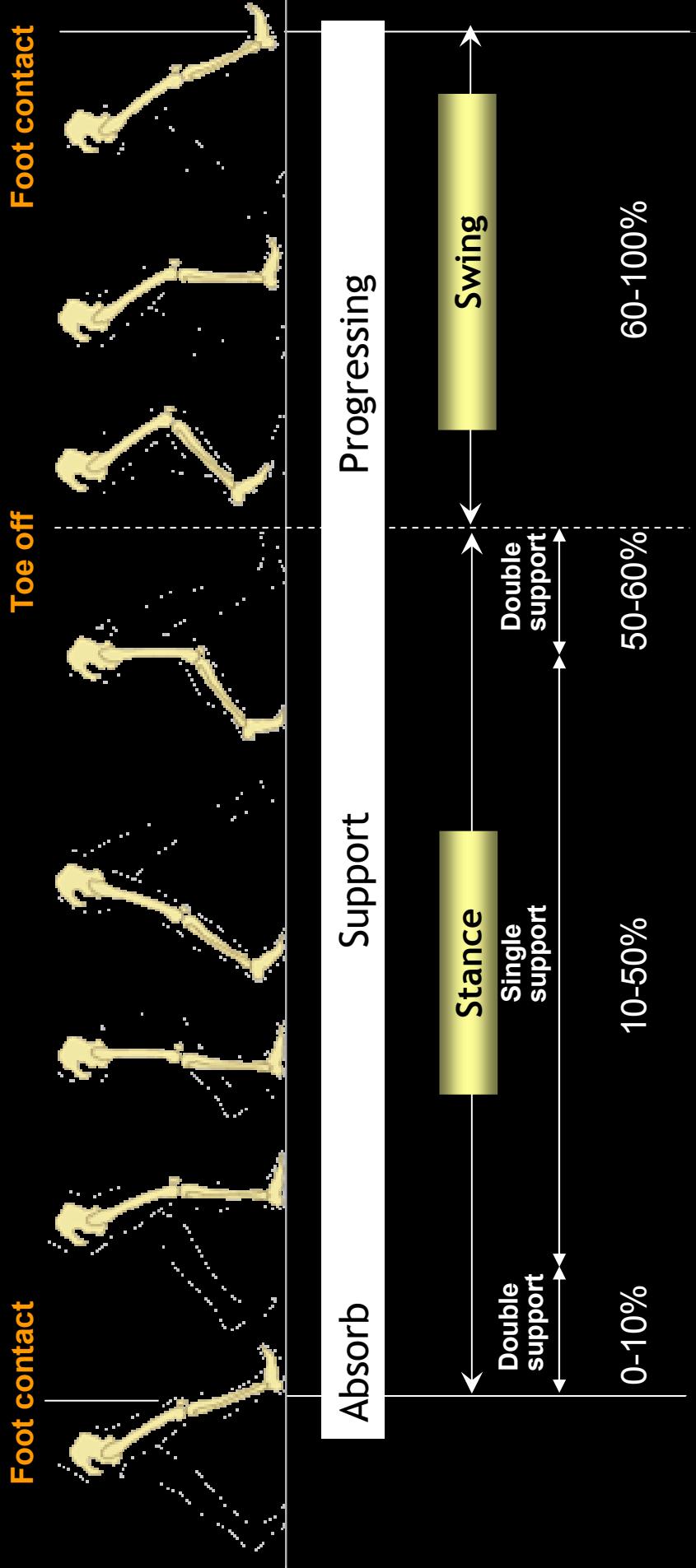


- Clinical observations
- Video
- Quantified analysis:
 - Vicon (IR camera)
 - Force platform
 - EMG
 - Pressure platforms
 - Energy consumption

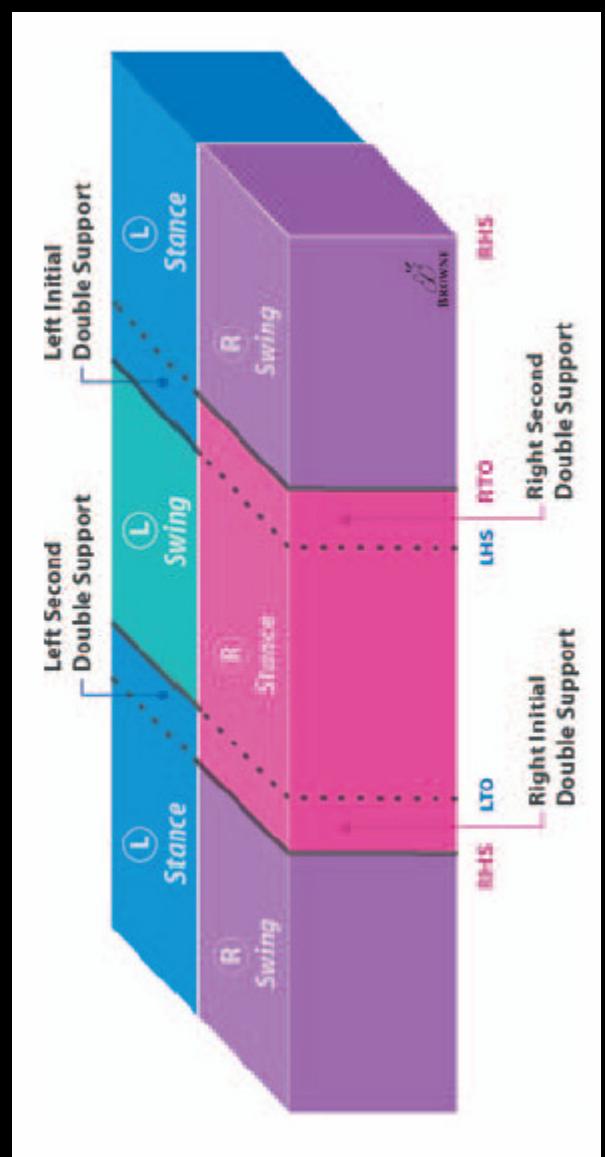
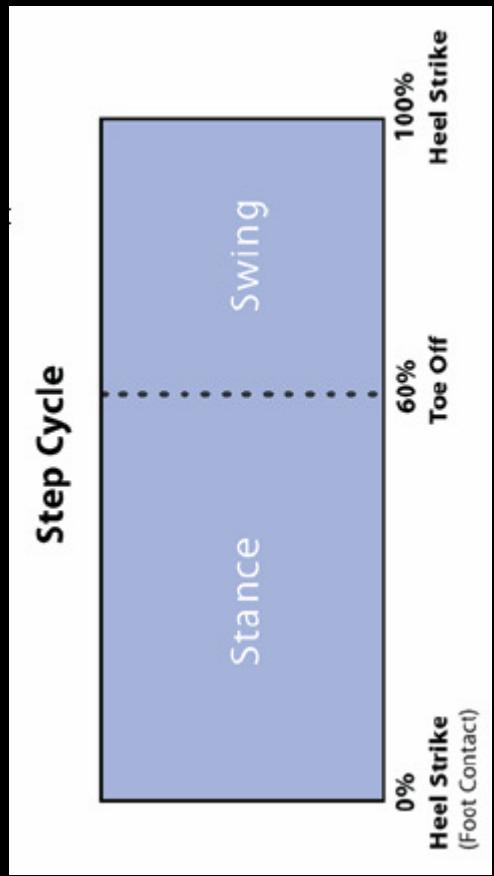
Gait definition

- Automatic function
- Cycle
 - Begins with foot contact
 - Standing phase and swinging phase
 - 2 periods of double standing

Gait Cycle

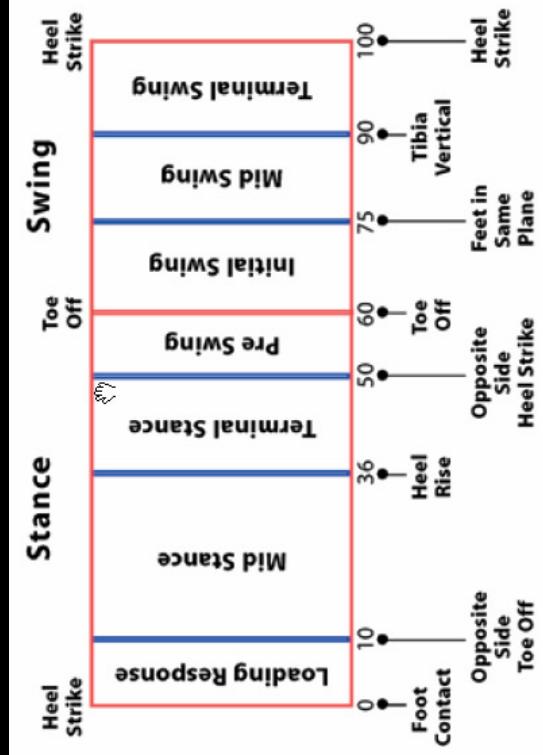


Gait Cycle



1. Loading Response

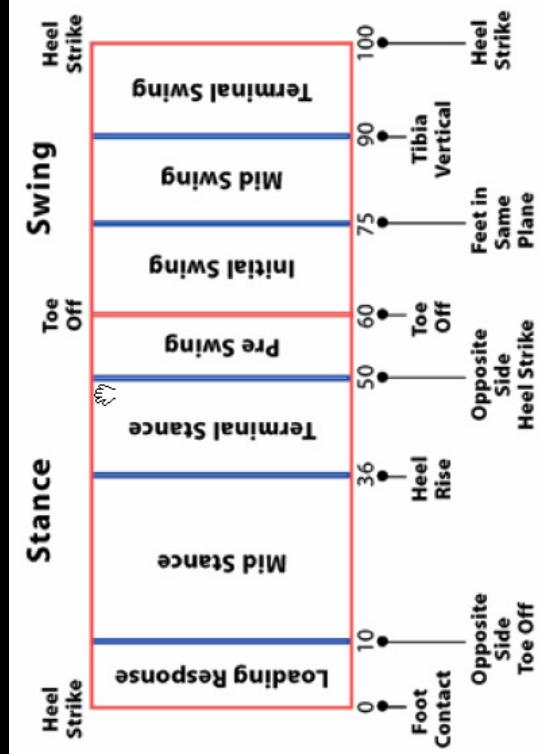
- Initial contact: 0-3%
- Loading response: 3-10%
- Double support: load transfer
 - Stabilise lower limb
 - Absorb impact



2. Mid Stance

Support load
Stability (contralateral swing)

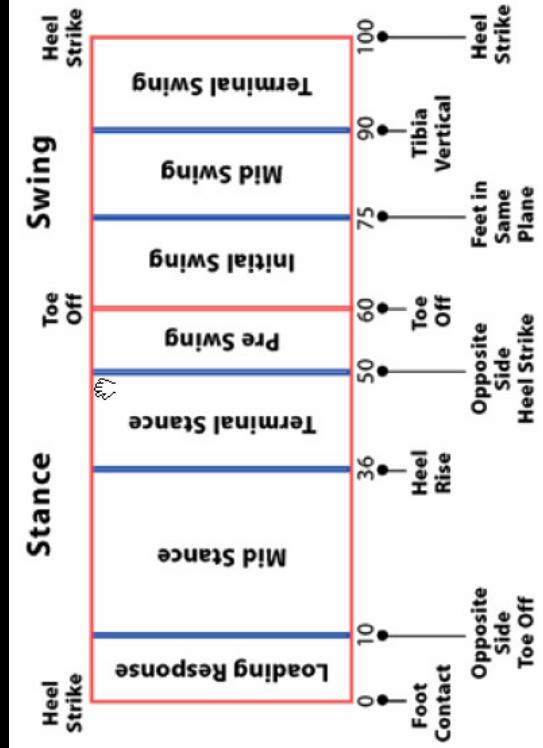
- Foot flat on the ground



3. Terminal Stance

Support load
Stability (contralateral swing)

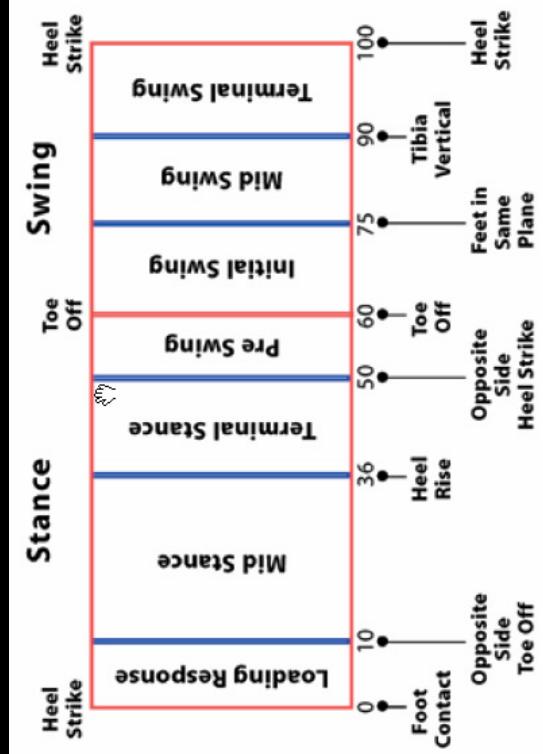
- Weight of body passes forward



4. Pre Swing

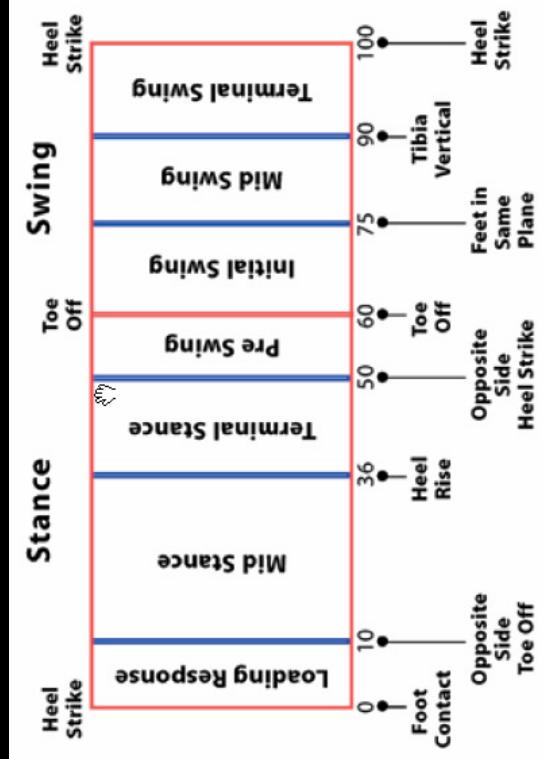
- Double support: load transfer

- Ready for swing



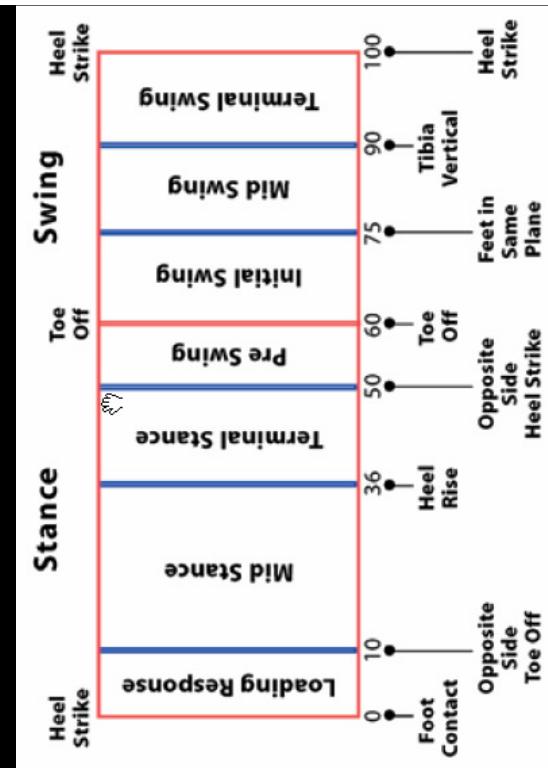
5. Initial Swing

- First third
 - Foot clearance:
 - Knee flexion
 - Ankle dorsiflexion



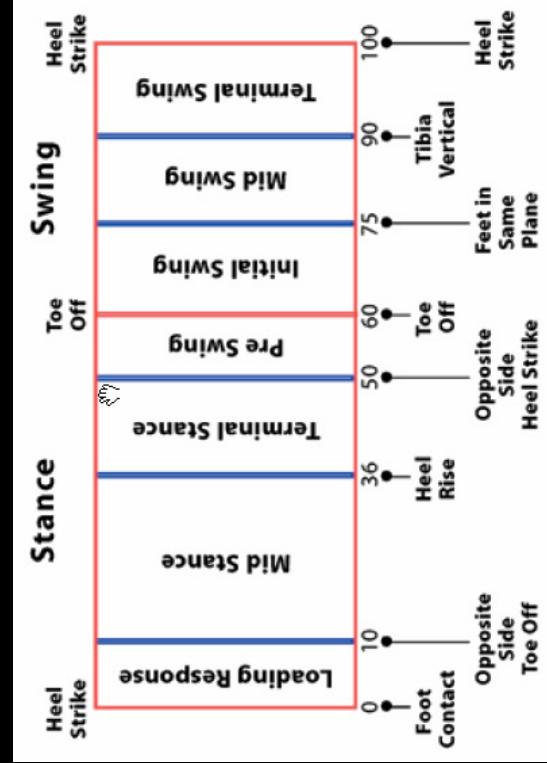
6. Mid Swing

- Second Third

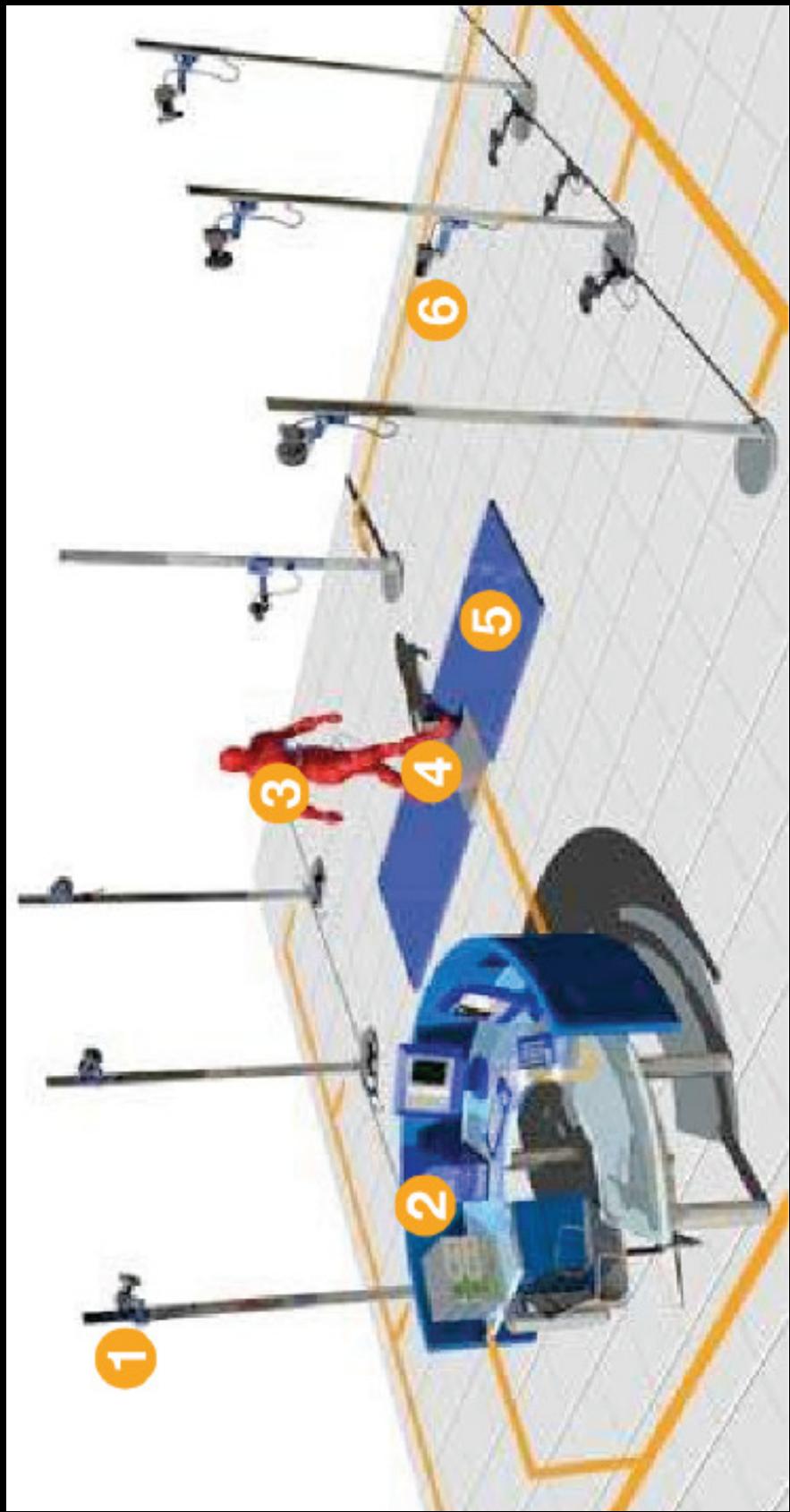


7. Terminal Swing

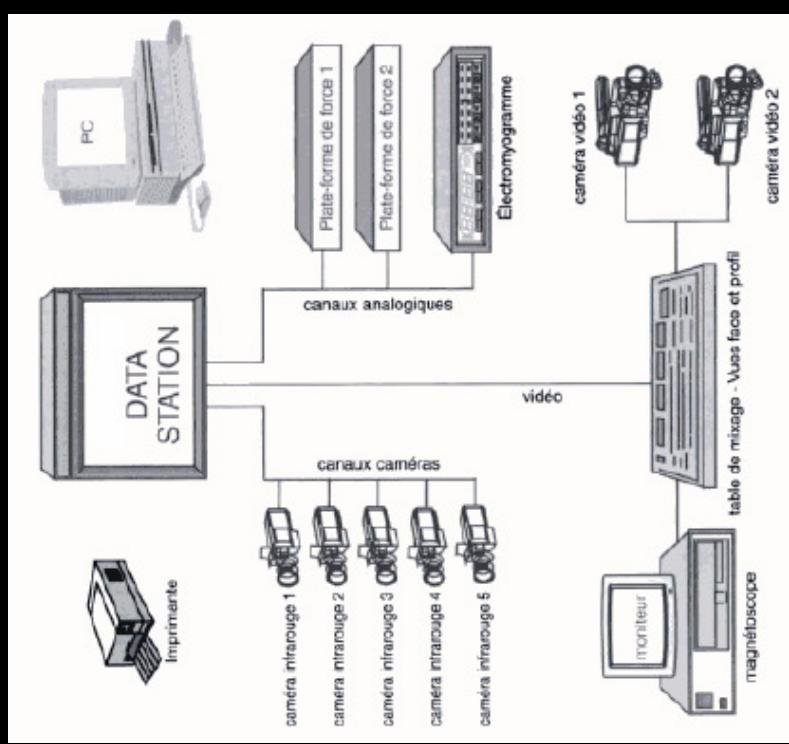
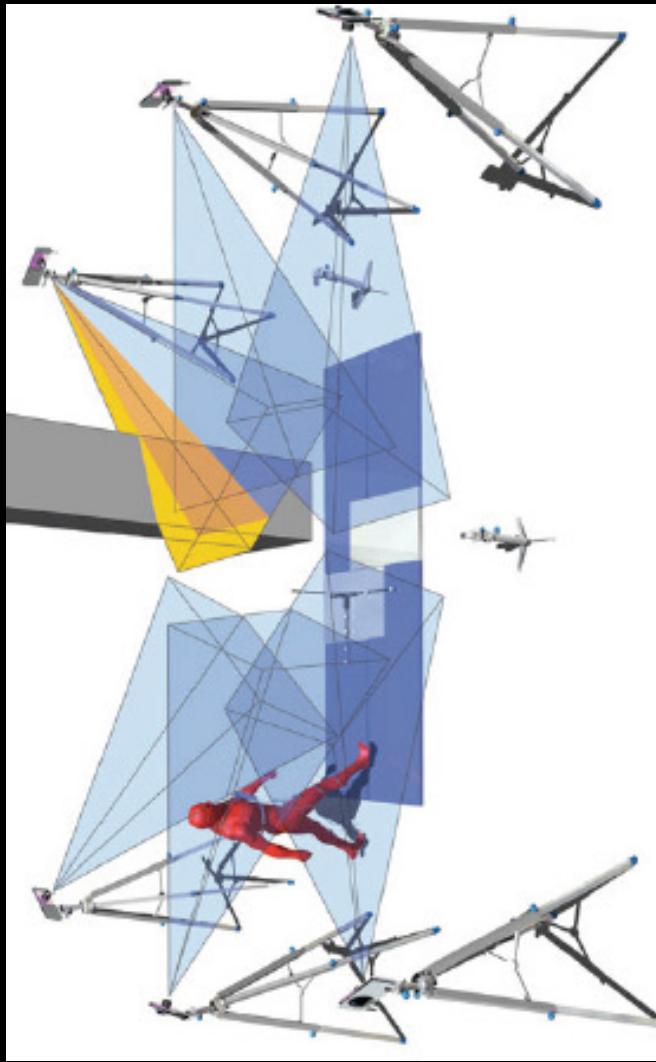
- Last third

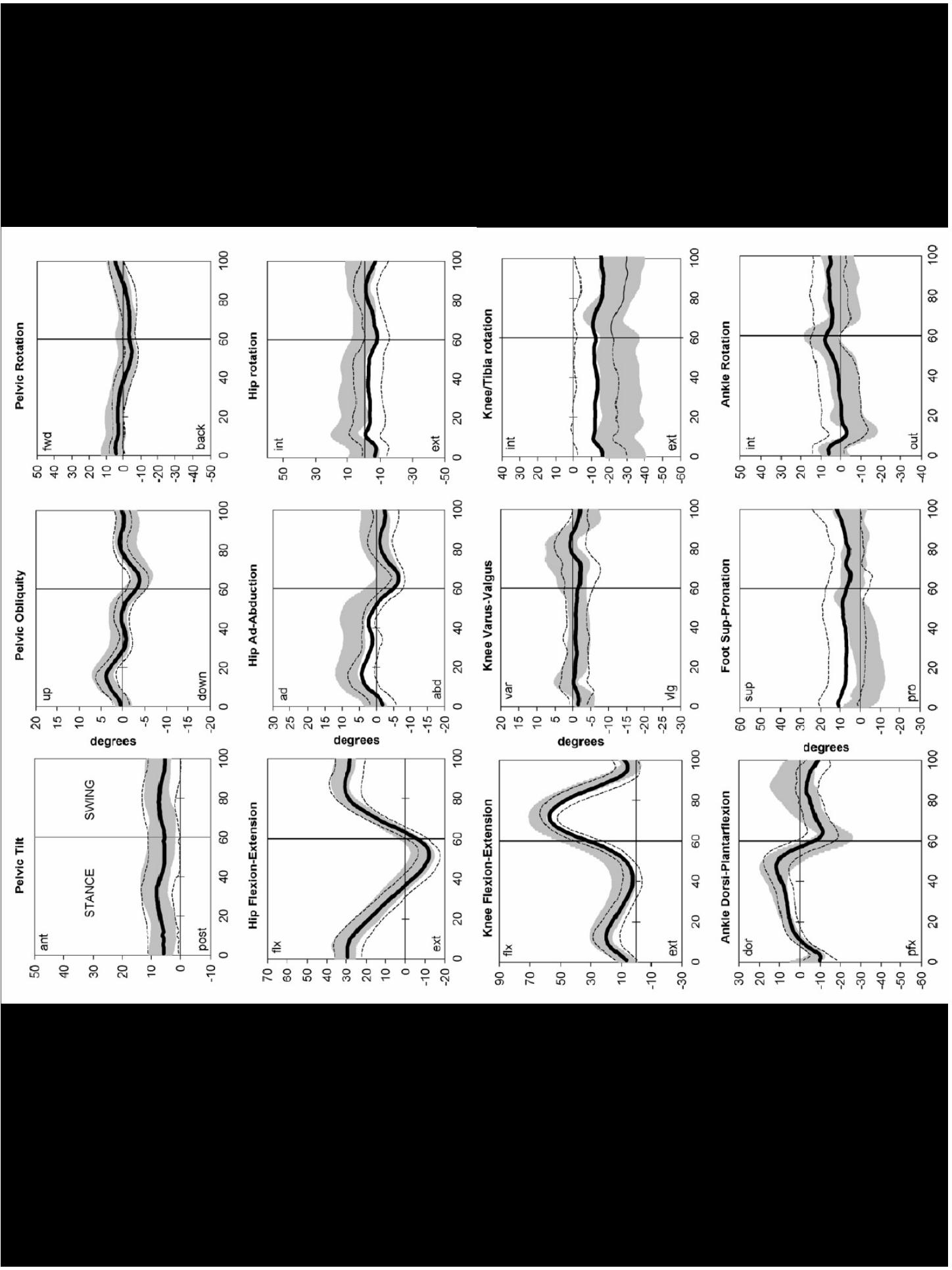


Gait Lab



Gait Lab





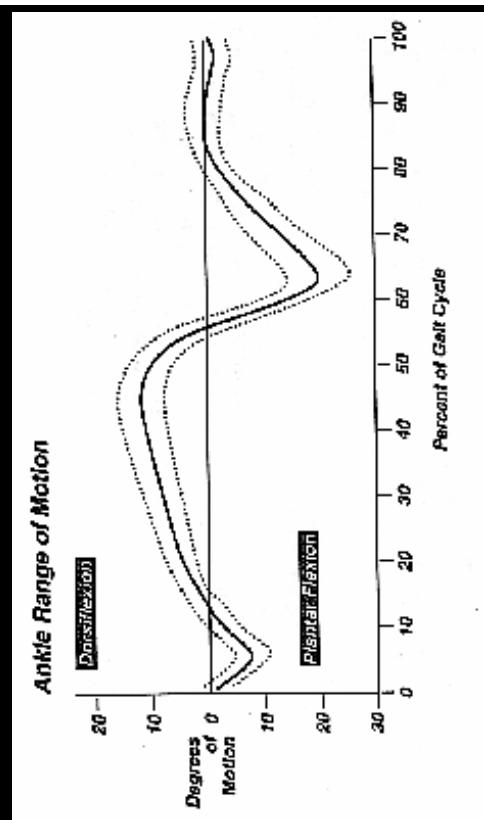
More definitions...

- Closed chain = weight bearing
- Open chain = NWB

Same muscle has different function!

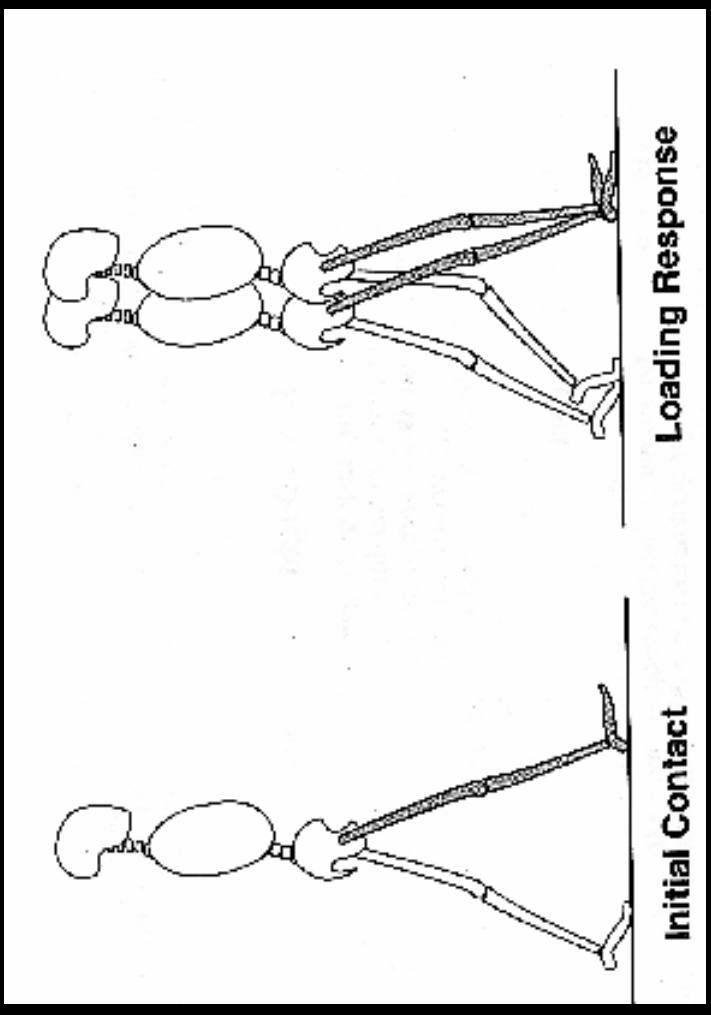
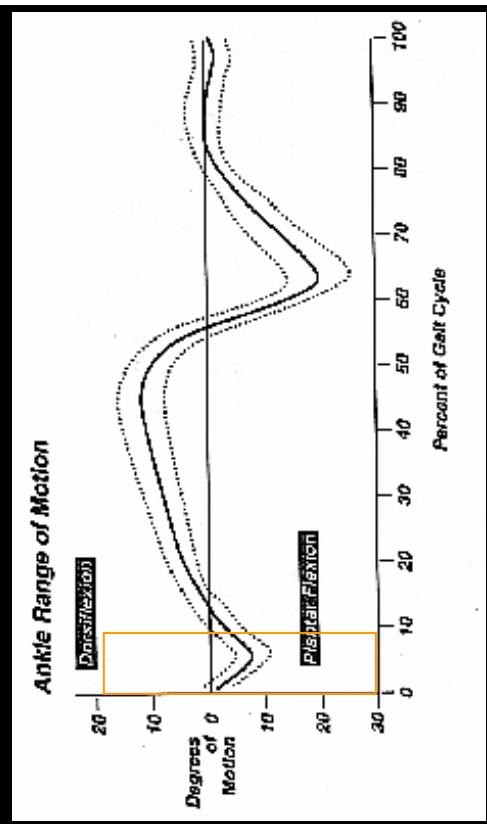
Ankle Movement

- Kinematic: angular motion around a joint
- Foot movement to the tibia
 - 0° = neutral position
 - Above = dorsal flexion
 - Below = plantar flexion



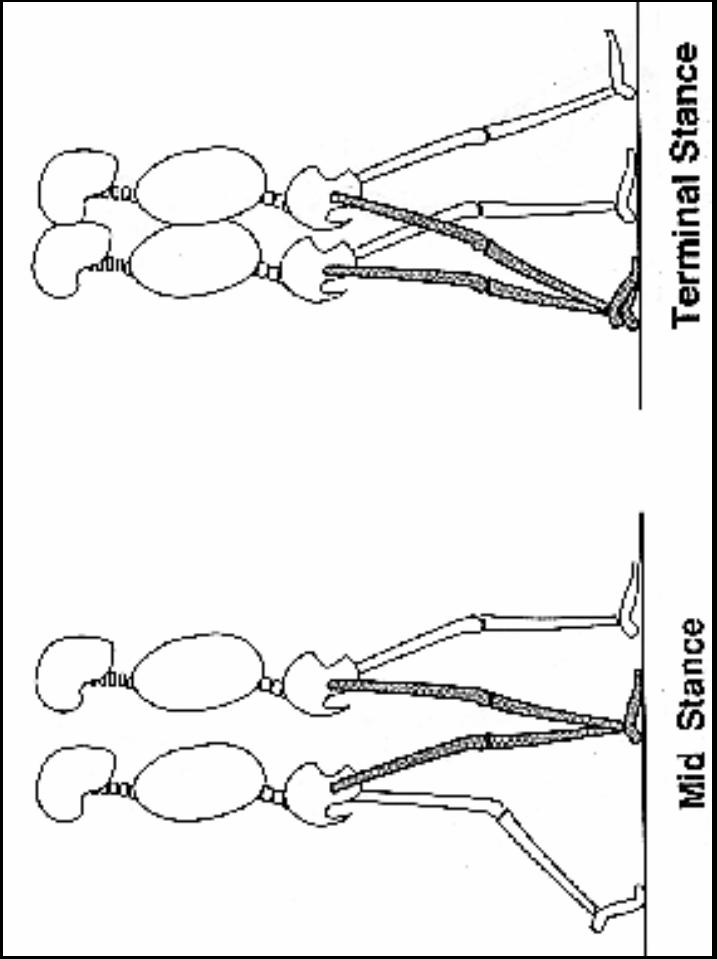
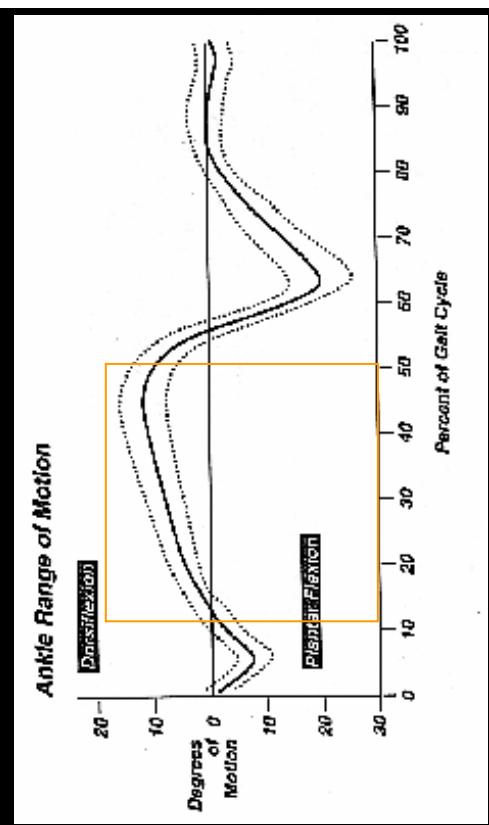
Ankle Kinematic – Loading Response

- Neutral position: 30° to the ground
- PF: foot flat on the ground
- First rocker



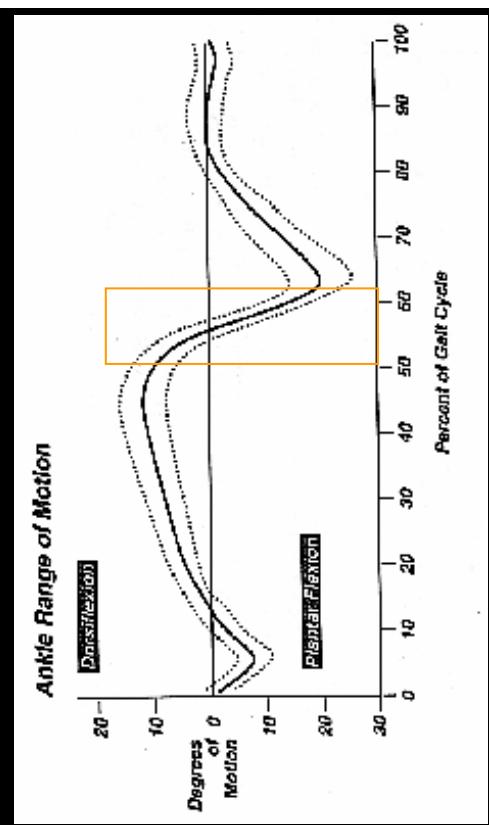
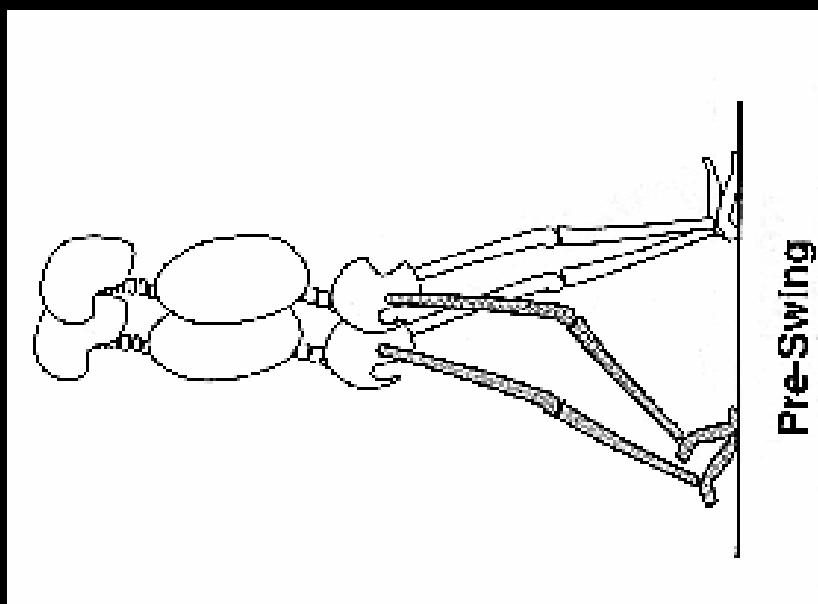
Ankle Kinematic – Stance

- DF: Tibia forward
- DF max = 15°
- Second rocker



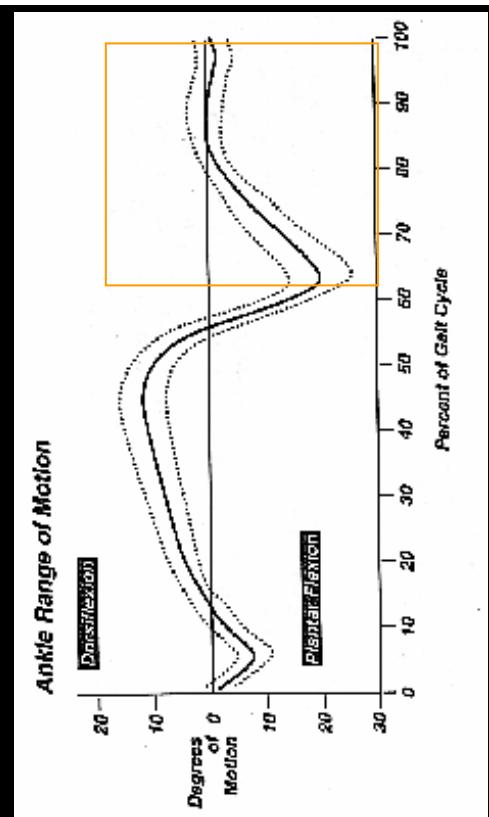
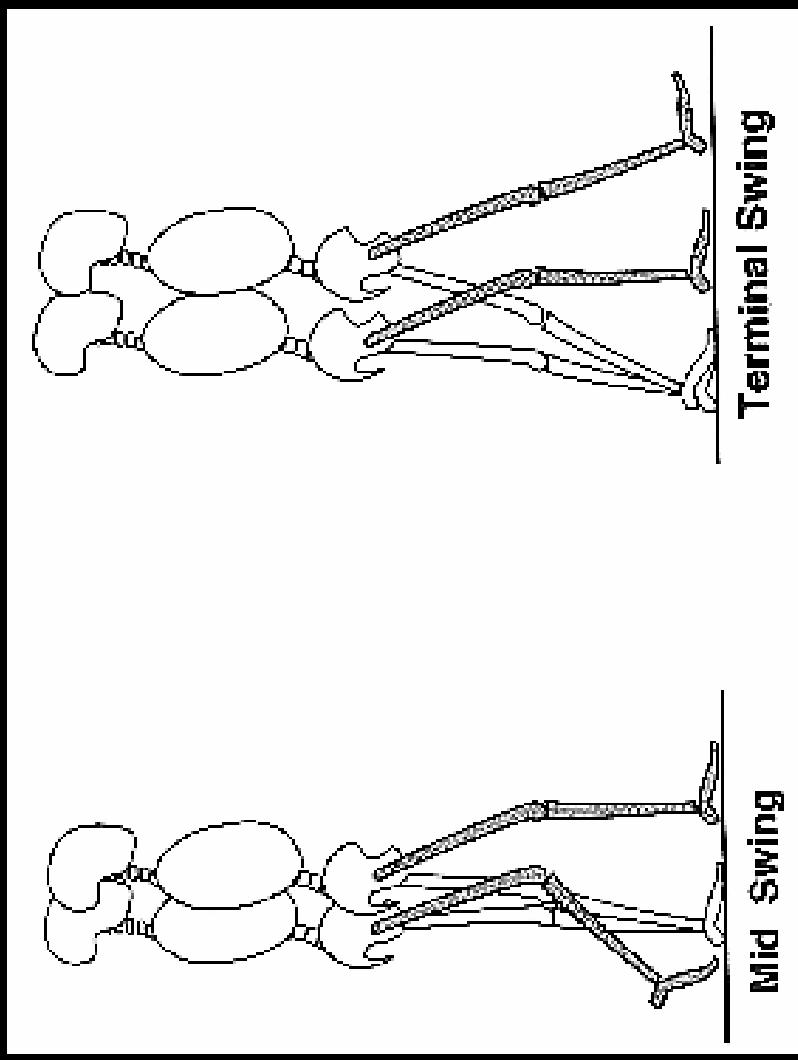
Ankle Kinematic – Pre Swing

- Fast PF up to 20°
- Third rocker



Ankle Kinematic – Swing

- Return to a neutral position

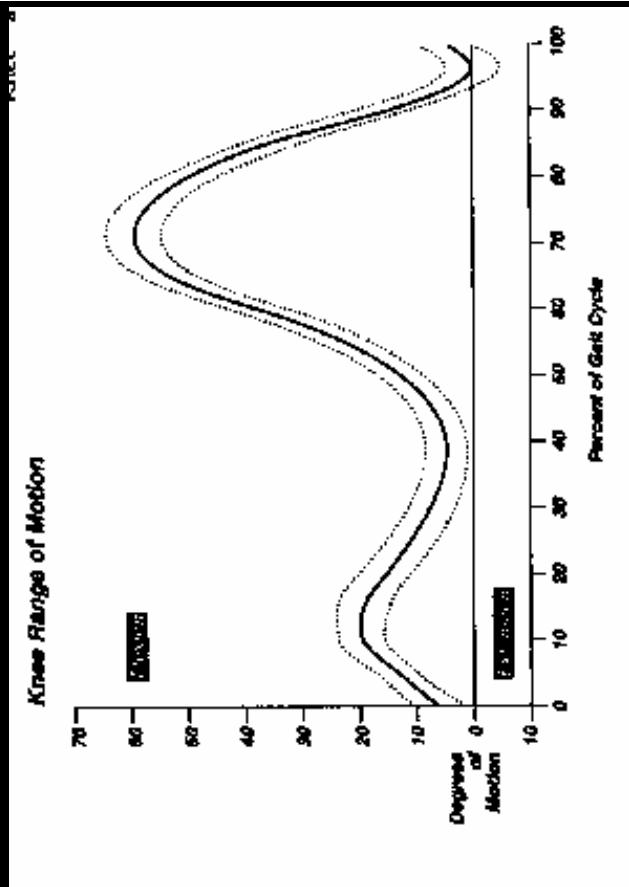


Ground Reaction Force (GRF)

- Newton's third law
- 3D vector
- Static (body weight) and
Dynamic (speed of ground contact)
- Orientation: passive angular motion
- Kinetics

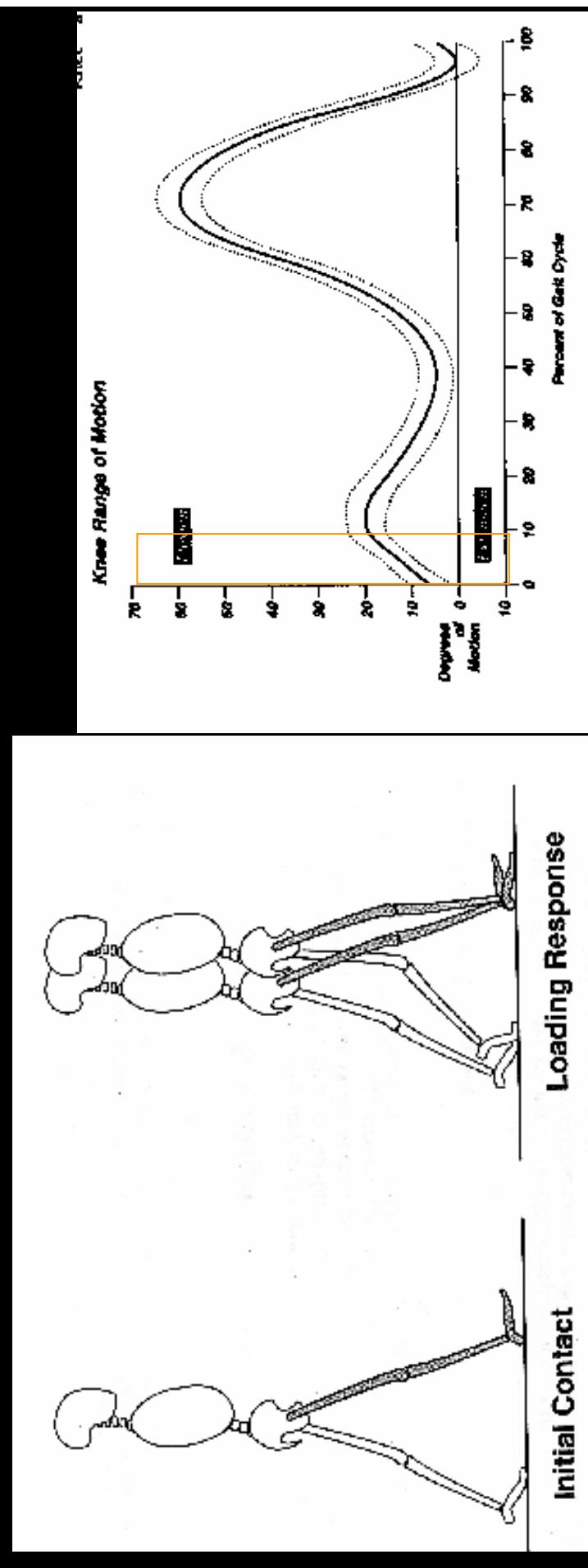
Knee Movement

- Kinematic: angular motion around a joint
- Tibia movement to the femur
 - 0° = neutral position
 - Above = flexion
 - Below = extension
 - No extension!



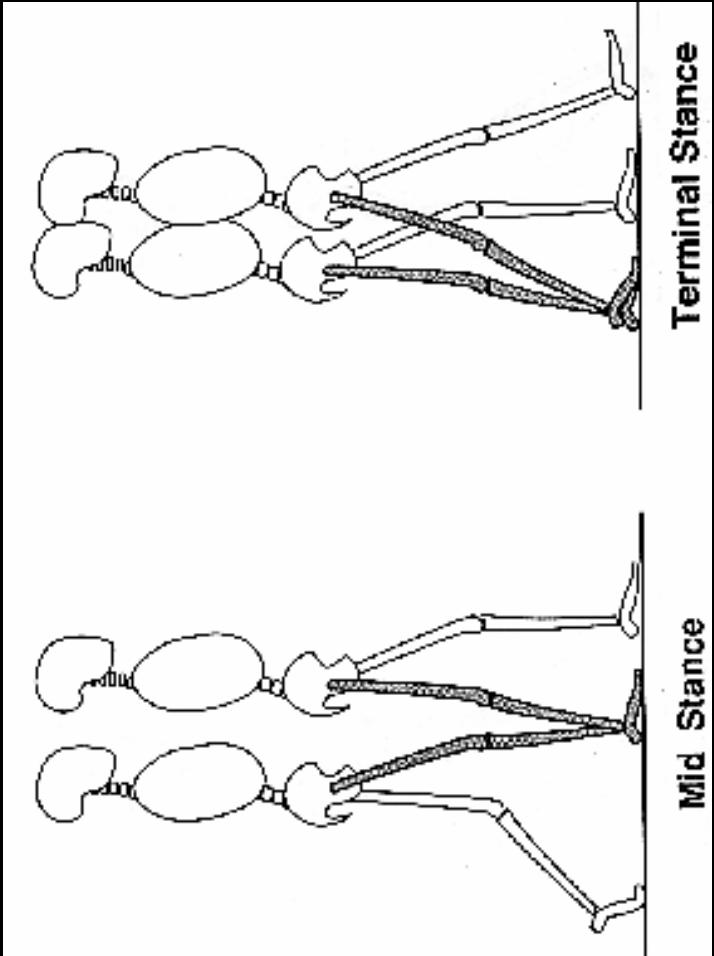
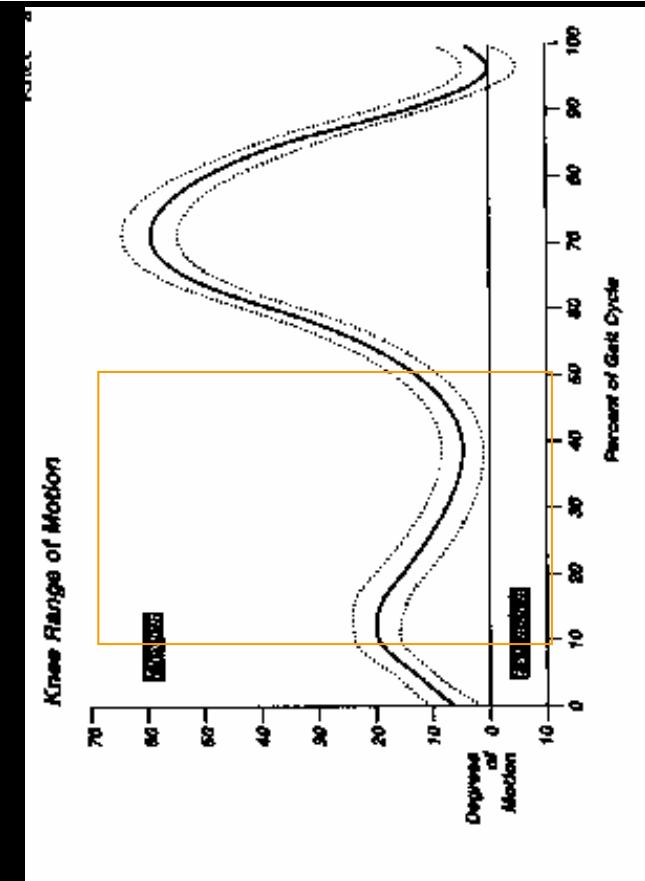
Knee Kinematic – Load Response

- Initial contact: 5°
- Flexion up to 20°



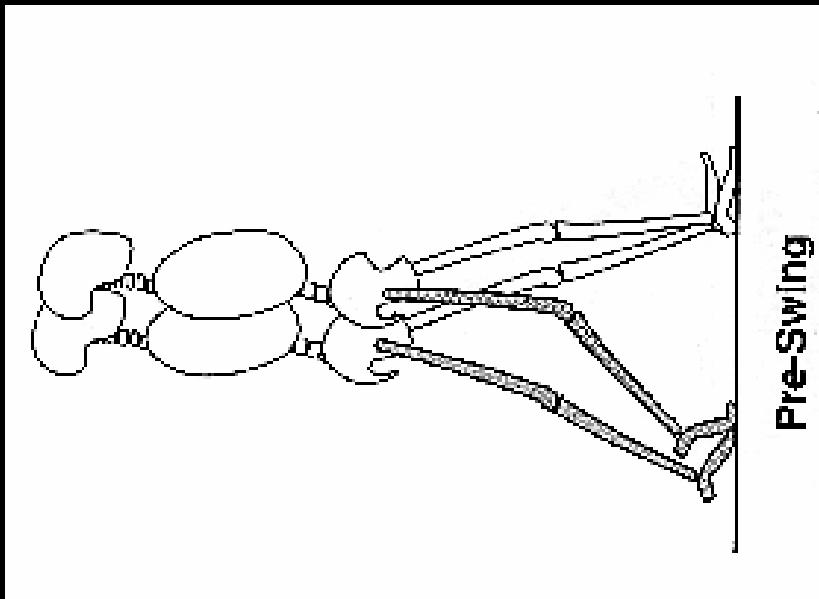
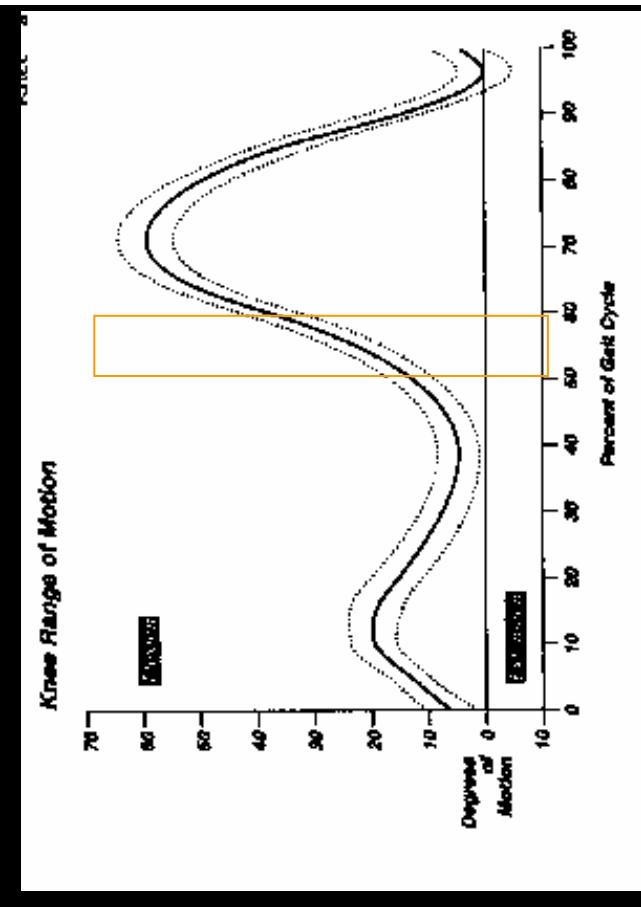
Knee Kinematic – Stance

- Reduced flexion
- Max at 40%



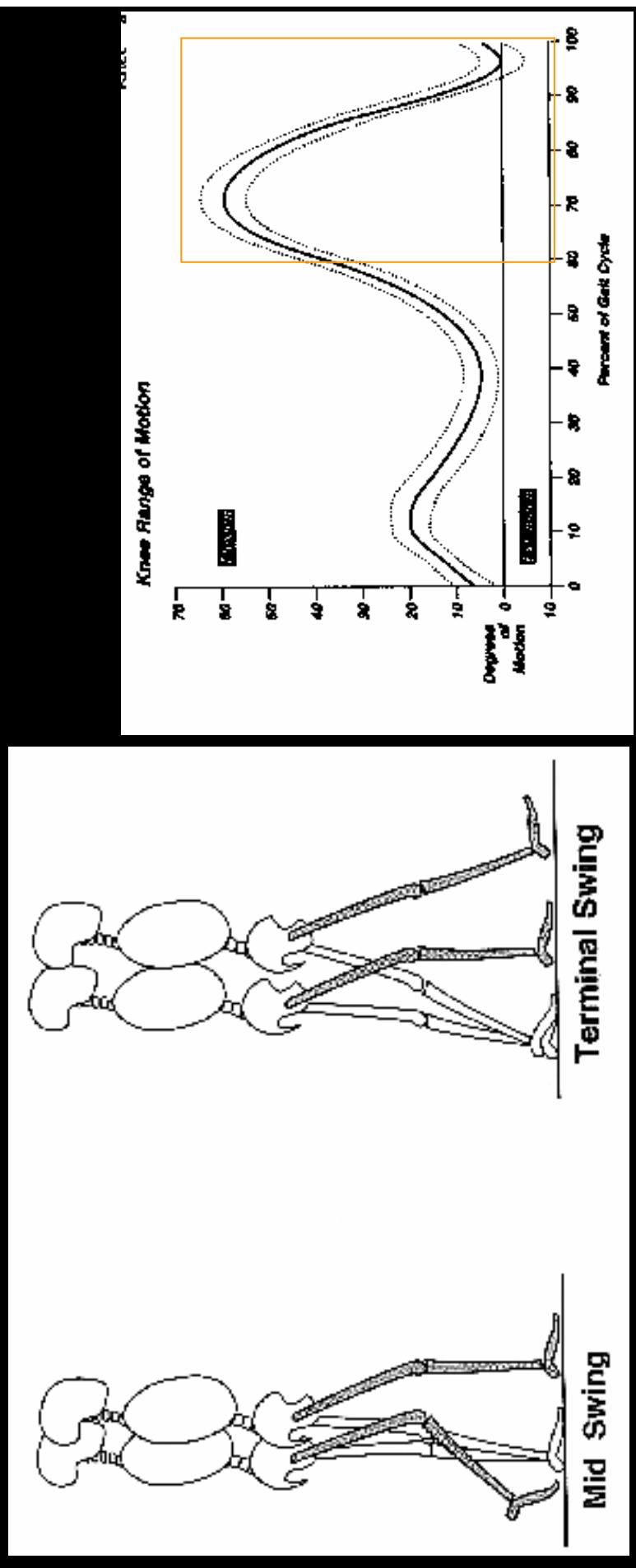
Knee Kinematic – Pre Swing

- Fast flexion



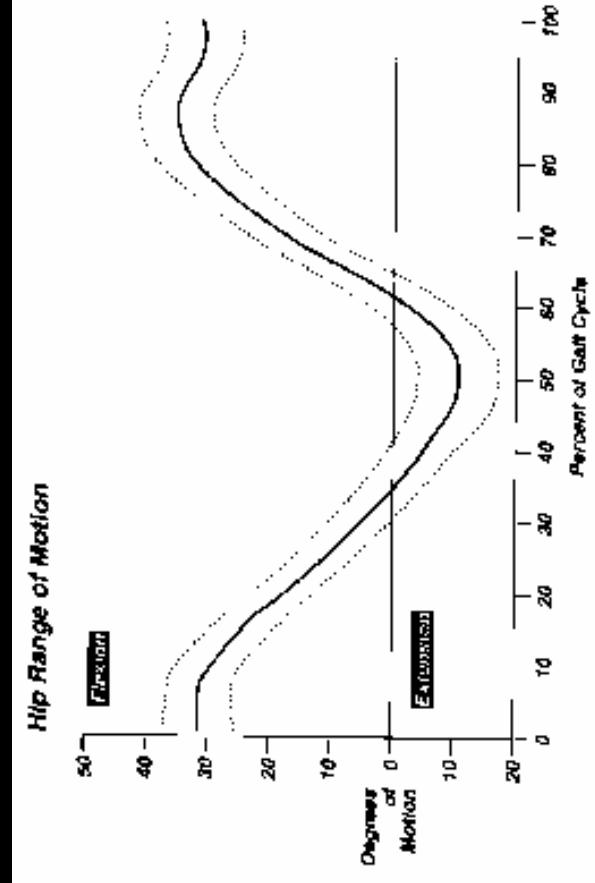
Knee Kinematic – Swing

- Max flexion at the end of initial swing



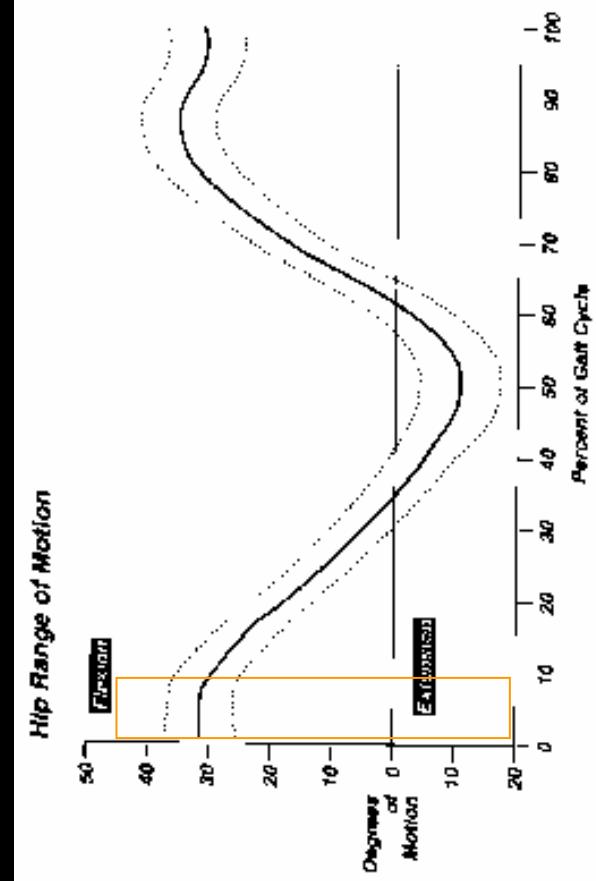
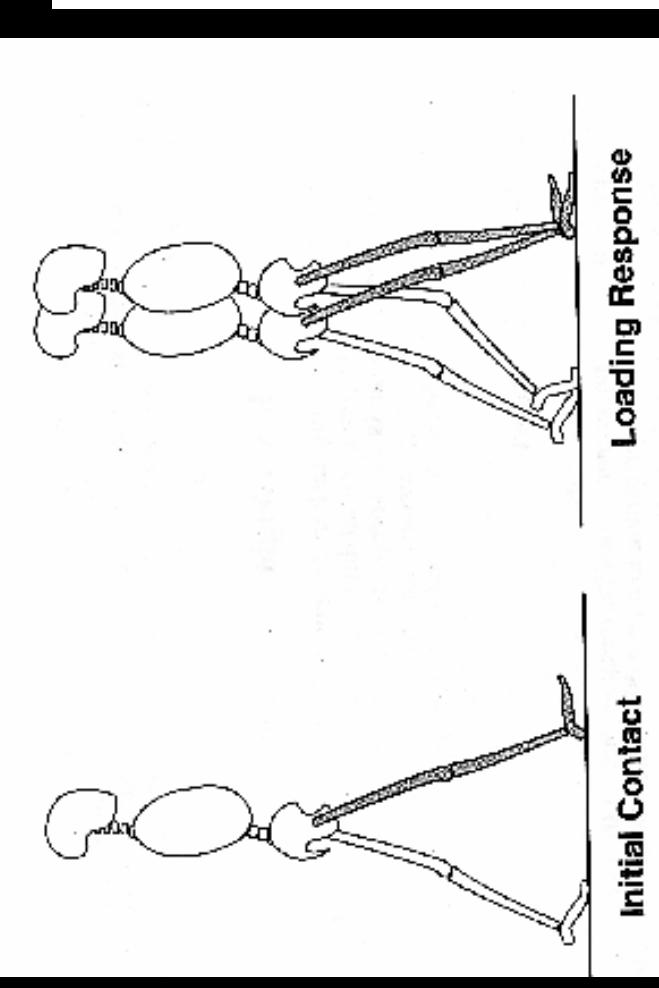
Hip Movement

- Kinematic: angular motion around a joint
- femur movement to the pelvis
 - 0° = neutral position
 - Above = flexion
 - Below = extension



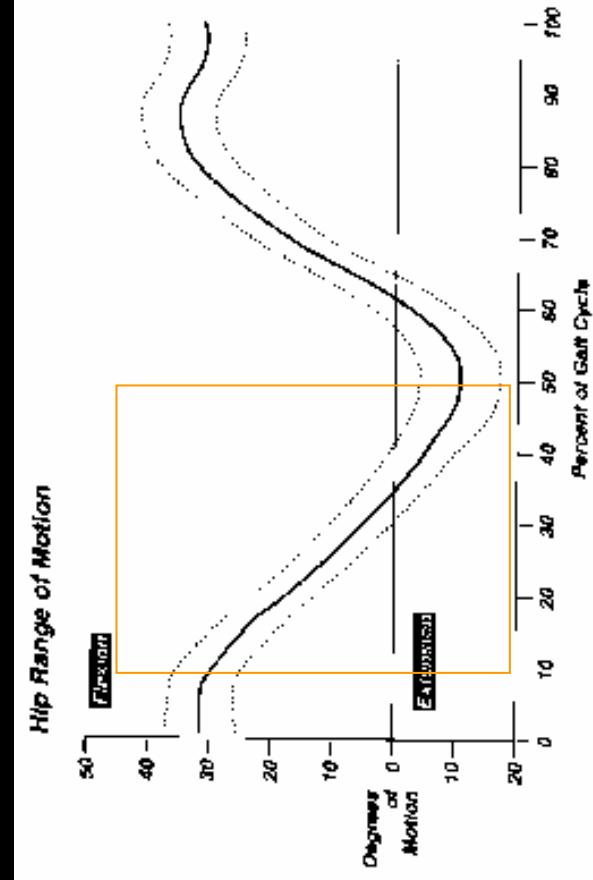
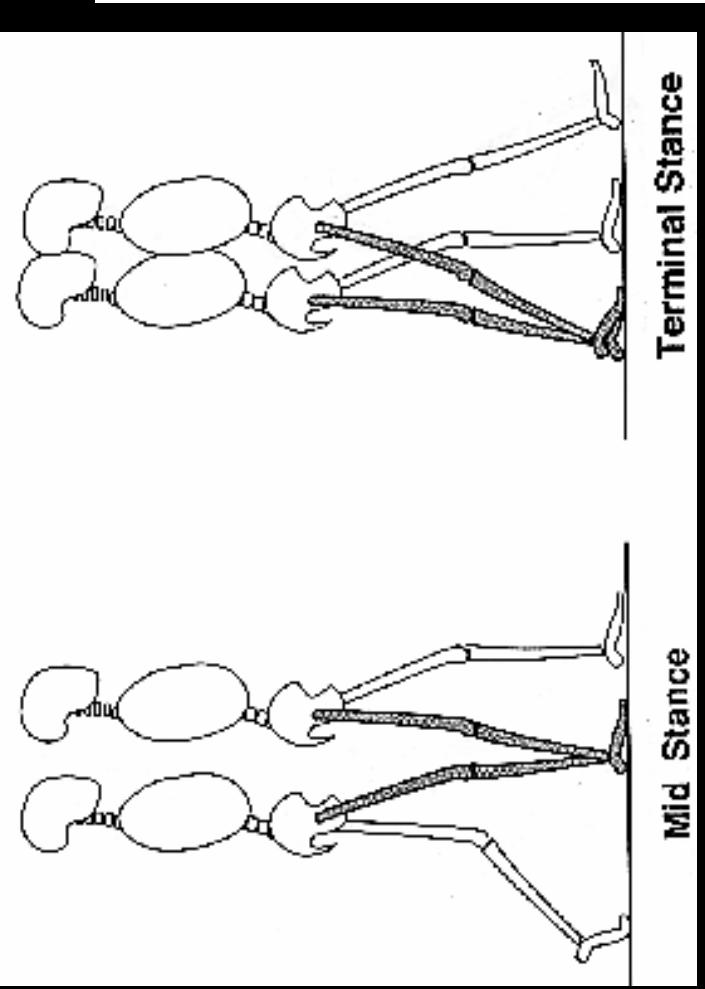
Hip Kinematic – Load Response

- Initial contact: 30° flexion



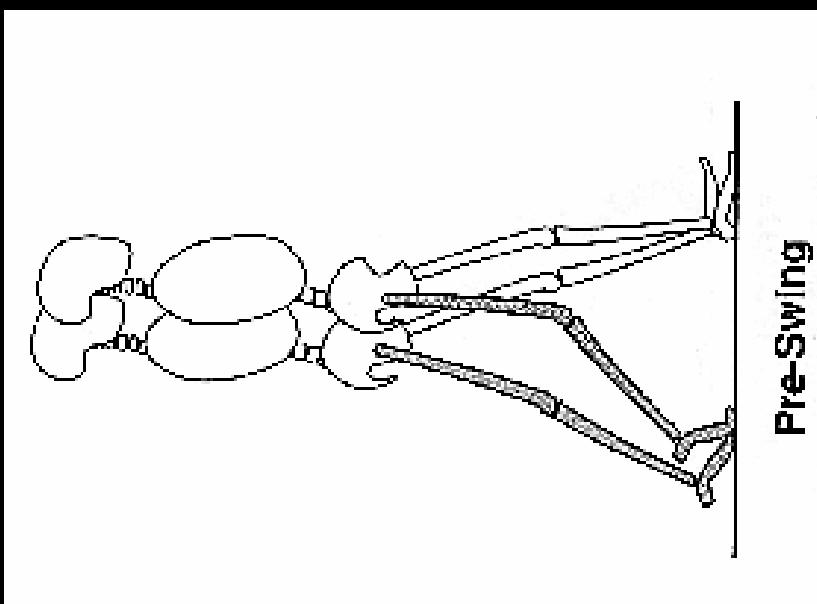
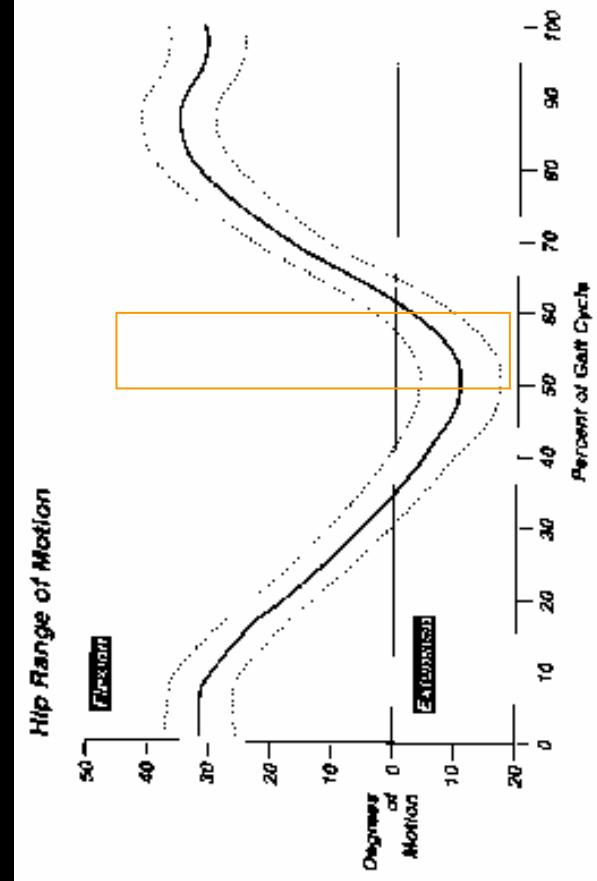
Hip Kinematic – Stance

- Neutral
- Max extension at 50%



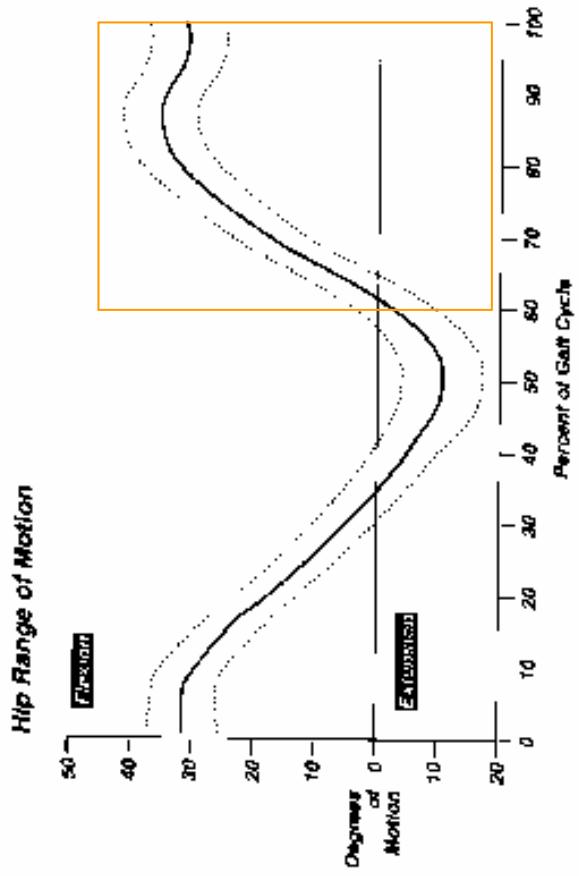
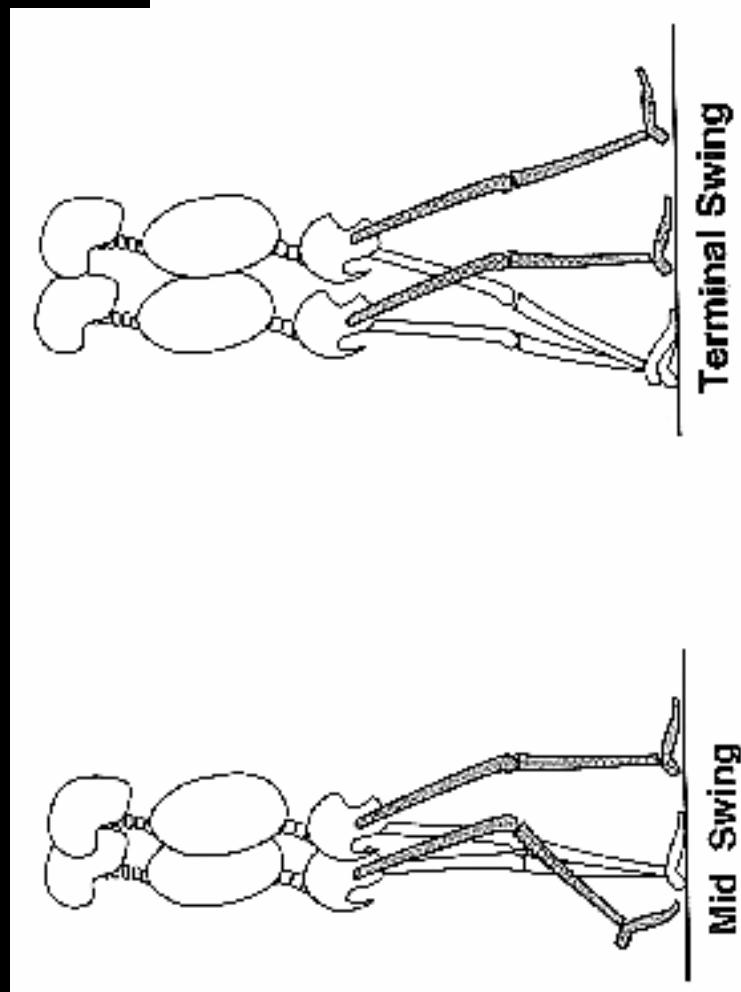
Hip Kinematic – Pre Swing

- Return to neutral



Hip Kinematic – Swing

- Max flexion at end of mid swing

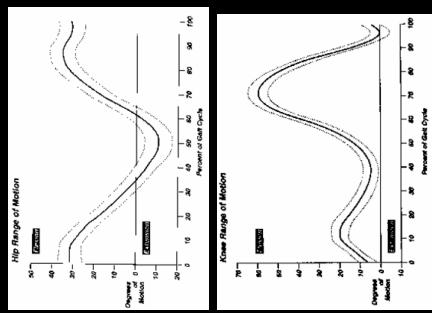
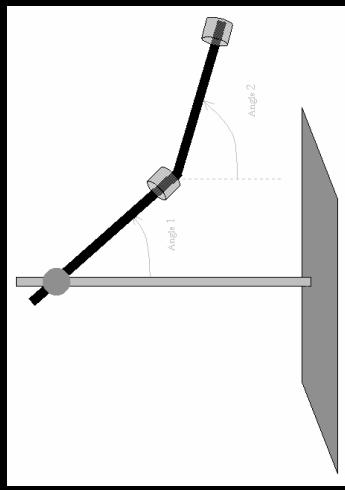


More definitions...

- Concentric = Energy lost
 - Joint motion in the same direction than the internal motion
 - Muscle activity with shortening
- Eccentric = Energy absorbed
 - Joint motion opposed to the internal motion
 - Muscle activity with lengthening

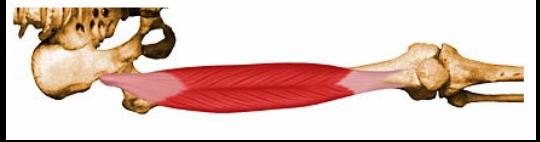
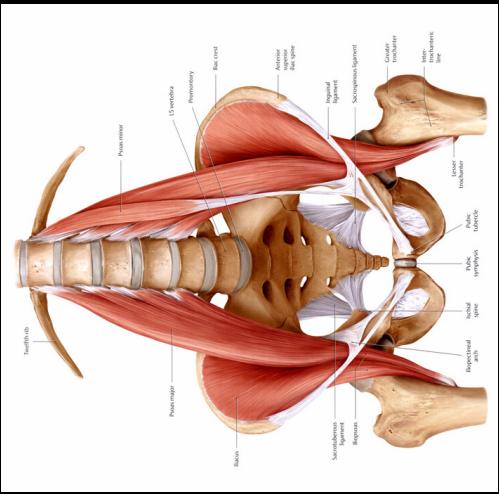
Double Pendulum

- Swing phase
- Motor:
 - Hip flexors
- Passive motion of knee and hip
 - Hip and knee flexion
 - Maximal flexion
 - Hip = 30°
 - Knee = 60°
- Passive extension until stance phase



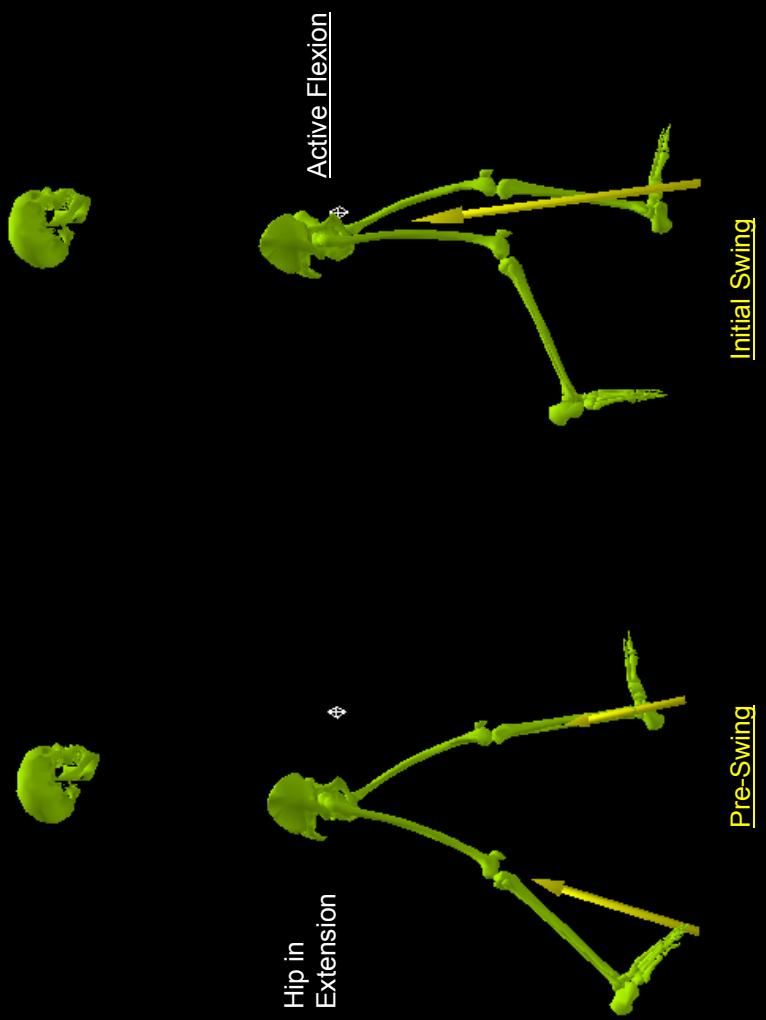
Flexors of the Hip

- Psoas (Ps)
 - Strongest hip flexor
 - Biarticular muscle

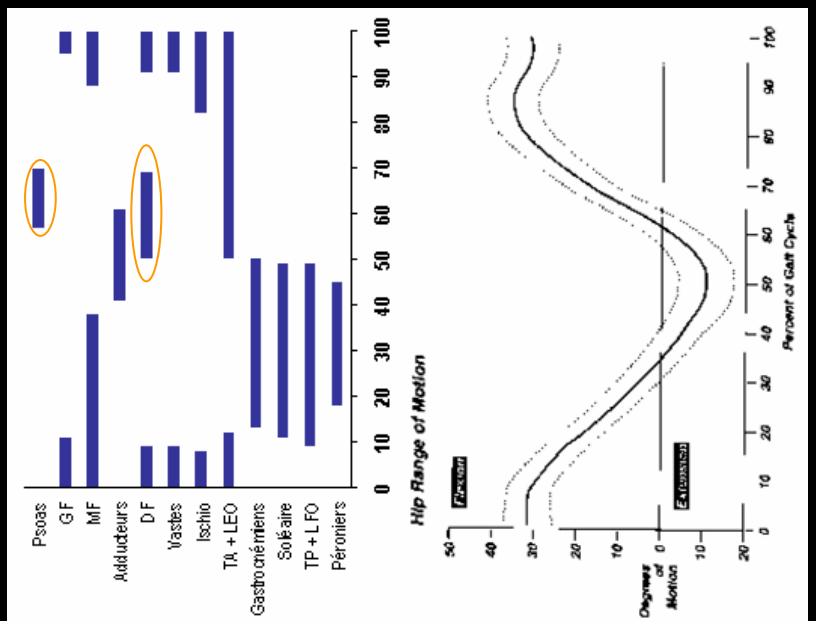


- Rectus Femoris (RF)
 - Hip flexor
 - Knee extensor (quadriceps)
 - Biarticular

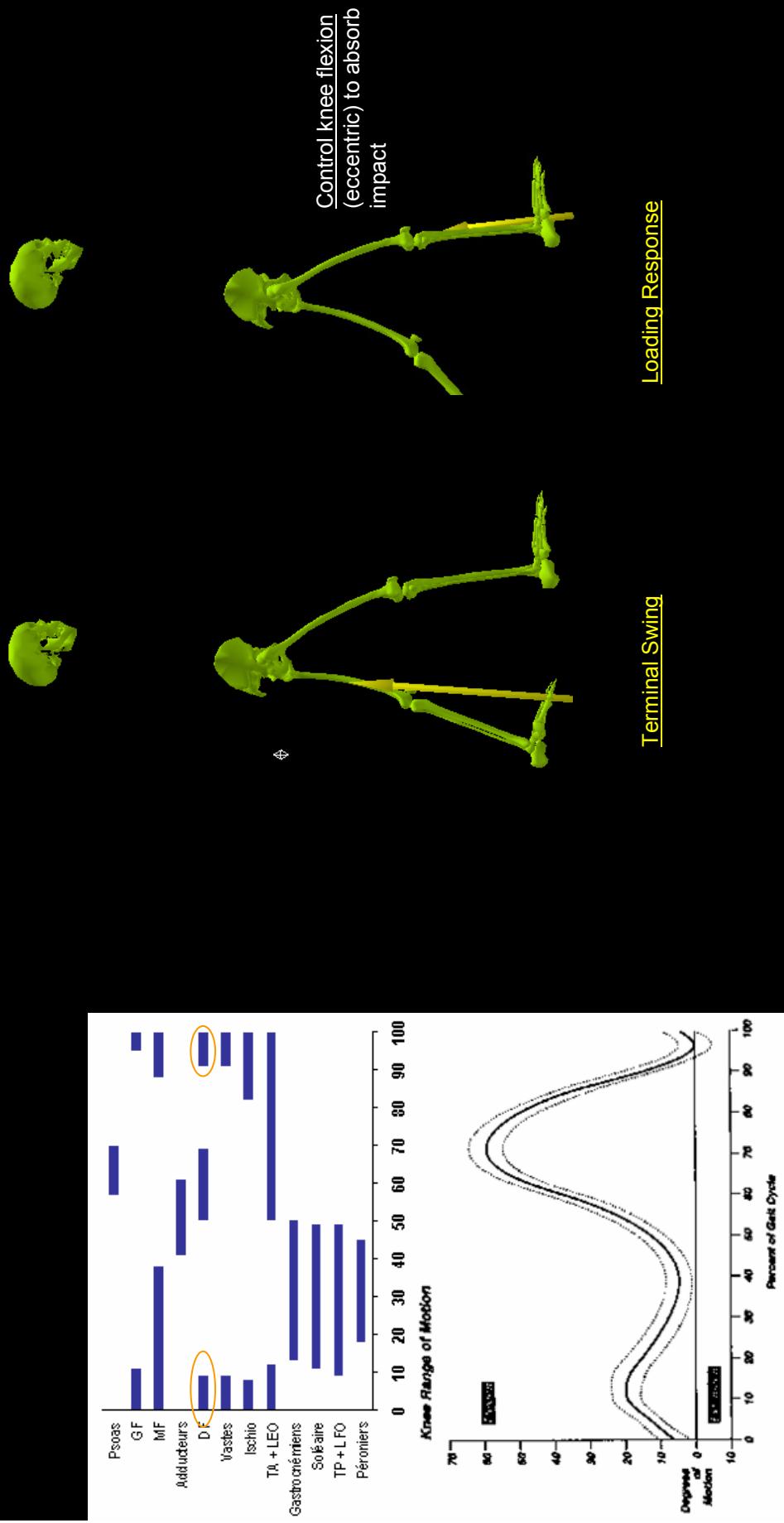
Hip's Flexors Function



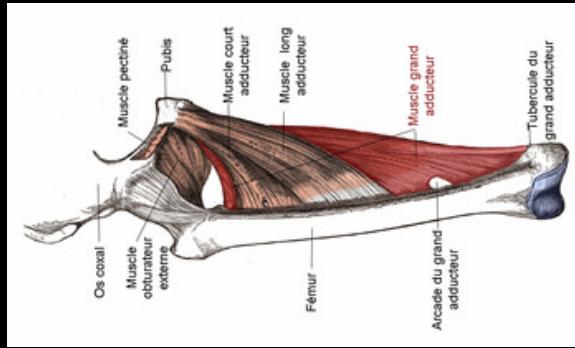
Double Pendulum's power



Extra role for Rectus Femoris



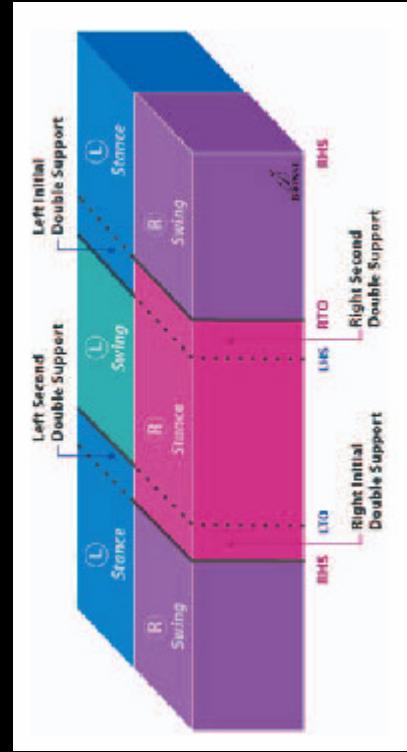
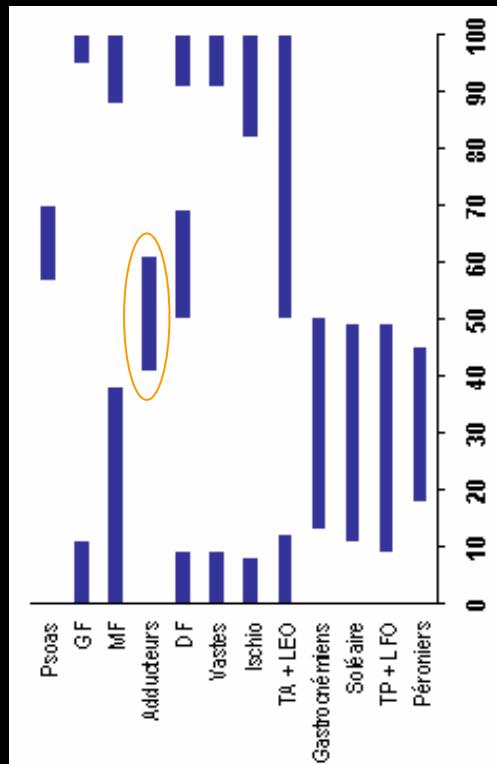
Adductors of the hip



Adductor Longus

Adductor Magnus

Adductor Brevis



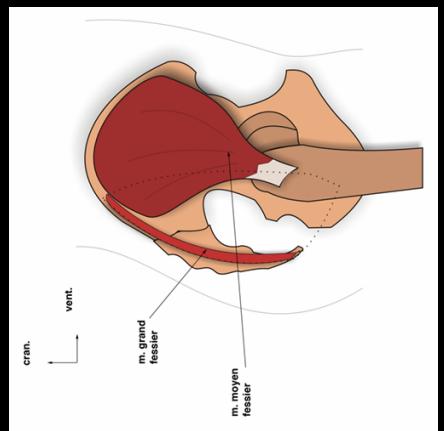
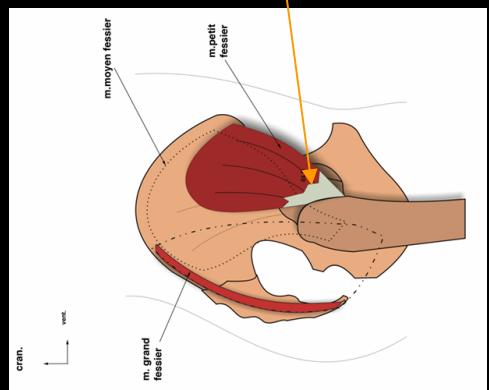
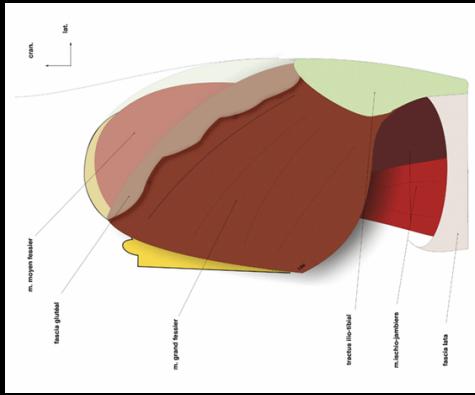
Transfer of load before
double support phase

Gluteus Muscle

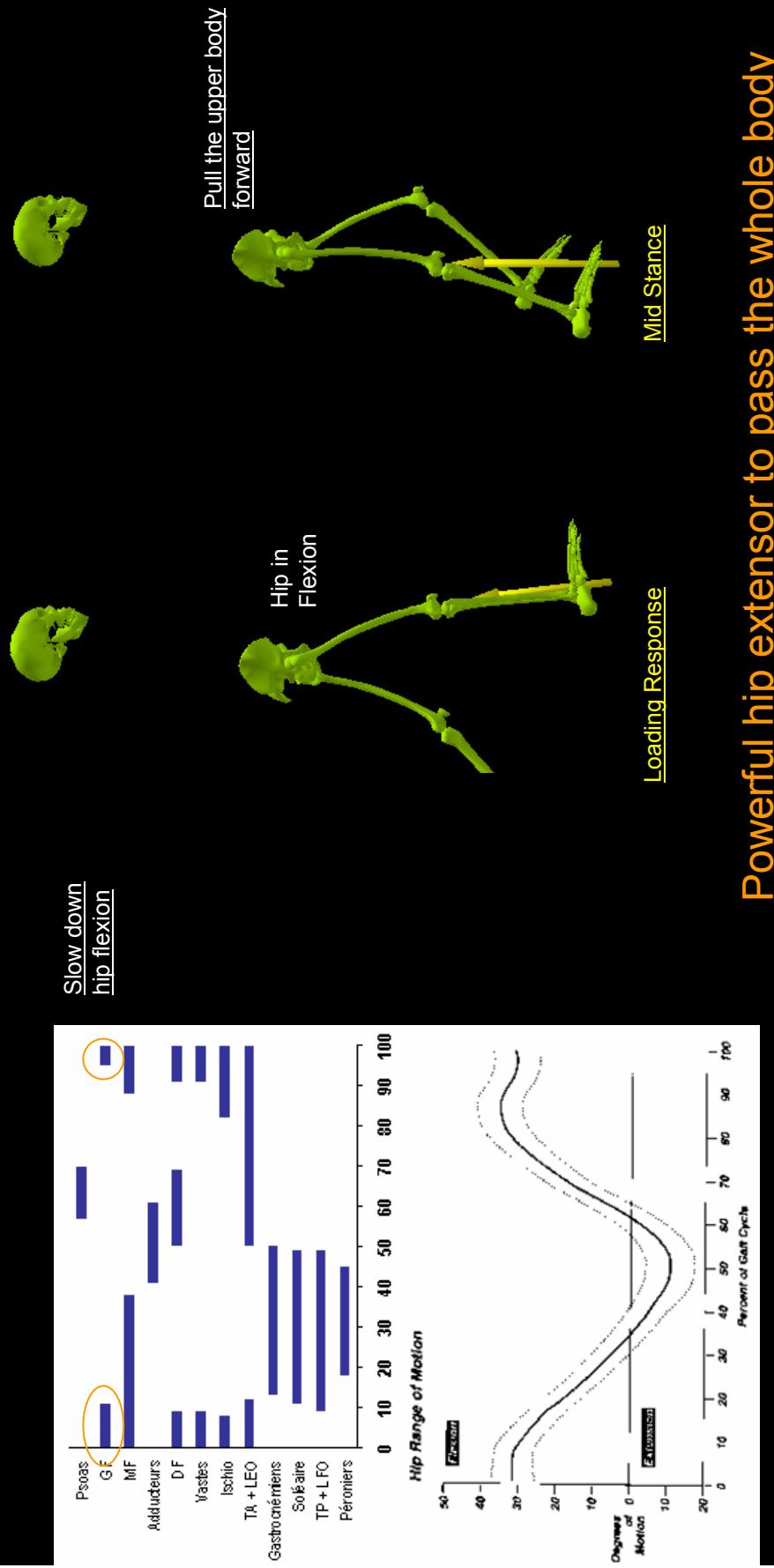
- Gluteus Maximus = extensor

- Gluteus Medius
- Gluteus Minimus

= abductor



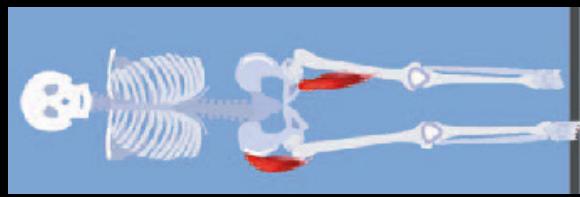
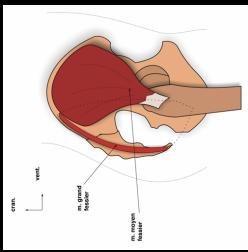
Gluteus Maximus Function



Gluteus Medius and Minimus

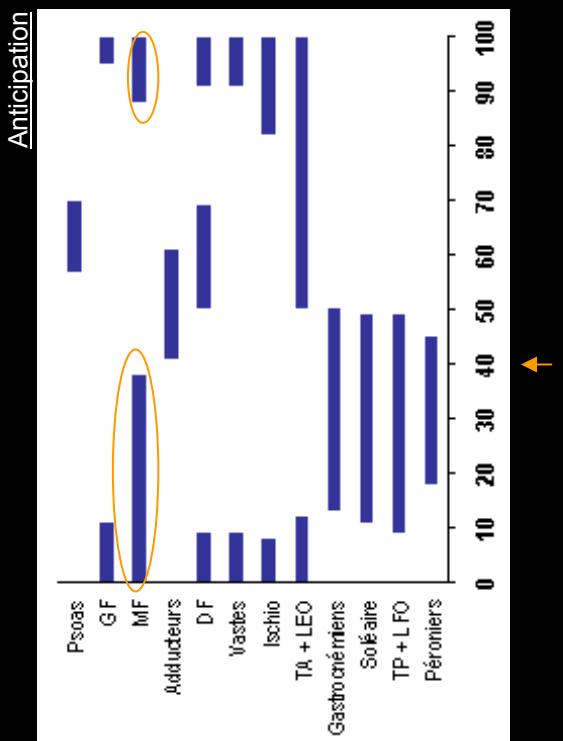
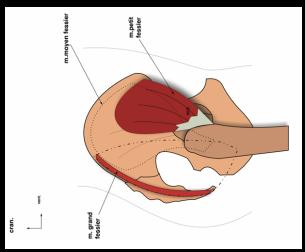
- Gluteus Medius:

- Powerful muscle
- Abductor for open chain
- Pelvic stabilizer in closed chain (eccentric)



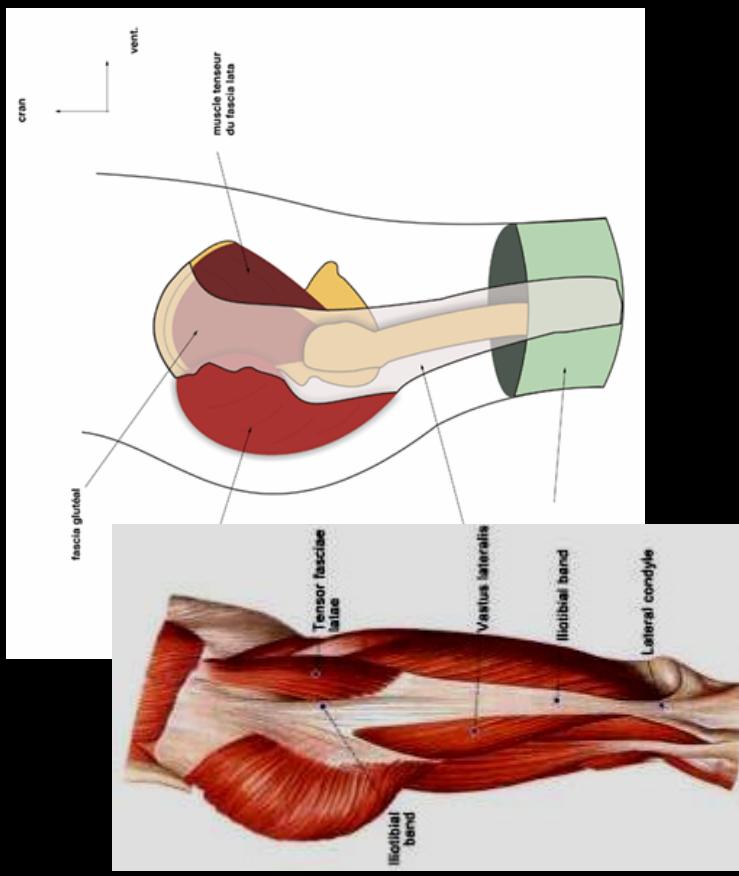
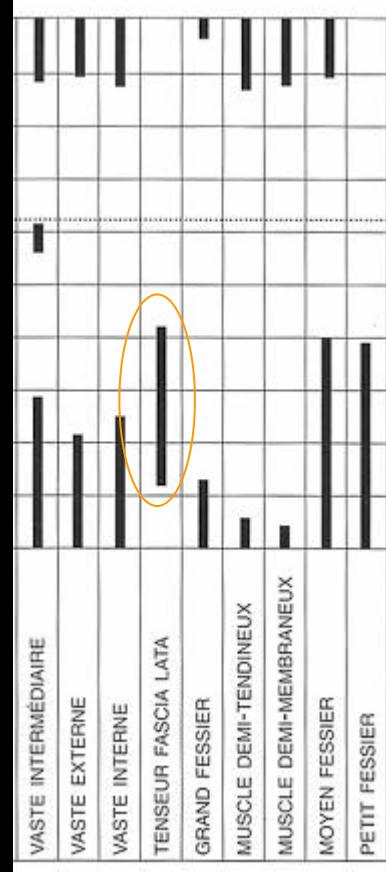
- Gluteus Minimus:

- Mainly Abductor
- Slightly Flexor



Tensor Fasciae Latae

- Hip and Knee Abductor
- Delayed action



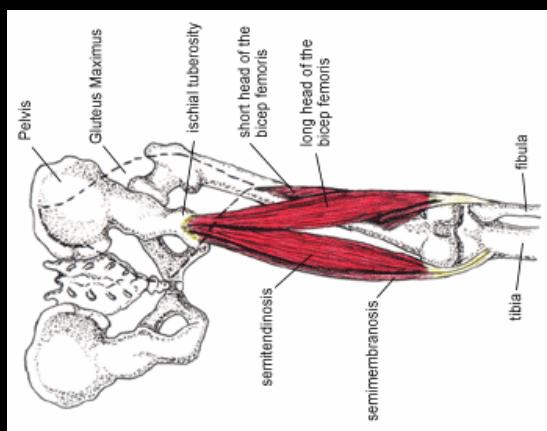
Hamstrings

- Medial = Semimembranosus + Semitendinosus

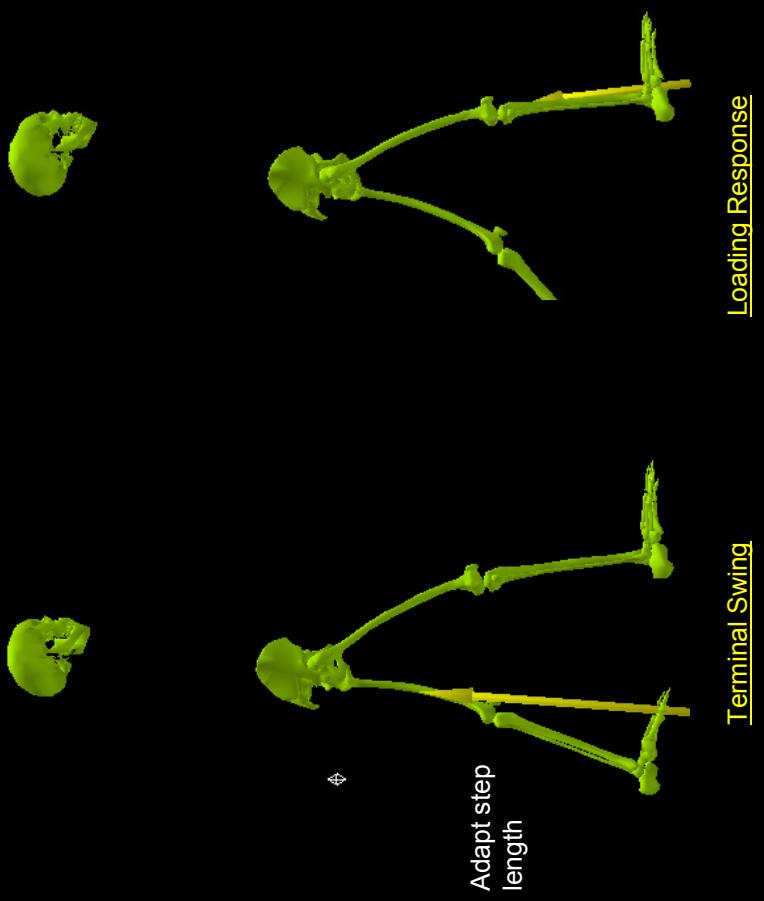
- Hip Extensor
- Knee Flexor
- Internal Rotation of the Leg

- Lateral = Biceps femoris

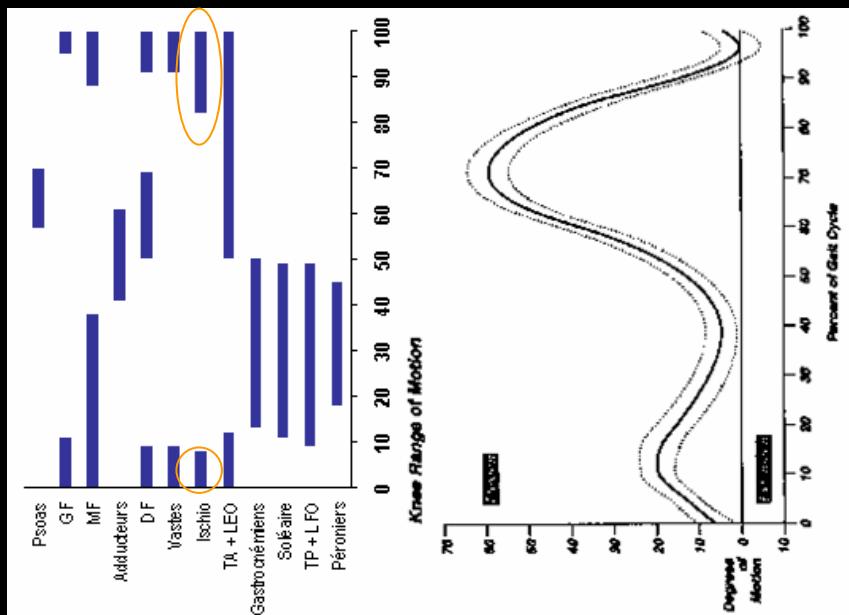
- Hip Extensor
- Knee Flexor
- External Rotation of the Leg



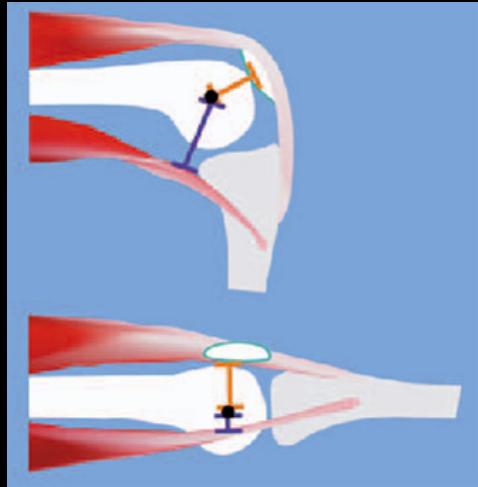
Hamstrings



1. Slow down Knee Extension and Hip Flexion
2. Help Hip Extension

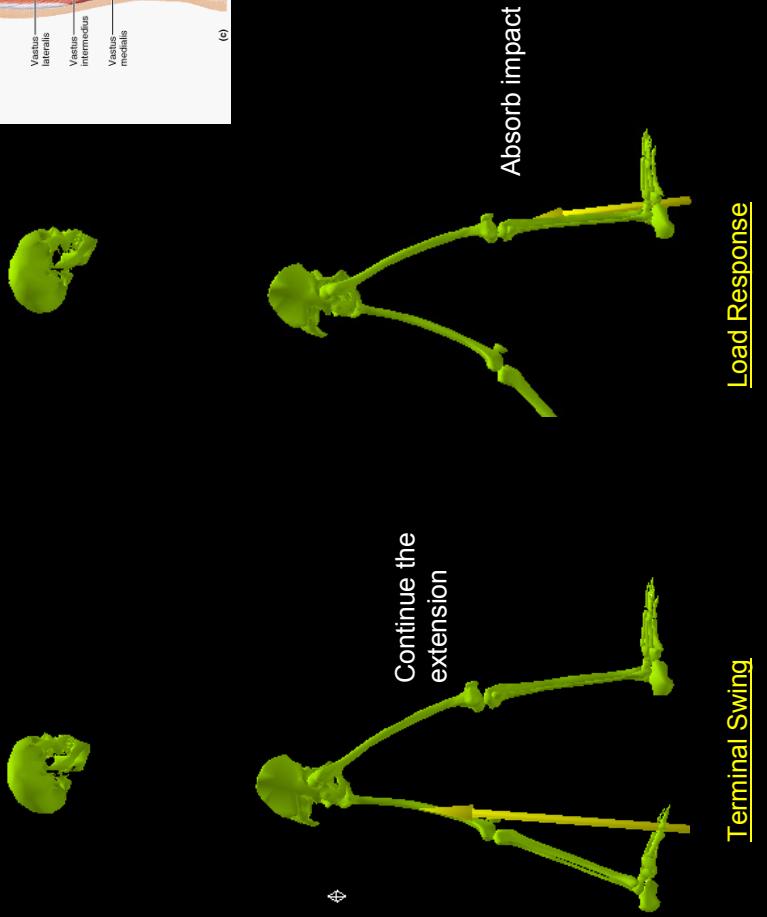
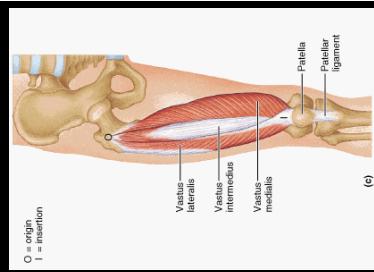


Hamstrings Stiffness

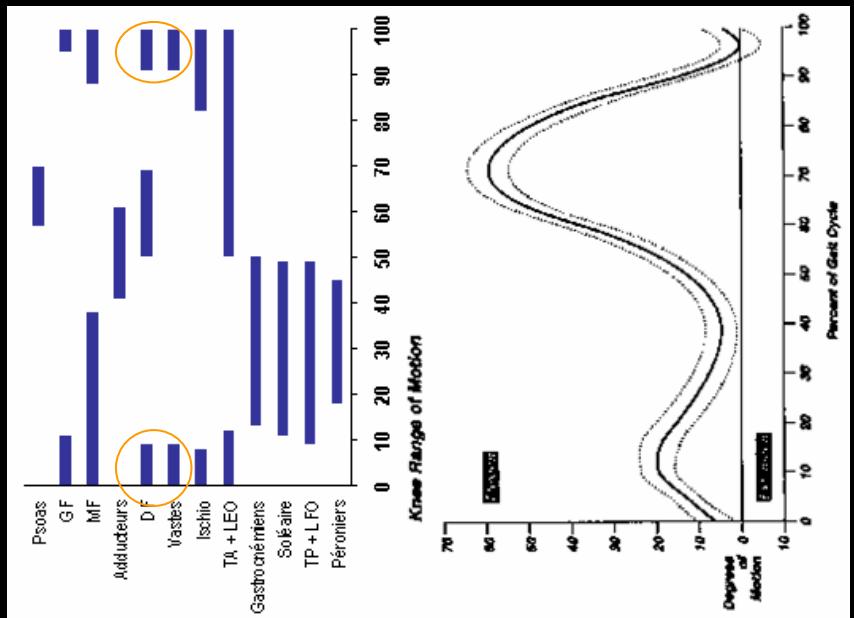


- Reduce step length
- Loading Response with tip toeing

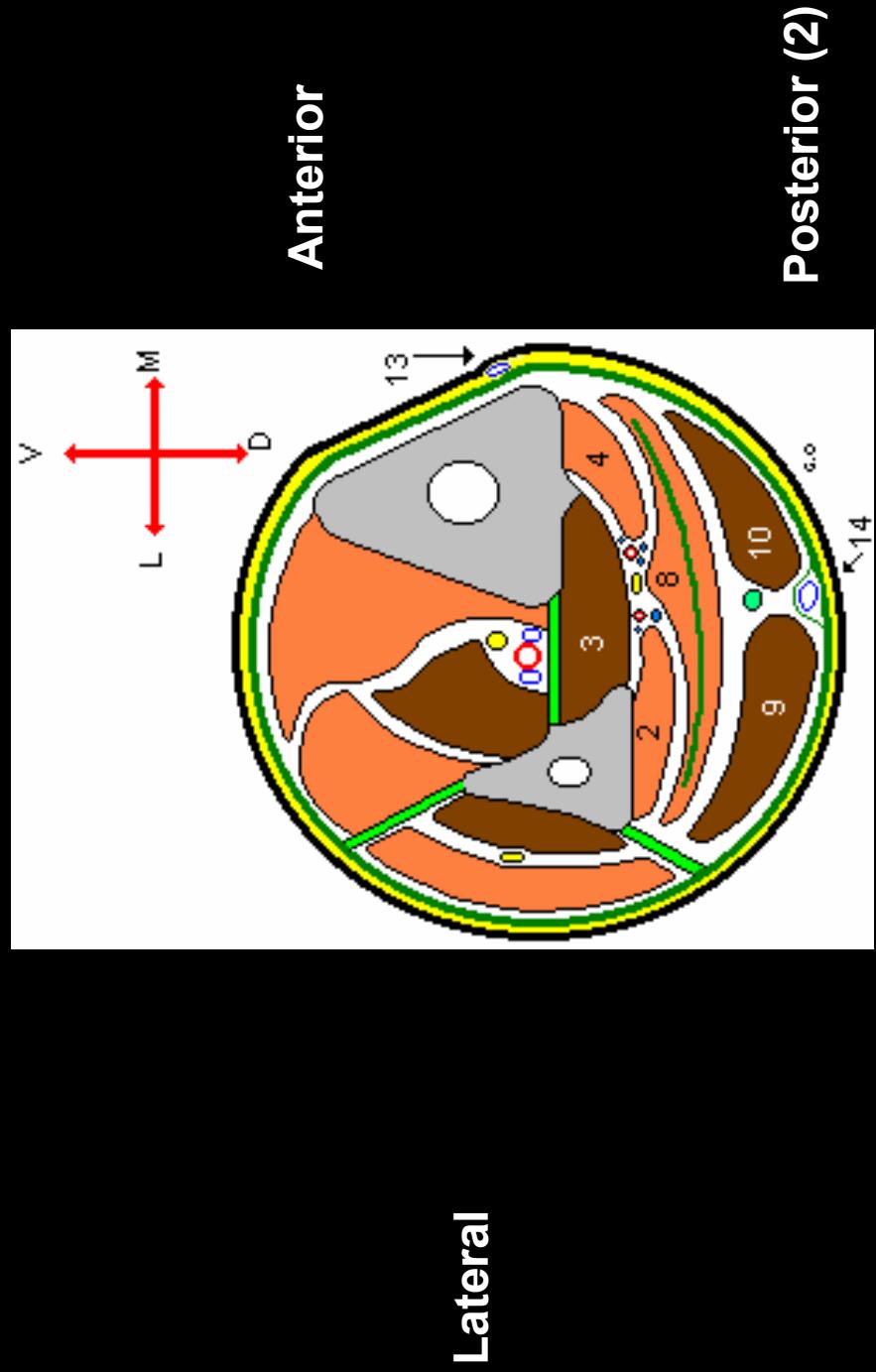
Knee Extensors Function



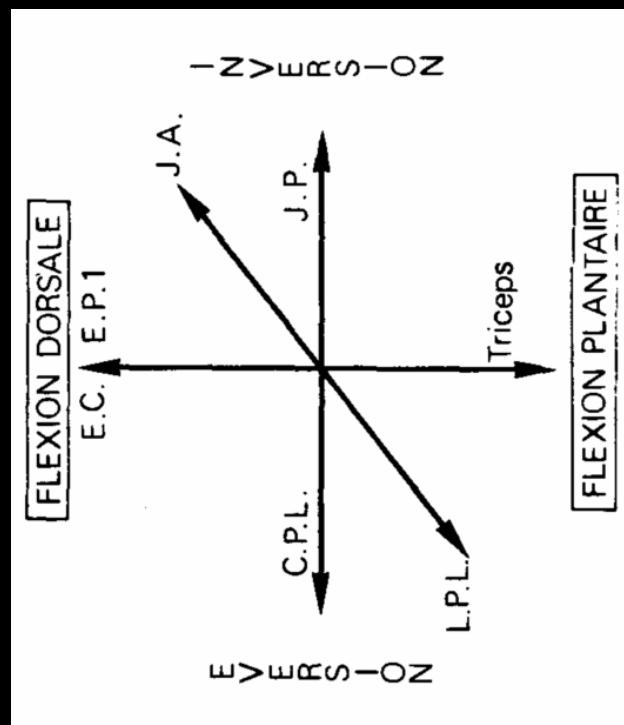
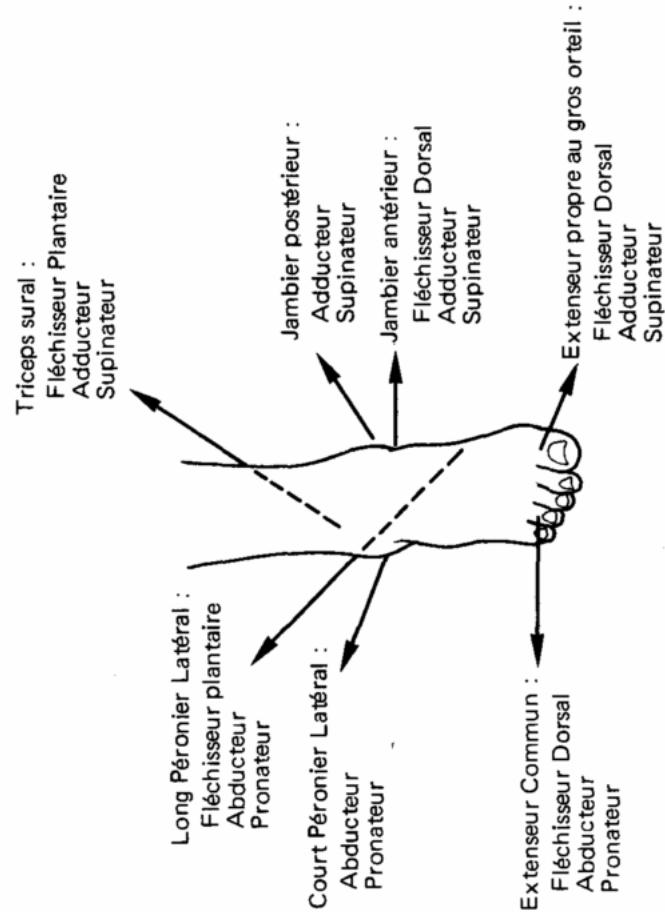
1. Absorb impact (eccentric)
2. Concentric Knee Extension



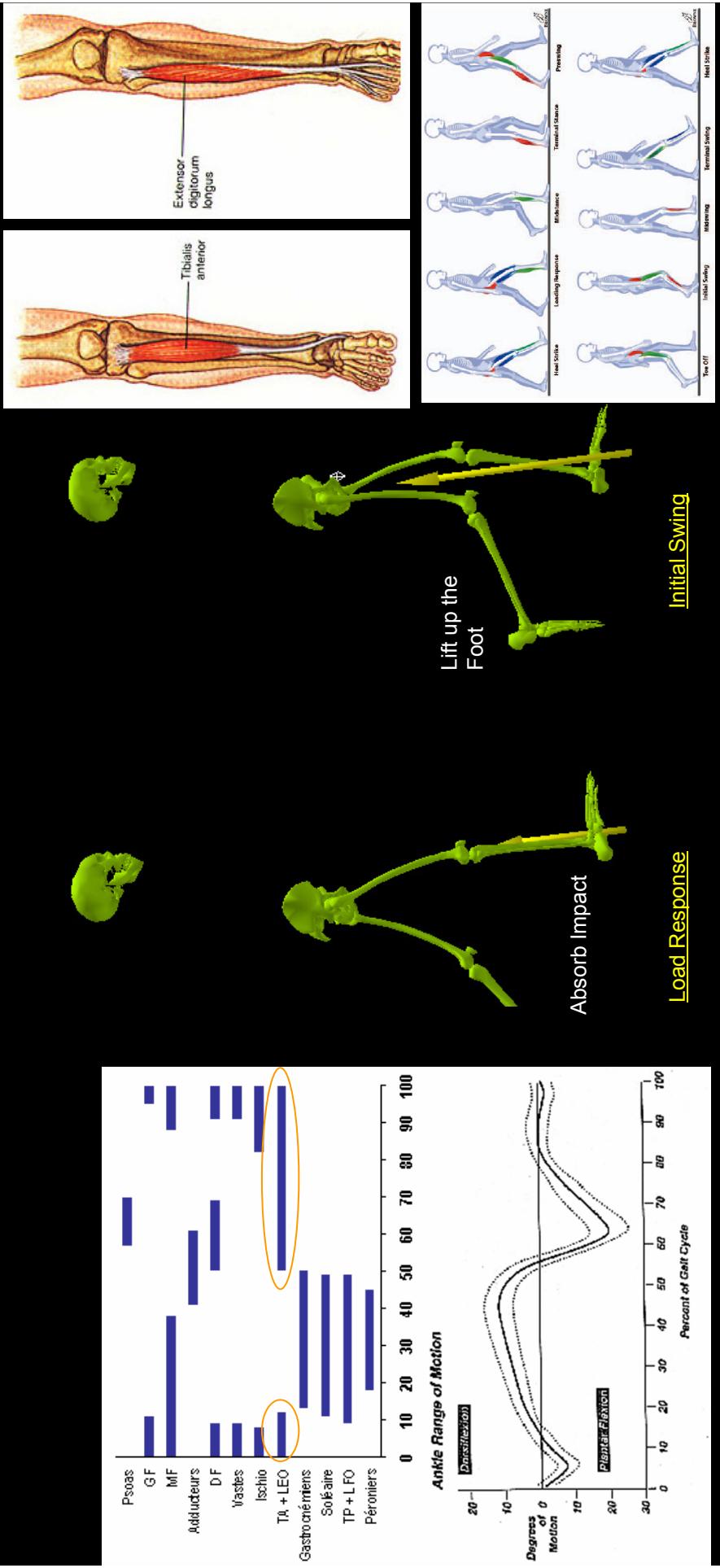
Leg Compartments



Foot ROM

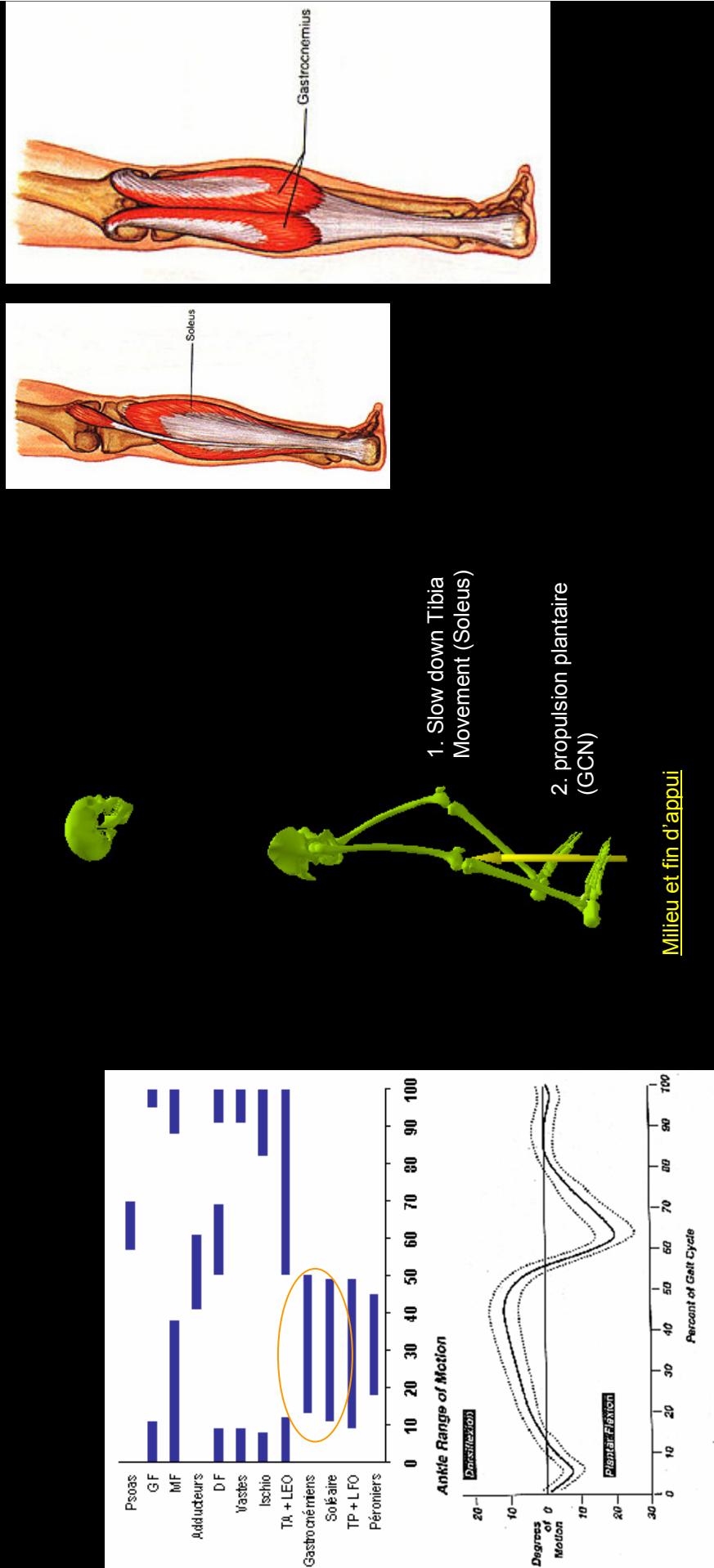


Anterior Compartment Function



1. Absorb load (eccentric)
2. Clearance (concentric)

Superficial Posterior Compartment



1. Slow down tibia (eccentric)
2. Plantar propulsion (concentric)

Soleus vs Gastrocnemius



- Soleus
 - Horizontal red fibers
 - Slow down tibia (eccentric)
- GCN
 - Vertical white fibers
 - Biarticular
 - Plantar flexor

Rockers



1st Rocker = Heel

Ex moment = PF

Tib Ant (eccentric)

Absorb impact

2nd Rocker = Ankle

Ex moment = DF

Soleus

Eccentric

Ankle trunk forward

3rd Rocker = Toes

Ex moment = DF

GCN

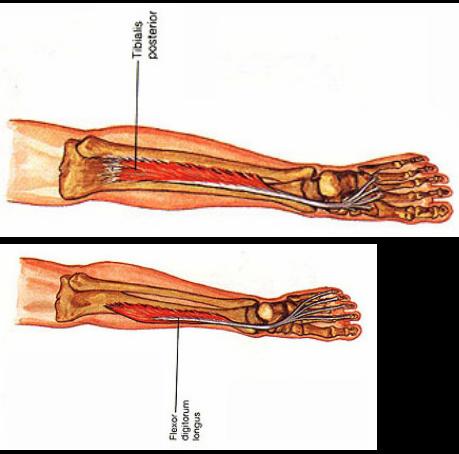
Concentric

Propulsion

Deep Posterior Compartment

- Tibialis posterior

- Extensive insertion
- Invert foot
- Stabilize the foot in WB (Balance with the lateral compartment)

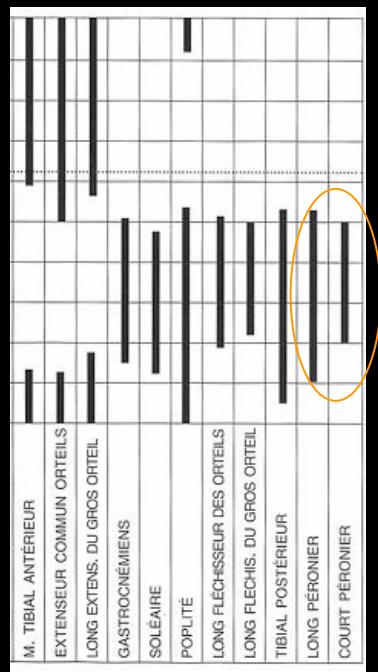
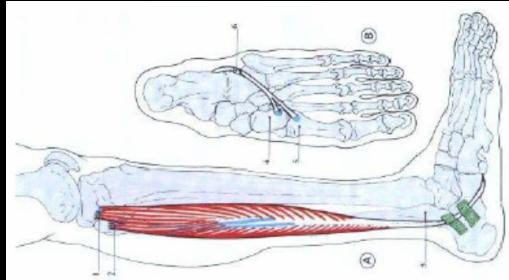


- Flexor hallucis longus
- Flexor digitorum longus

Ankle Plantar Flexion

Lateral Compartment

- **Peroneus longus**
 - Longer activity than PB
 - Support longitudinal arch
 - Plantar flex 1st ray (pronation)



Gage's prerequisites for normal gait

1. Prepositioning of the foot
2. Clearance of the foot swing
3. Stability in stance
4. Adequate step length
5. Energy conservation

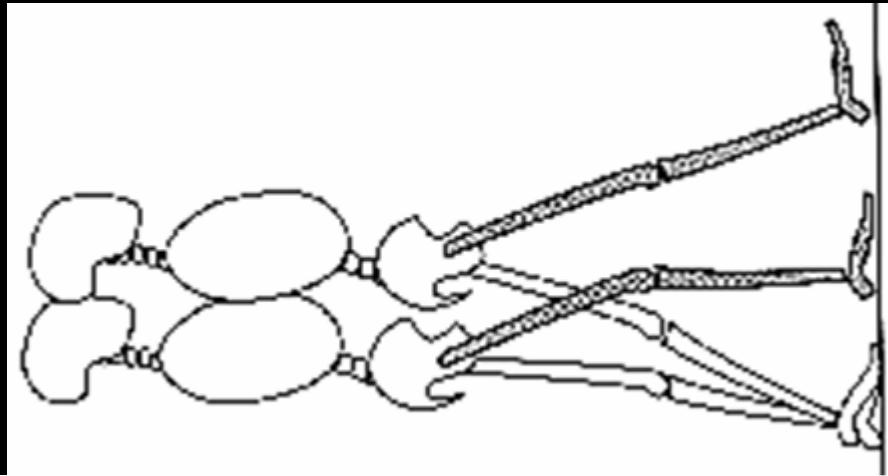
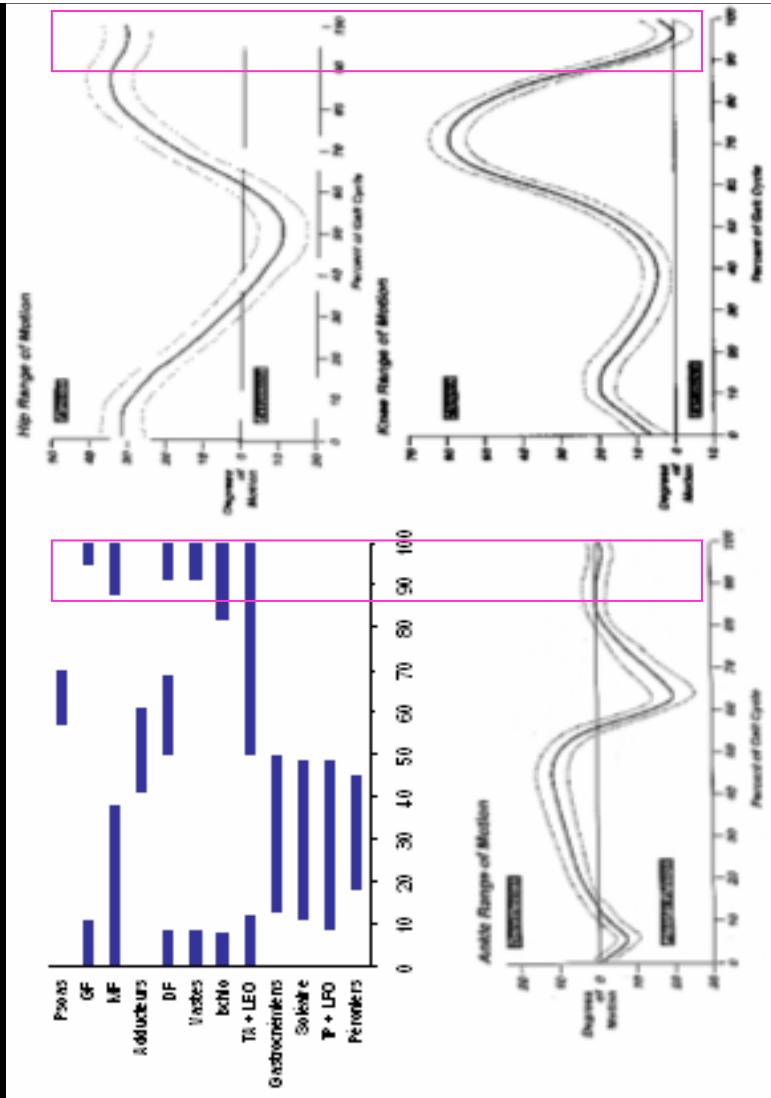
End of swing phase

Preparation for initial contact

Slow down (eccentric) the pendulum (GMx + Hamstrings)

Prepare to absorb shock

Tib Ant present the heel in neutral position

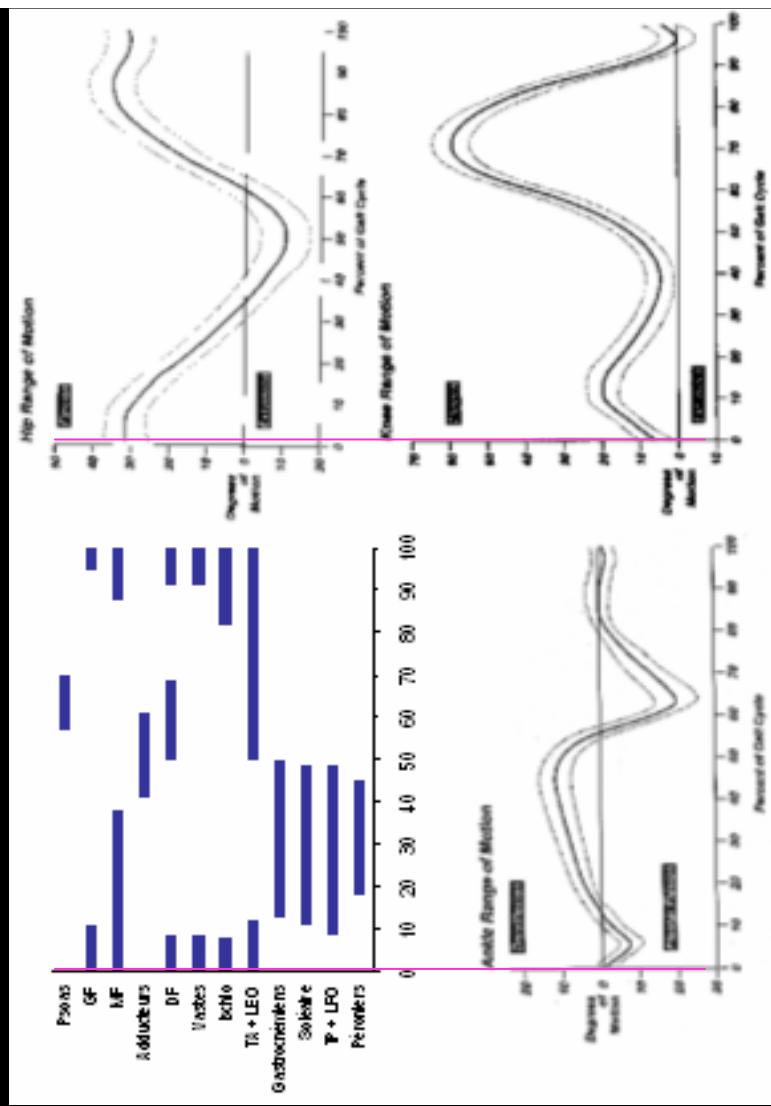
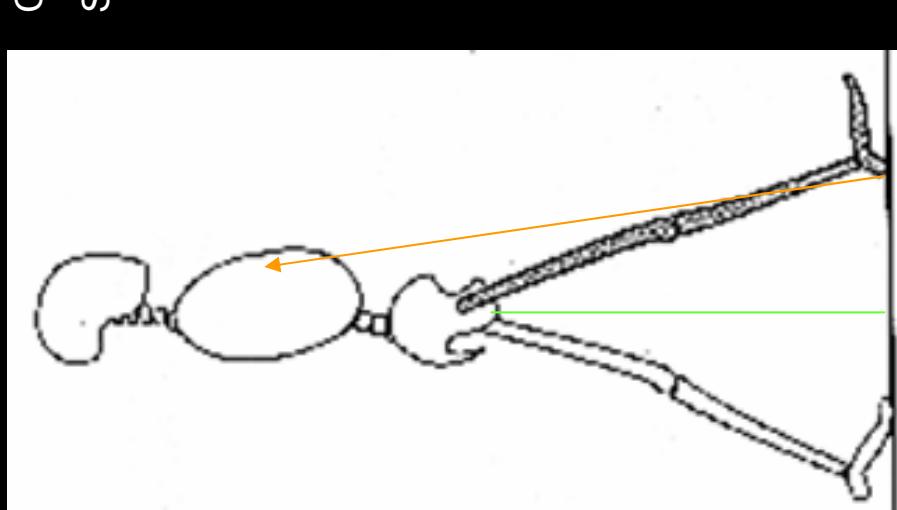


Initial contact

Reaction to GRF

Continue the previous phase

Slow down the momentum of the whole body: GMx, Hamstrings, Tib Ant



Loading Response

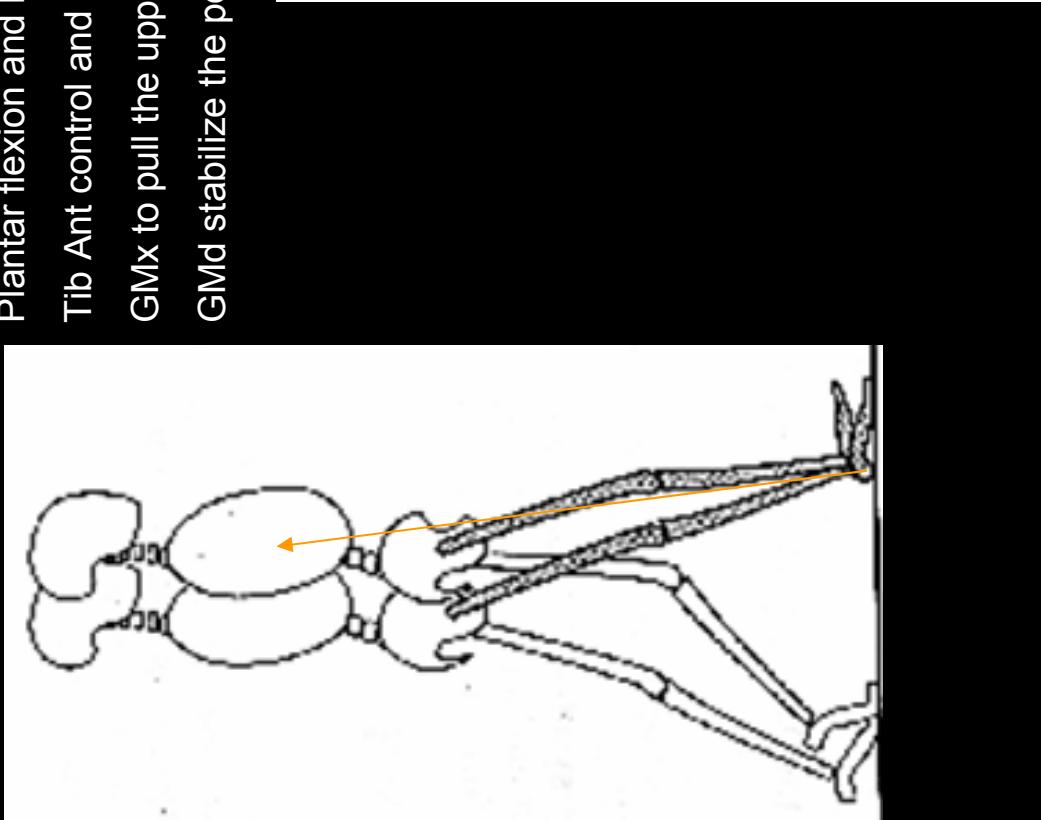
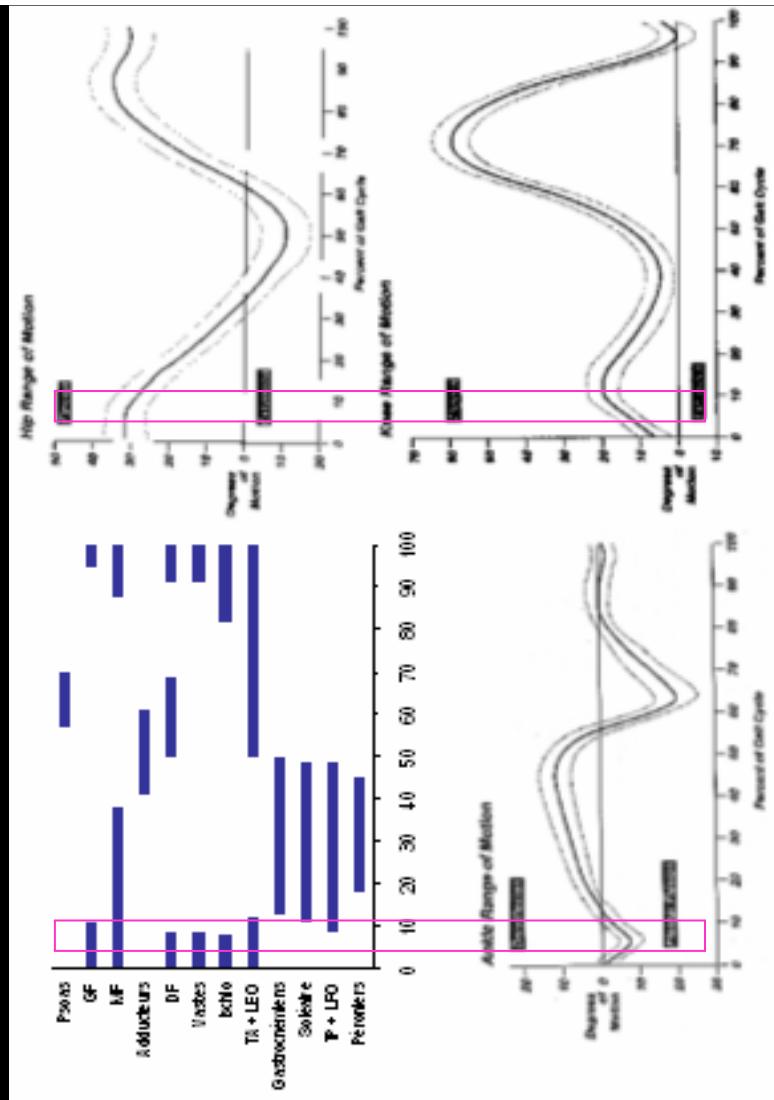
Impact phase

Plantar flexion and knee flexion

Tib Ant control and knee extensors control (eccentric)

GMx to pull the upper body forward (concentric)

GMd stabilize the pelvis



Mid Stance

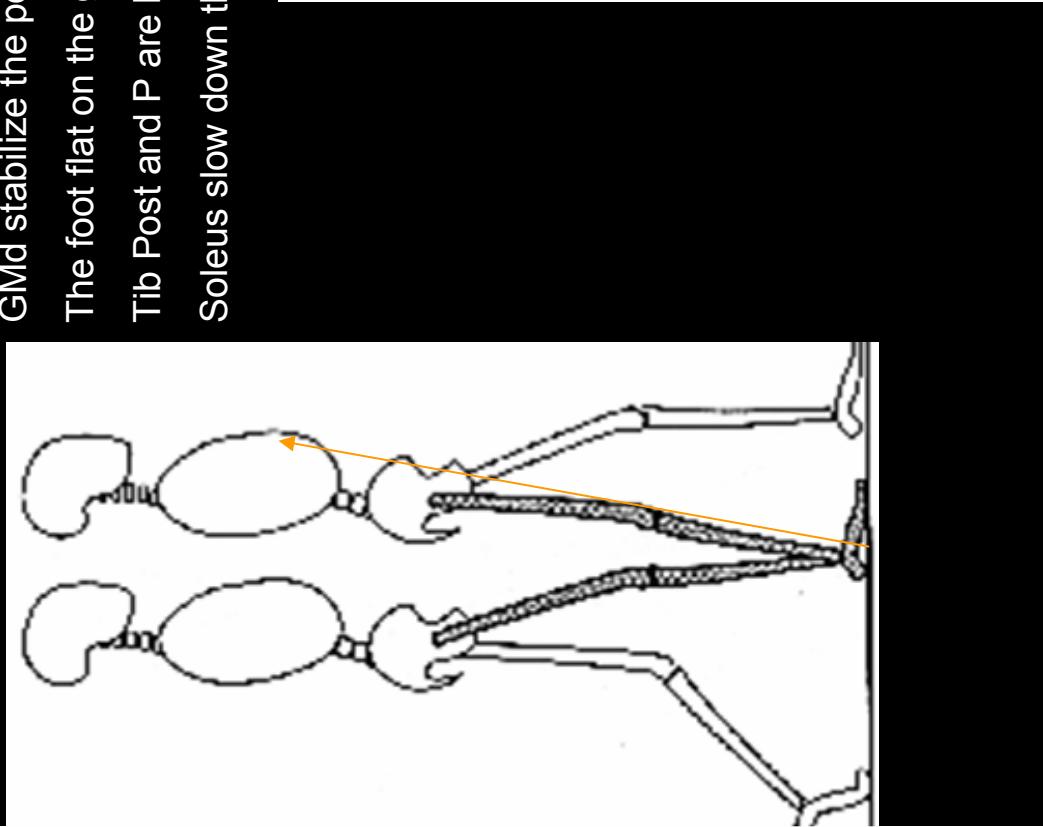
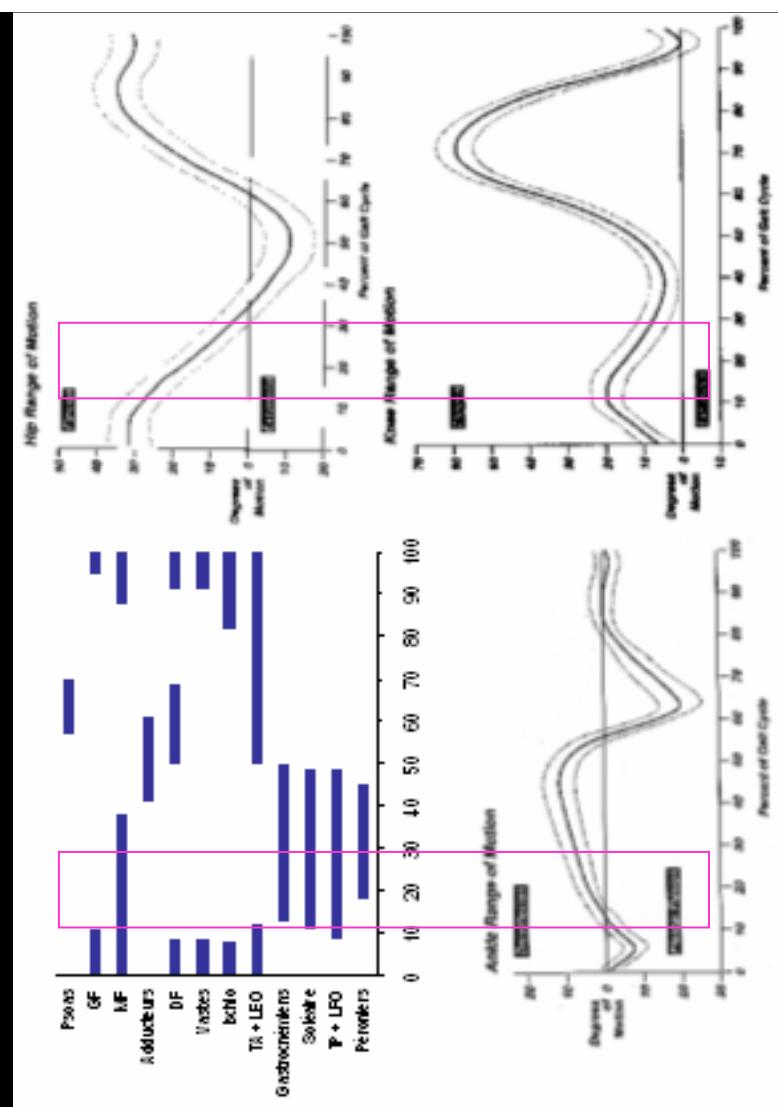
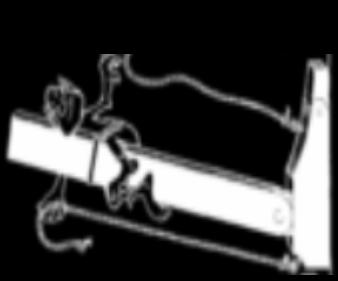
Stability phase

GMD stabilize the pelvis

The foot flat on the ground don't need the action of the Tib Ant

Tib Post and P are balanced

Soleus slow down the dorsal flexion (eccentric)



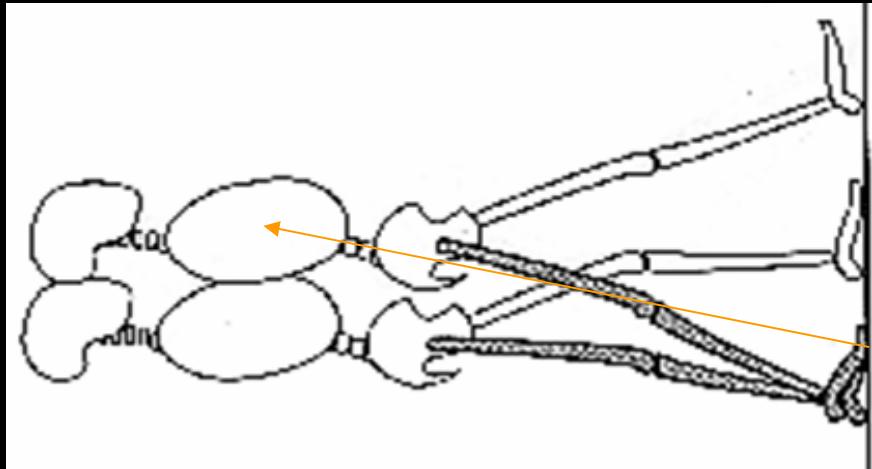
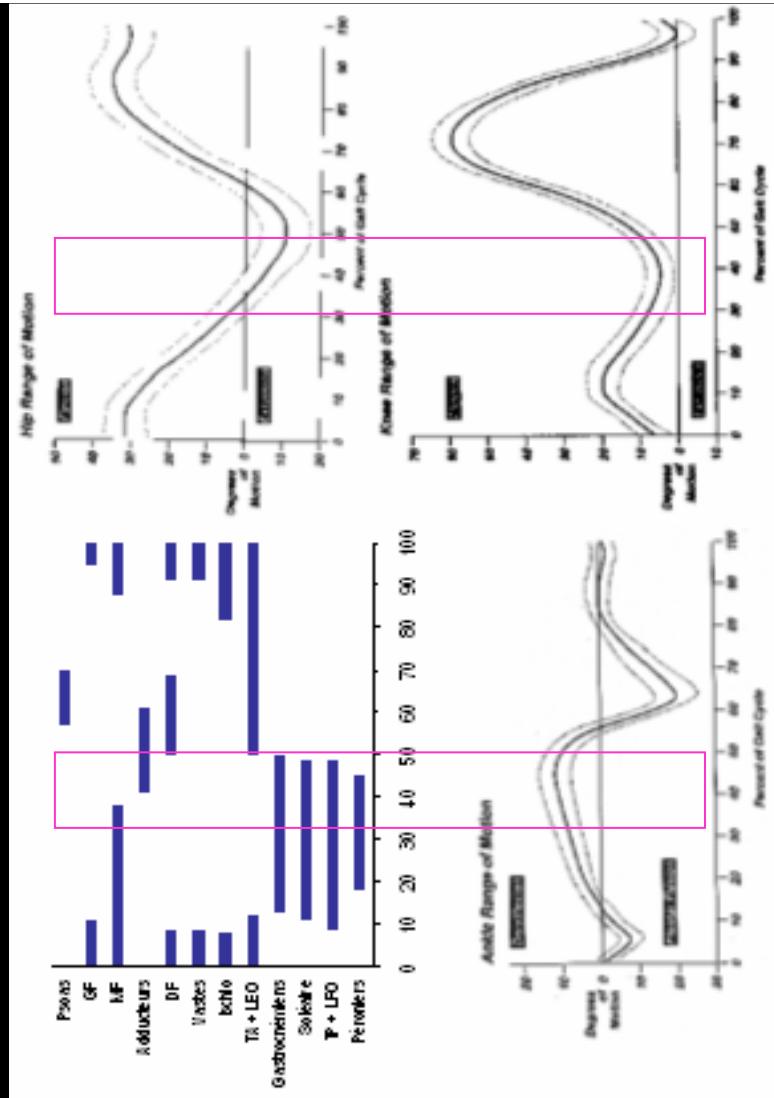
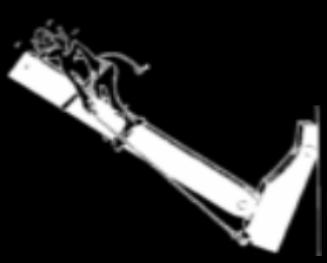
Terminal Stance

Prepare for load transfer

Centre of gravity in front of the ground contact

Knee locked in extension

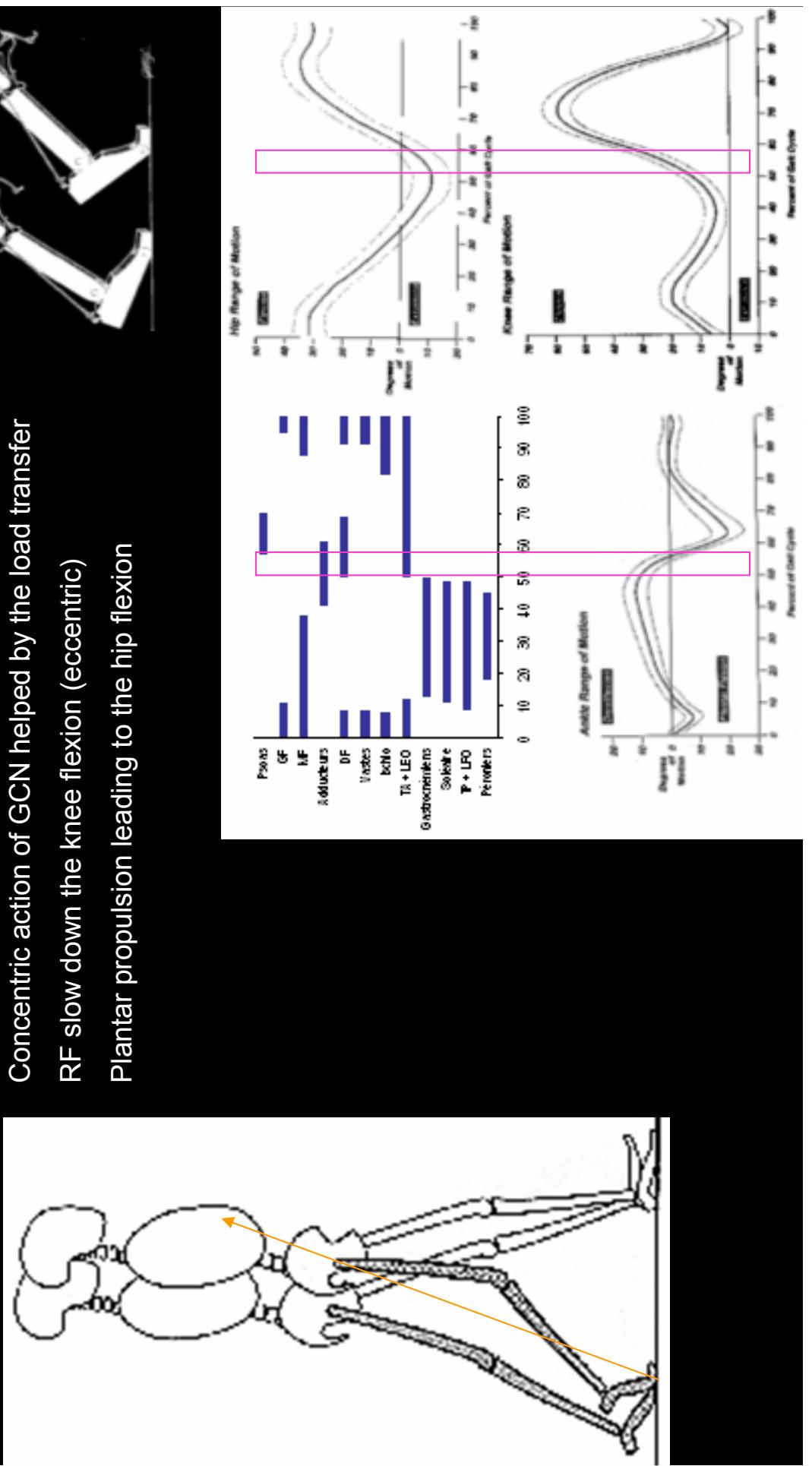
Soleus slow down tibial advancement (eccentric)



Pre Swing

Load Transfer

Concentric action of GCN helped by the load transfer
RF slow down the knee flexion (eccentric)
Plantar propulsion leading to the hip flexion



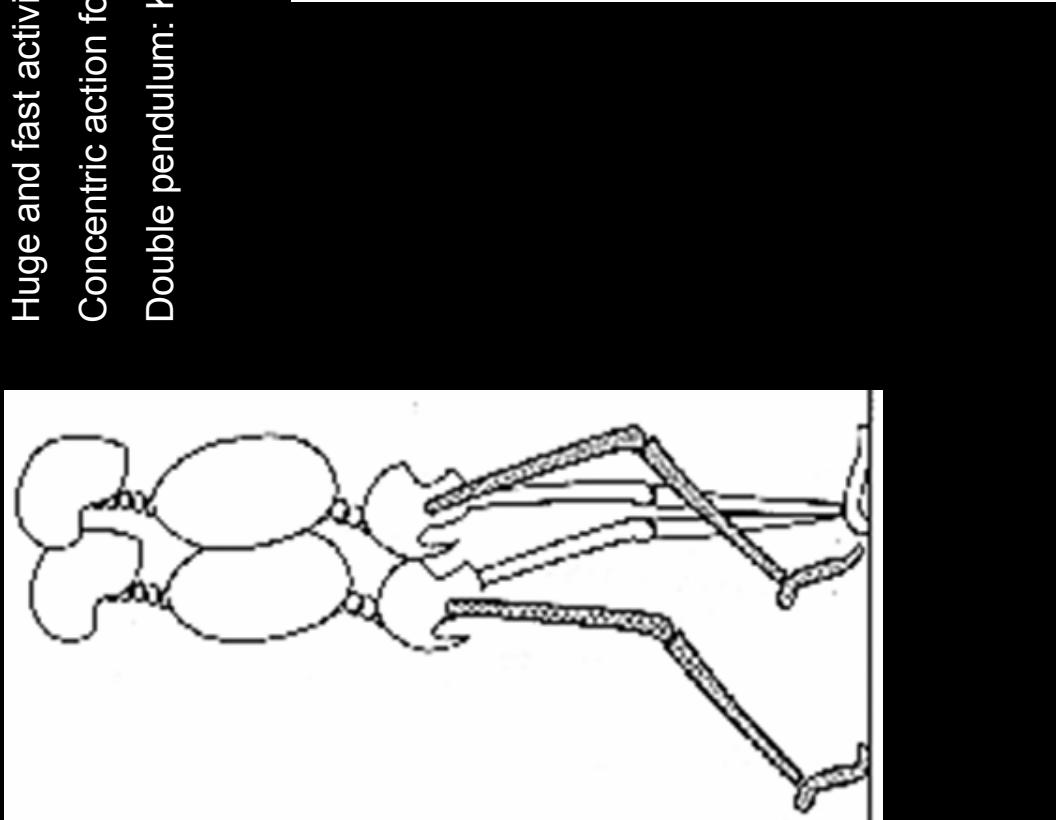
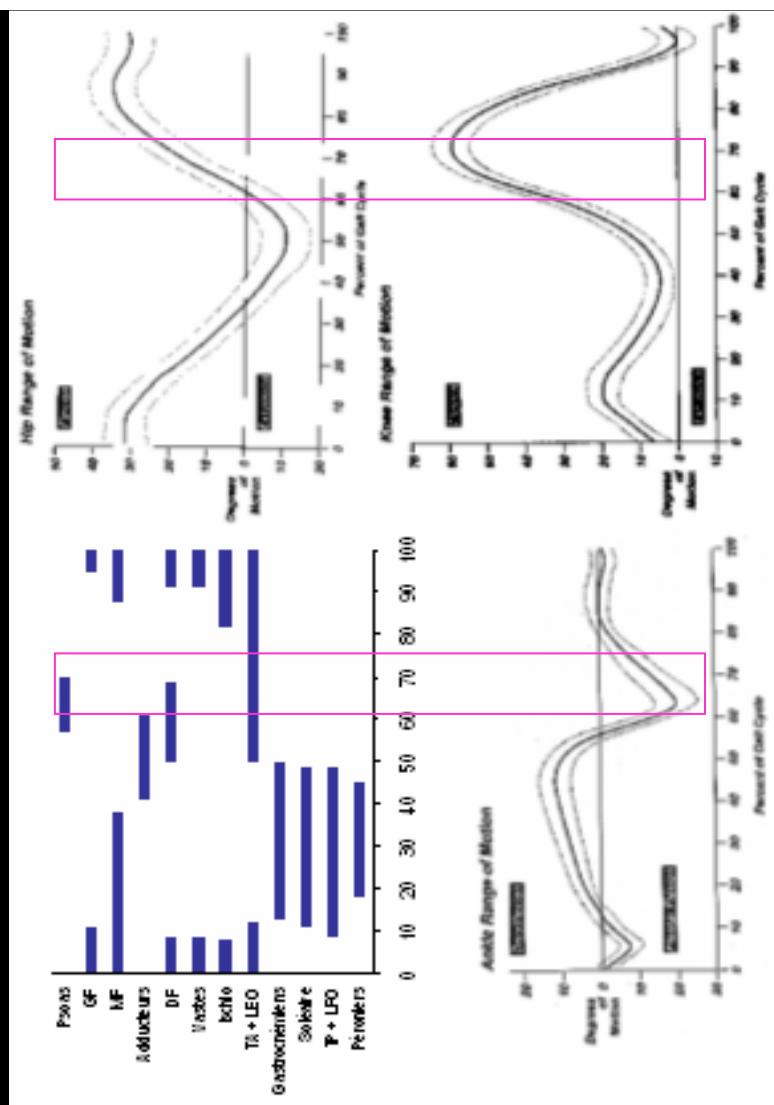
Initial Swing

Clearance

Huge and fast activity of the hip flexors (Psoas)

Concentric action for Tib Ant

Double pendulum: Knee flexion

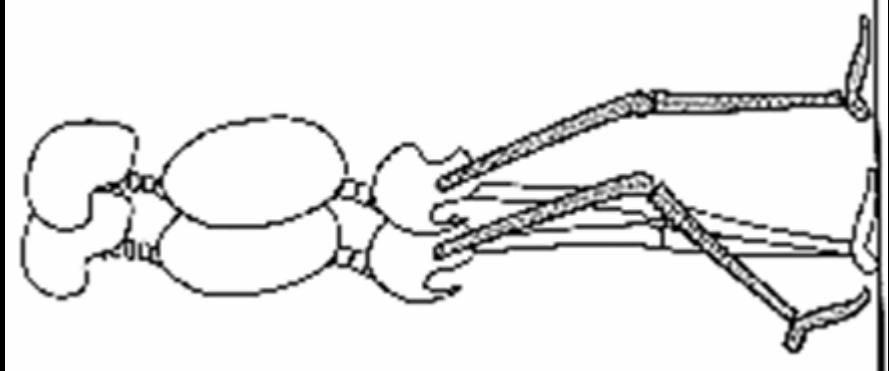
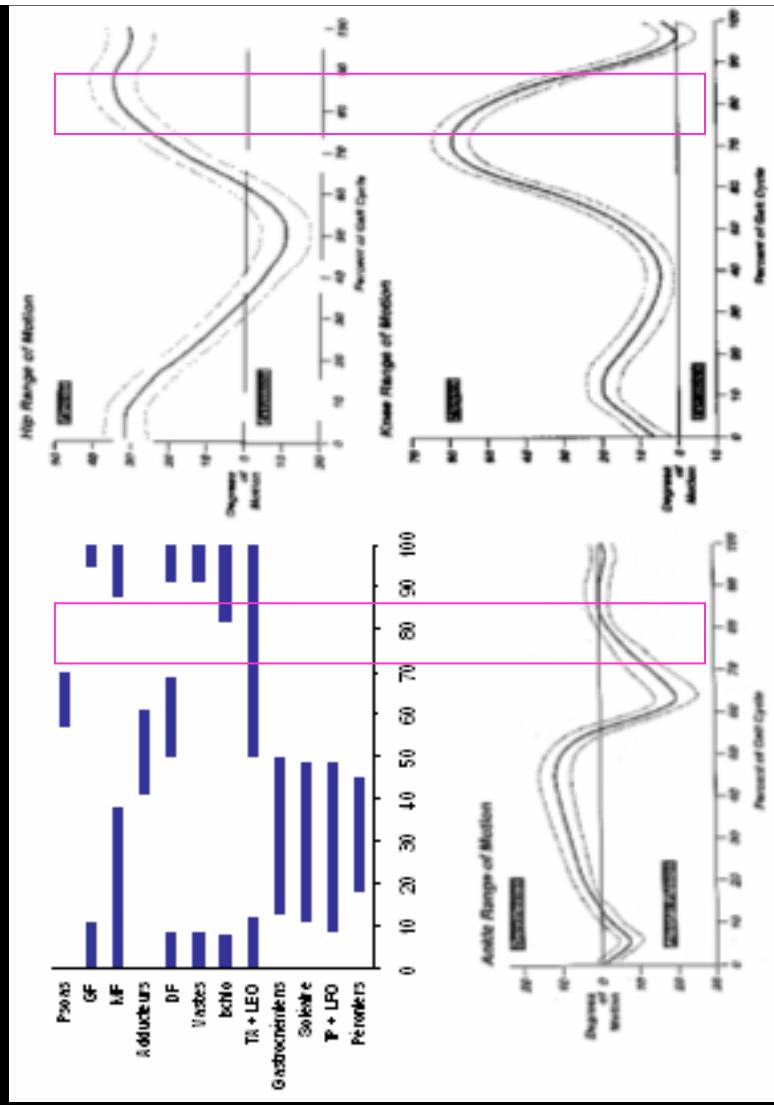


Mid Swing

Double pendulum

Passive phase

Only Tib Ant is active



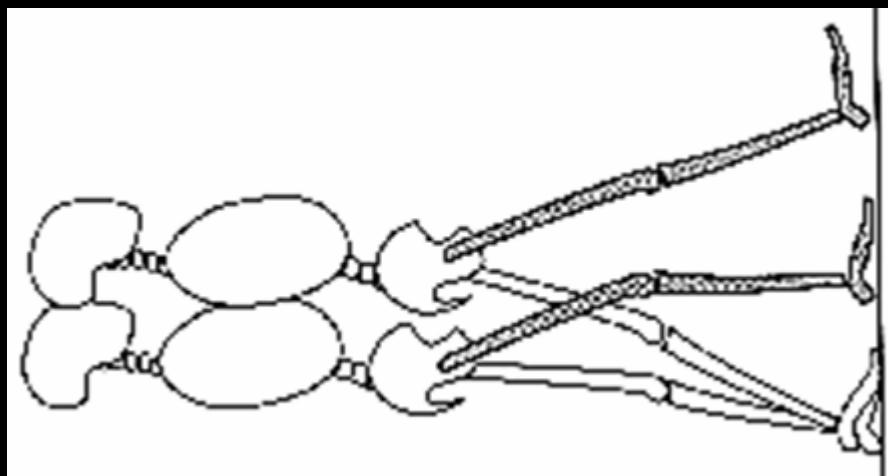
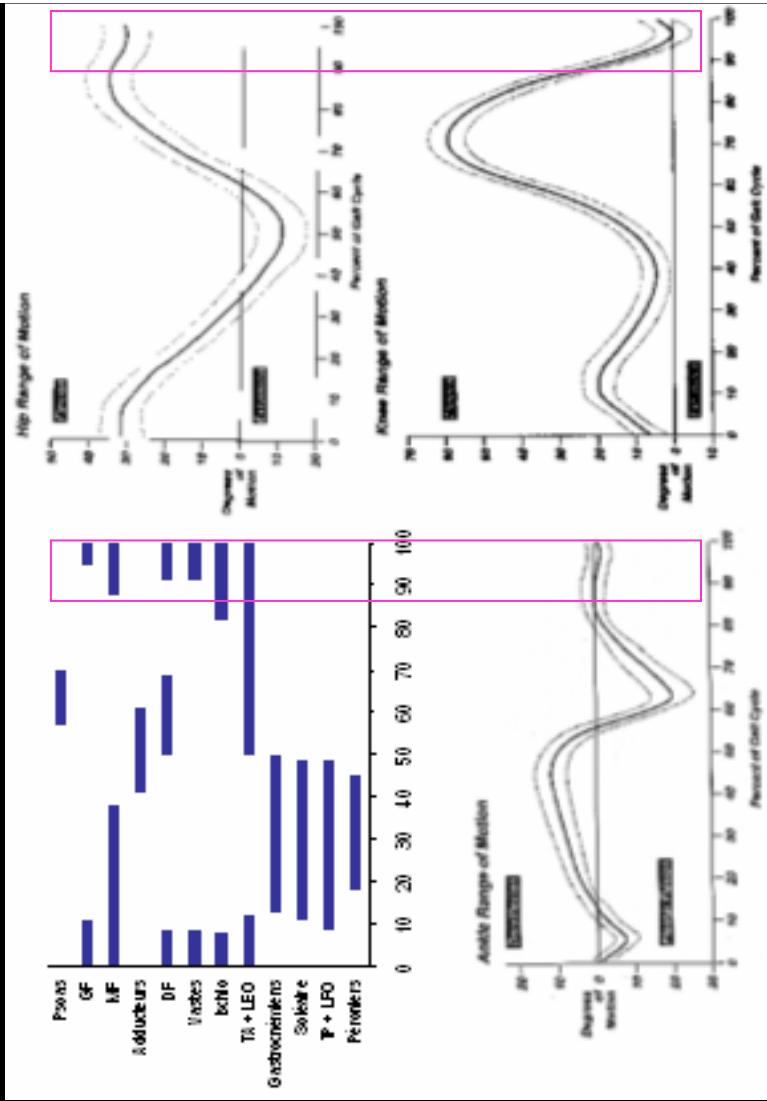
Terminal Swing

Preparation for initial contact

Slow down (eccentric) the double pendulum (GMx + Hamstrings)

Prepare to absorb impact

Tib Ant present the heel in neutral position



Keys for FRCS examination

- Gage's prerequisites ?
- How a gait analysis work ?
- Description of the gait cycle ?
- Description of the 3 rockers ?