Normal Gait

Chapter 10
Transtibial Prosthetics
P&O UMTY 2018

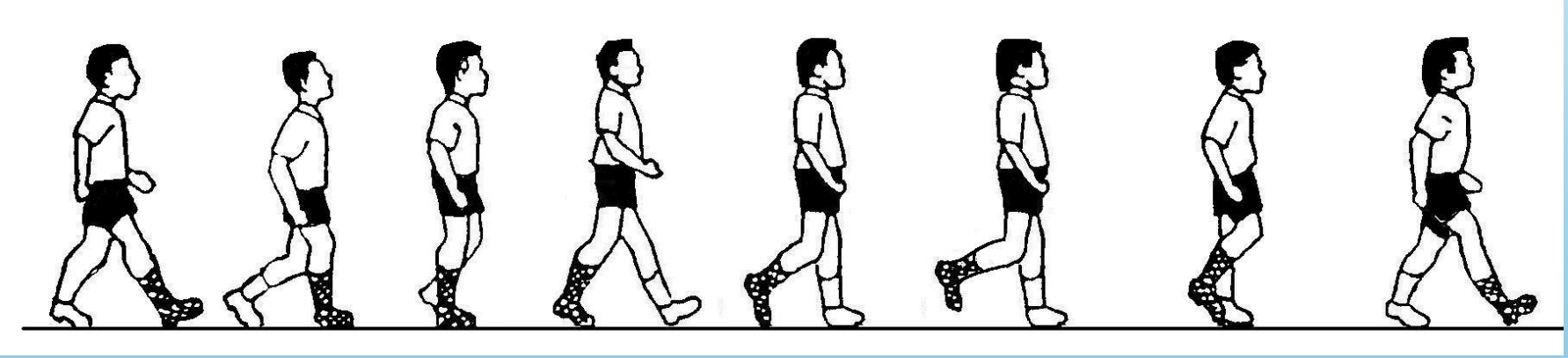
Prepared by Markku

Introduction

- Normal Gait is the way that normal people walk even though everyone walk slightly differently
- As a PO, we need to understand what is normal before we can observe the abnormal gait
- One complete gait cycle is from heel strike to heel strike once more on the same leg.
- Understanding well about the normal gait enables us to set up the best alignment in the prosthesis.

Gait Cycle

- One complete gait cycle starts from heel strike to heel strike at the same leg.



Gait Cycle

During walking, gait can be divided into two main phases

- Stance Phase: is the time when the foot is touching the ground (60%)
- Swing Phase: is the time when the foot is not touching the ground (40%)

- Double support: is the time when both feet are touching the ground (20%)

The gait cycle

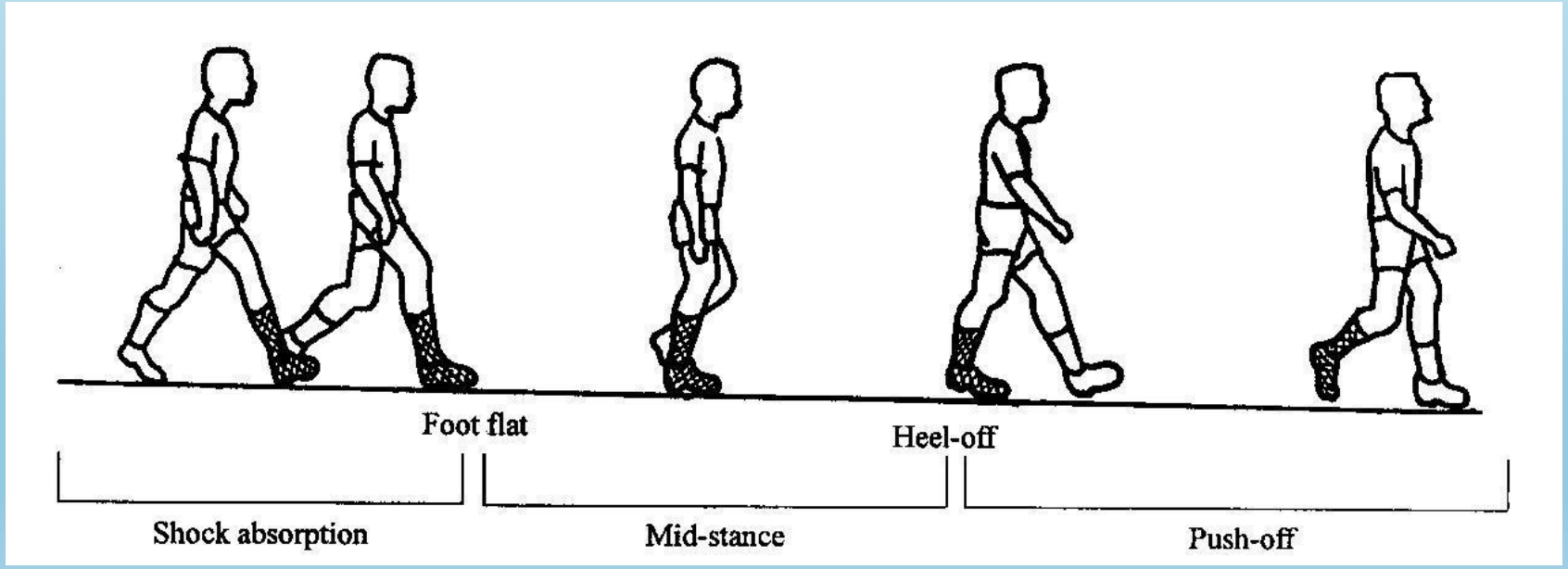
One gait cycle can be divided into several phases.

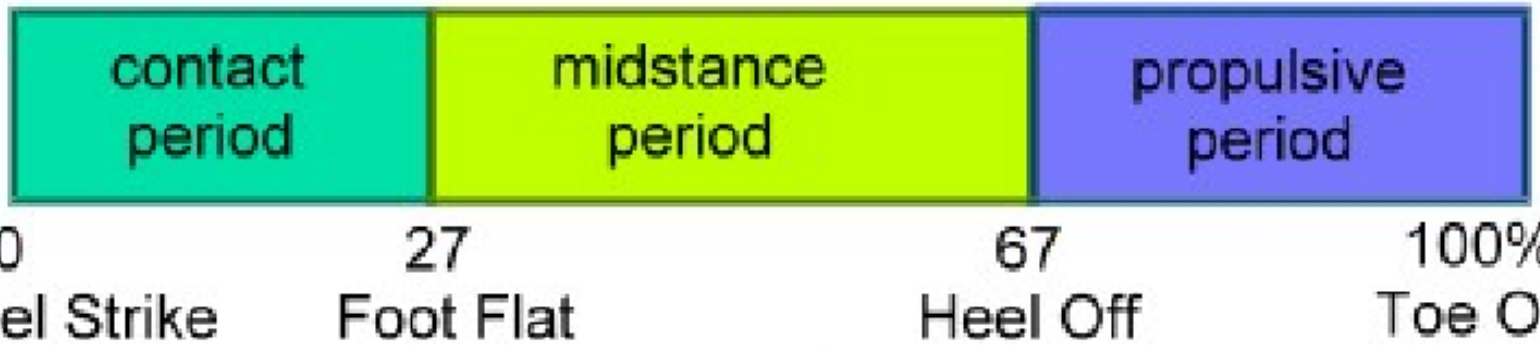
- Stance phase – when the foot is touching the ground.
  - Shock absorption
  - Mid-stance
  - Push off
- Swing phase – when the foot is not touching the ground.
  - Acceleration
  - Mid-swing
  - Deceleration

Stance Phase

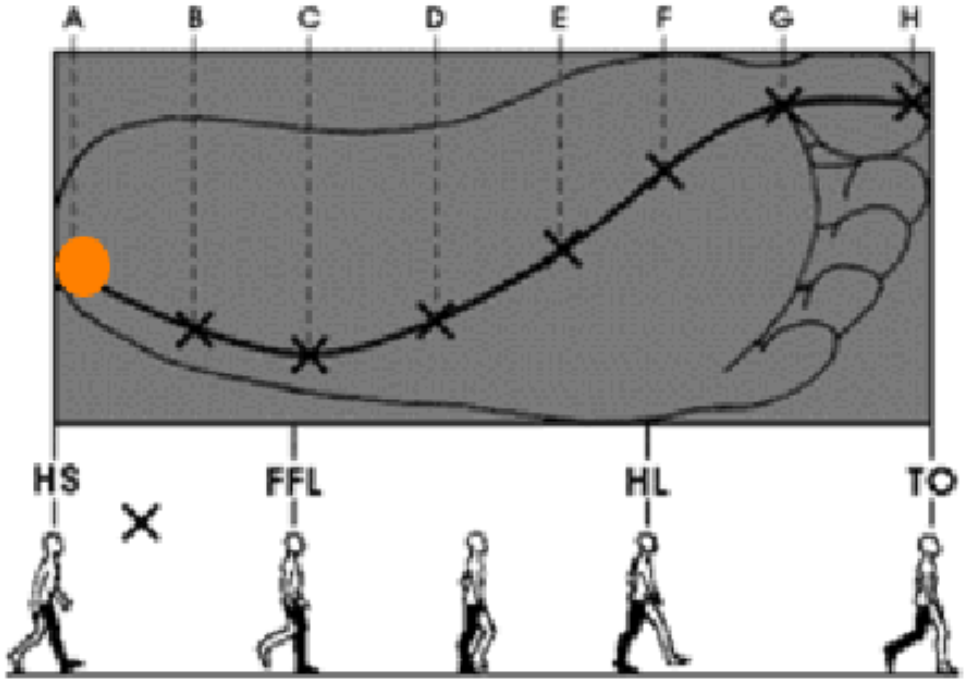
Stance phase can be divided into three stages

- Shock absorption
- Mid-stance
- Push-off

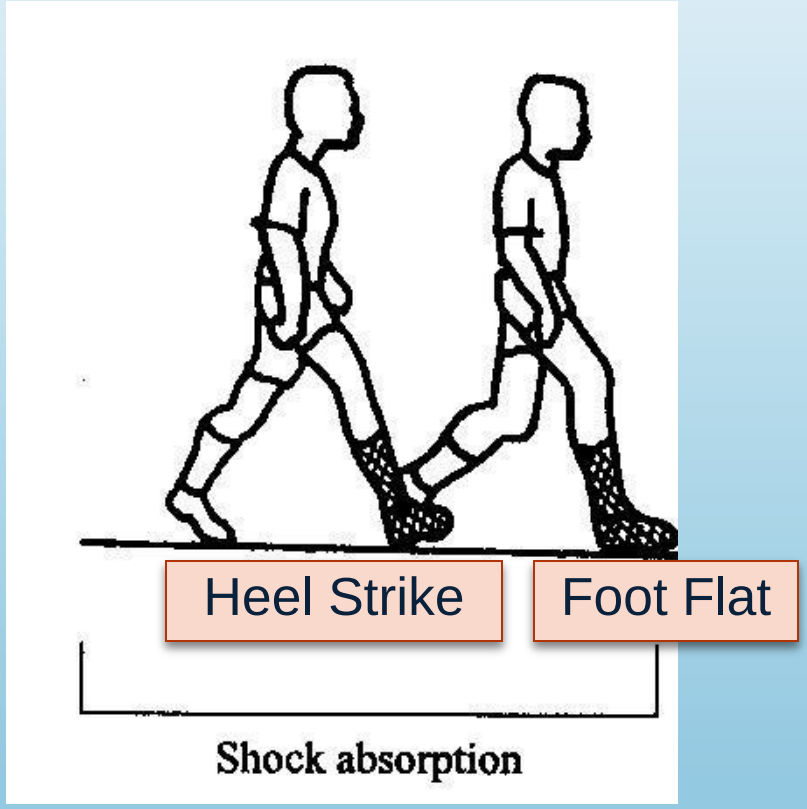




Periods During A Stance Phase



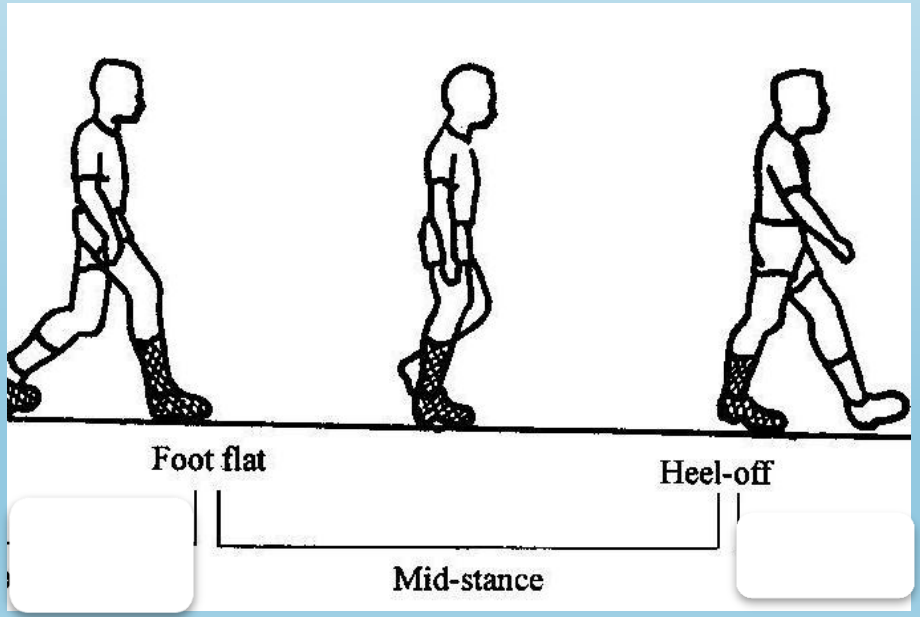
Stance phase – shock absorption



- This protects the body from impact.
  - Think about What structures contributing to this protection?

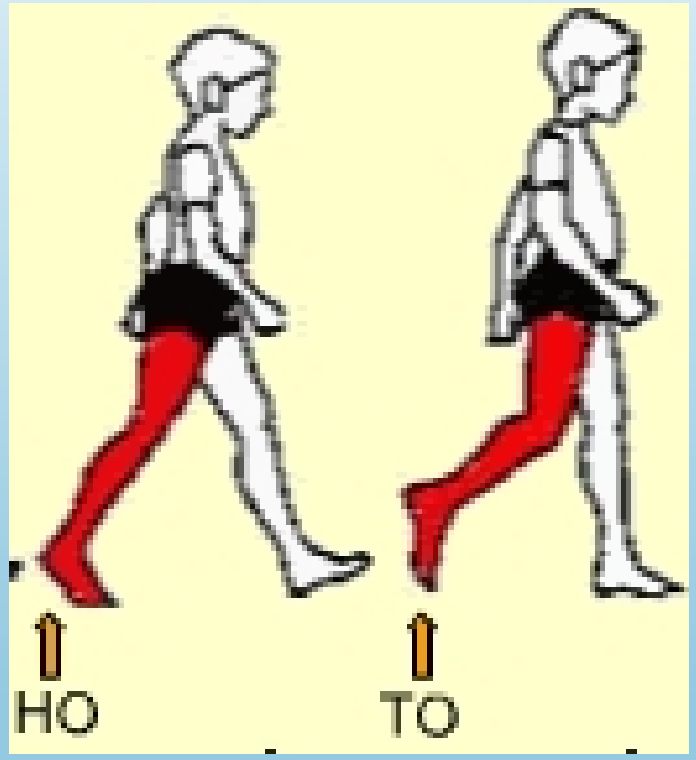
Stance Phase – Mid-stance

- From Foot flat to heel off
  - The entire body weight is on one leg



Stance Phase – Push-off

- From Heel-off to toe-off
  - Pushing the body forward



Push-off

Swing phase - Definitions

- ***Acceleration*** occurs as the toe leaves the floor and the leg picks up speed as it begin to pass the body.
- ***Mid-swing*** occurs as the heels pass each other
- ***Deceleration*** occurs after mid-swing, when the leg slows down to a stop just before heel strike.

Swing Phase

Acceleration

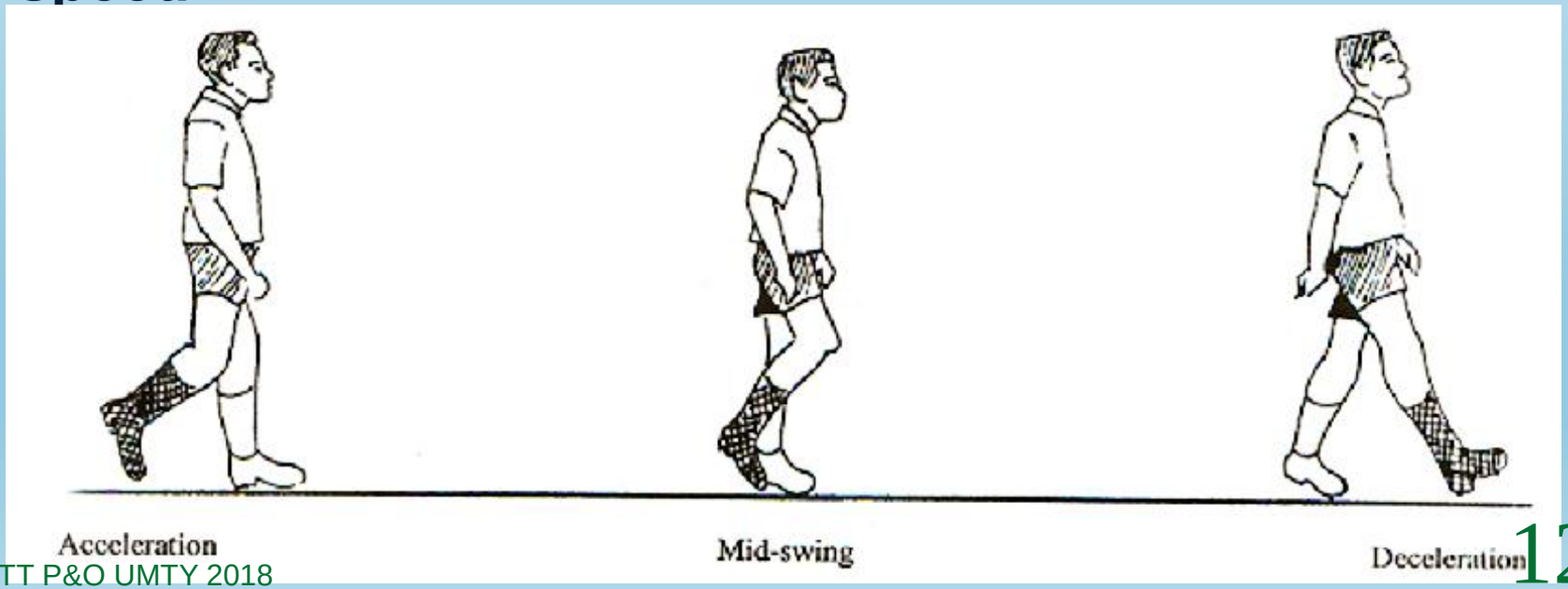
Toe leaves the floor and pick up speed

Mid-swing

Heels pass each other

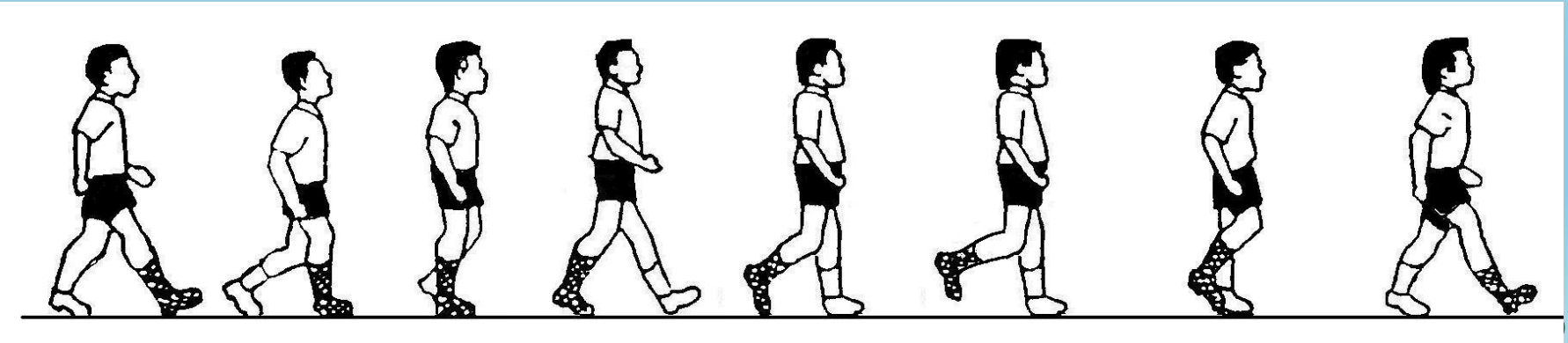
Deceleration

as the foot slows down before heel strike



Specific time points

- Time points help us to analyze the gait
  - Heel Strike
  - Foot flat
  - Mid-stance
  - Heel-off
  - Toe-off
  - Mid-swing



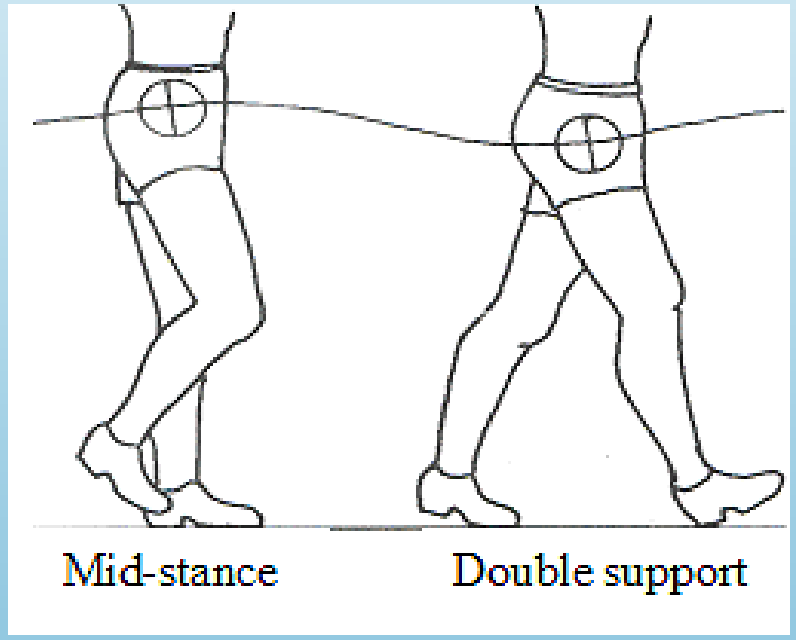
Characteristics of the gait

- Vertical displacement
- Lateral displacement
- Pelvic dip
- Pelvic rotation
- Walking base
- Double support
- Timing
- Cadence

Characteristics of Gait

Vertical Displacement

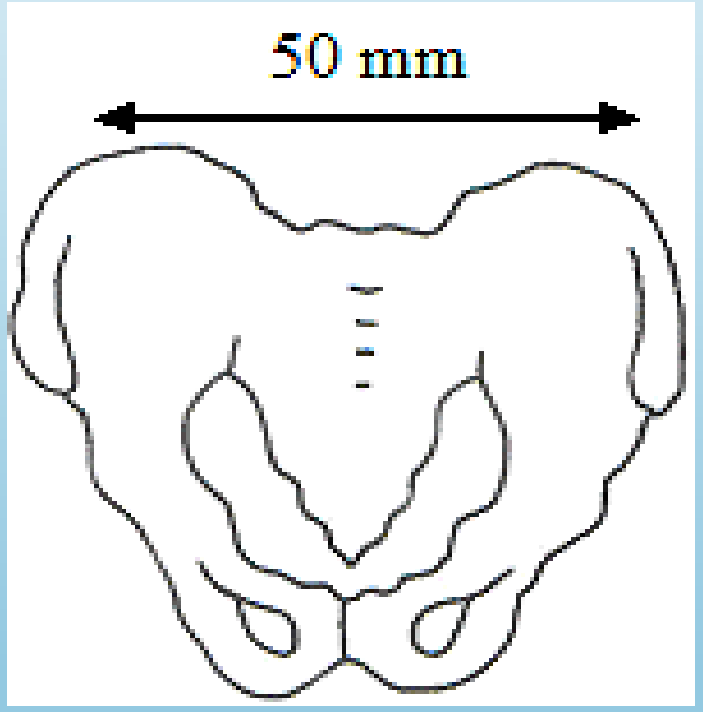
- The centre of gravity (CG) rises at mid-stance and falls at double support
- The range of vertical displacement is less than 50mm.



Characteristics of Gait

Lateral Displacement

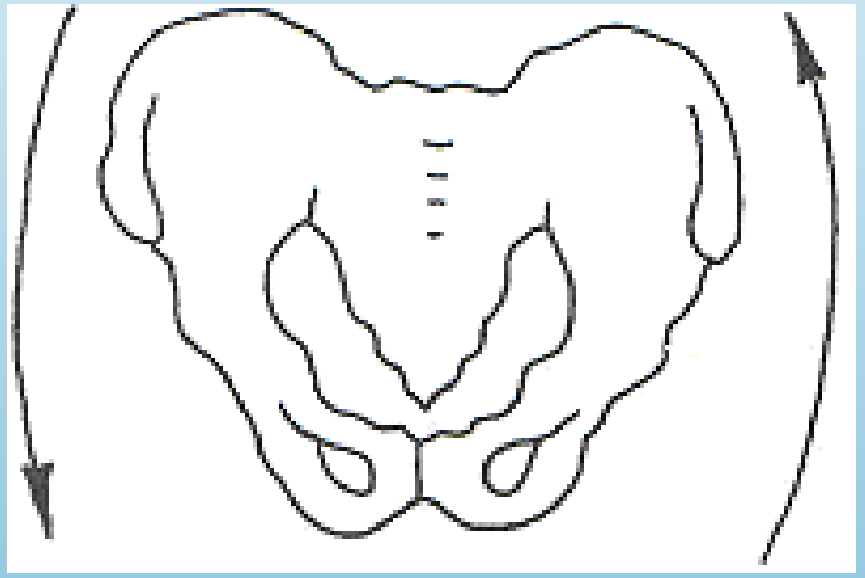
- The body sways to the leg that is on the ground
- The range of movement is less than 50mm



Characteristics of Gait

Pelvis Dip

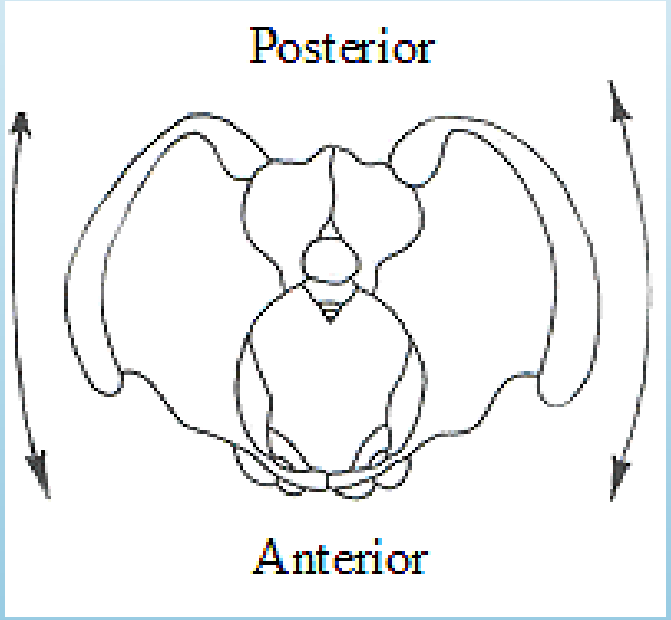
- The pelvis drops towards the swing side
- The range of drop is about 5^0



Characteristics of Gait

Pelvis rotation

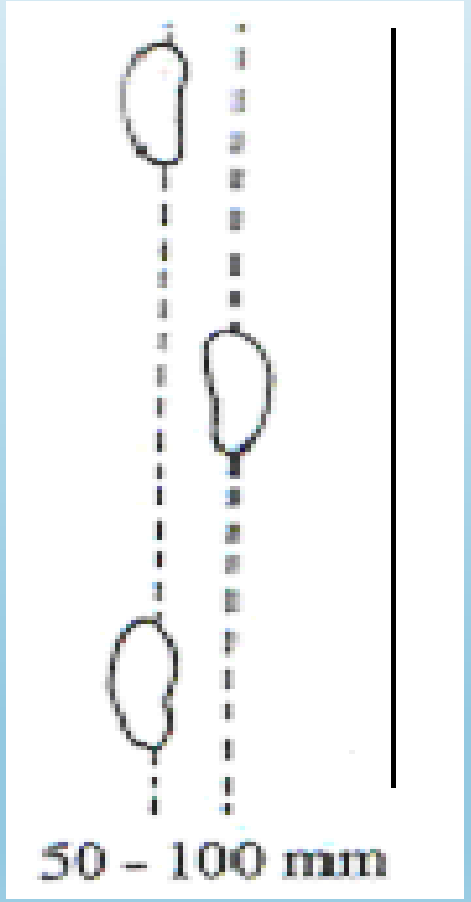
- Pelvis swings A-P direction
- The pelvis swings anteriorly with the swing leg
- The range of movement is about 4^0



Characteristics of Gait

Walking base:

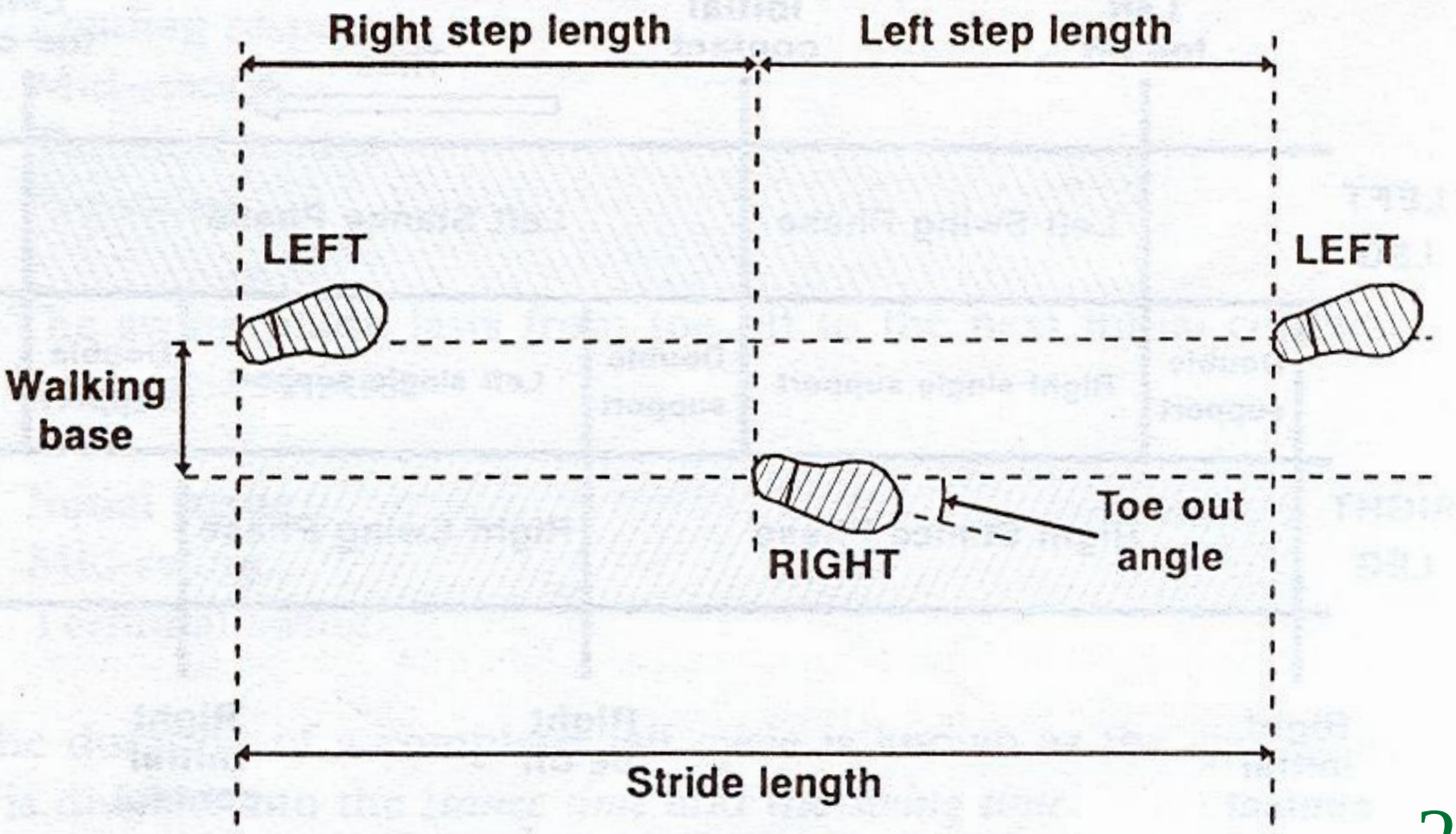
- is the distance between mid-point of the heels
- The usual distance is 50-100mm



Characteristics of Gait

- Walking is a cyclic moving that involves placement of one foot in front of other. It has periods of single support and double support.
- Running has only periods of single support and flight (non-contact period)
- Step
- Stride
- Cadence: an number of steps per minute during walking

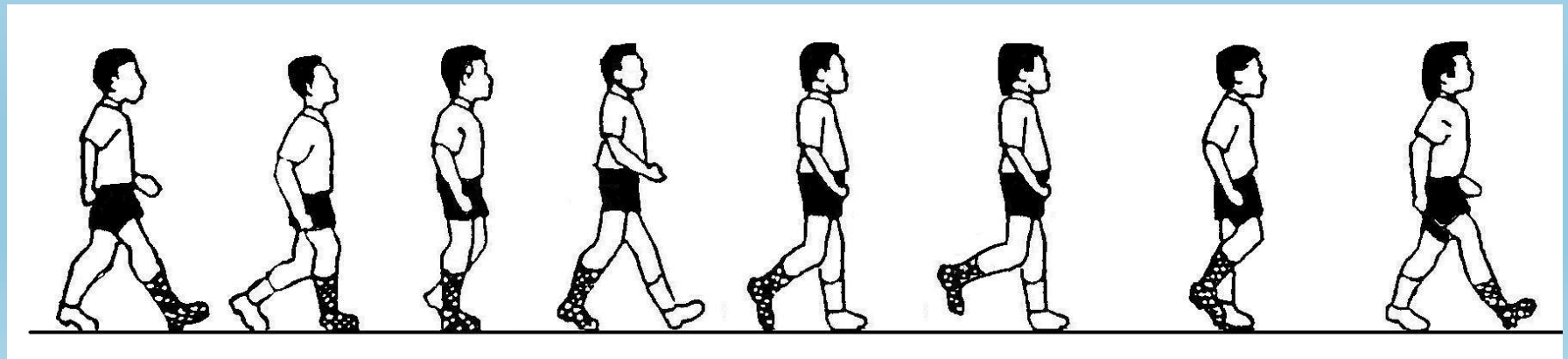
Step and Stride



Characteristics of Gait

Double support (20%)

- Both feet are on the ground
- One foot from heel strike to foot flat and other foot from heel-off to toe off
- Double support only occurs in walking
- Running is defined as no double support

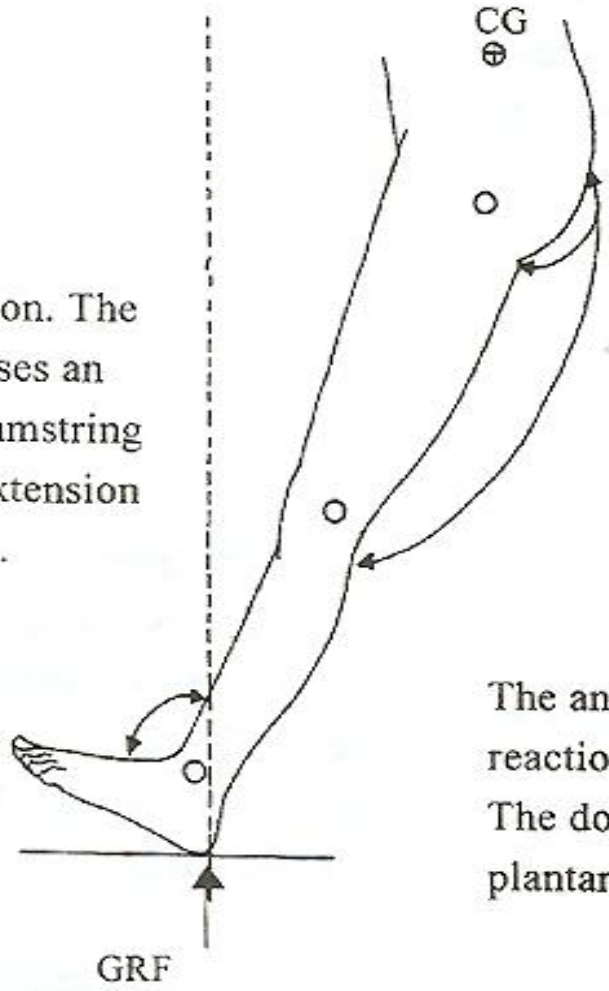


Analysis of normal walking motion next

- Time points of gait
- CG (Centre of Gravity)
- GRF (Ground Reaction Force)
- Moment in each joint
- Muscle contraction

Heel strike

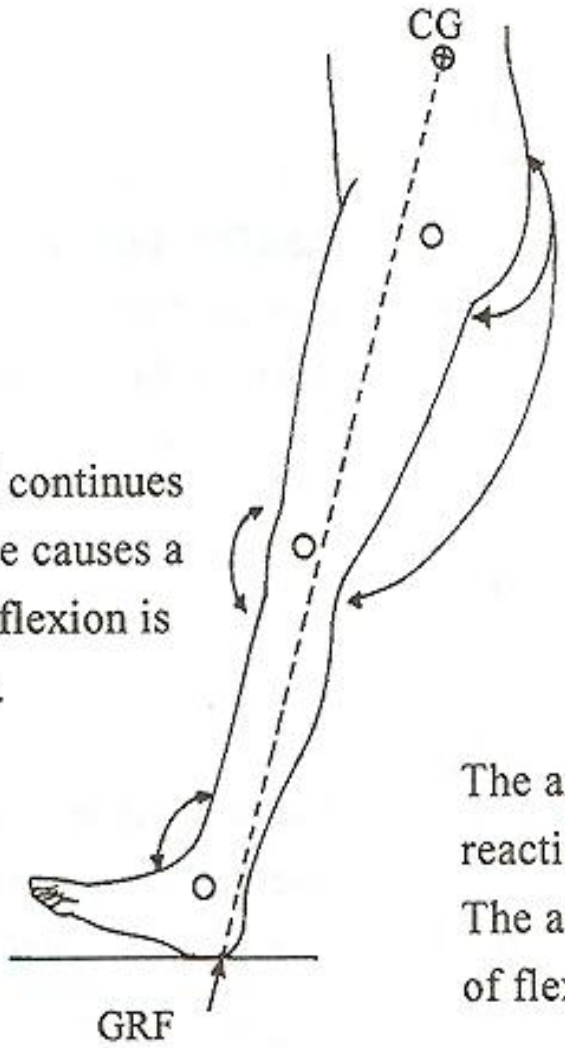
The knee is in full extension. The ground reaction force causes an extension moment. The hamstring muscles prevent further extension and begin to flex the knee.



The hip is in 25° flexion. The ground reaction force causes a flexion moment. The gluteus maximus and hamstrings prevent further flexion.

The ankle is in neutral position. The ground reaction force causes plantarflexion moment. The dorsiflexors control the speed/rate of plantarflexion.

Shortly after Heel strike



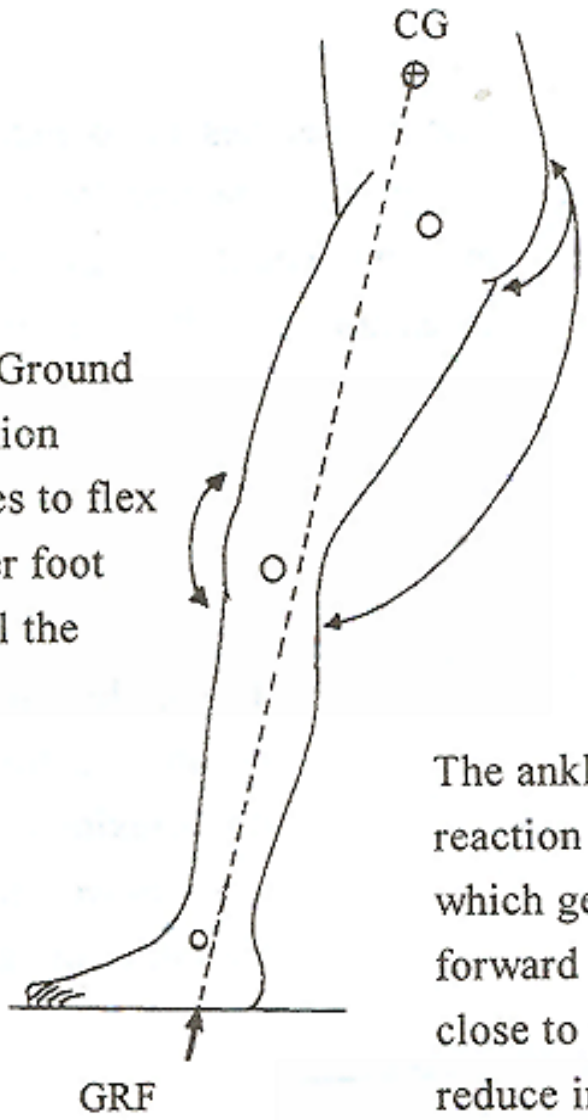
The hip is in 25⁰ flexion. Ground reaction force causes a flexion moment. The gluteus maximus and hamstrings hold this position.

The knee is in 5⁰ flexion and continues to flex. Ground reaction force causes a flexion moment. The rate of flexion is controlled by the quadriceps.

The ankle is in 5⁰ plantarflexion. Ground reaction force causes plantarflexion moment. The ankle continues to plantarflex. The rate of flexion is controlled by the dorsiflexors.

Fig 10.11

Foot Flat



The hip is in 25⁰ flexion. Ground reaction force causes a flexion moment. The hip begins to extend by the action of the gluteus maximus and hamstrings.

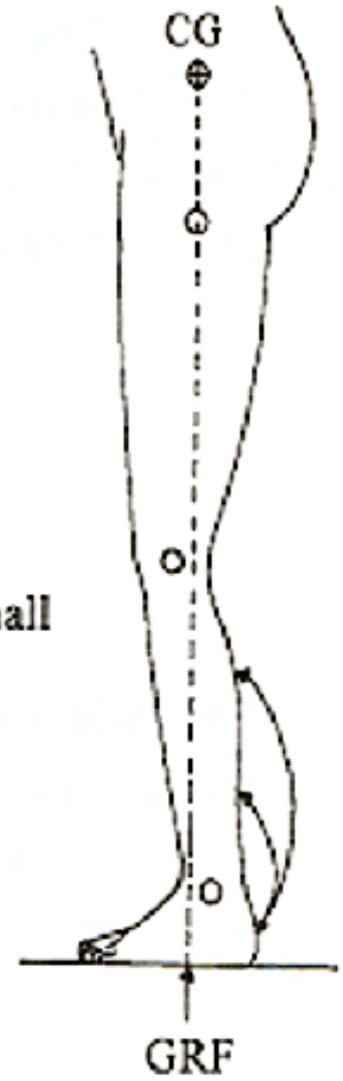
The knee is in 15⁰ flexion. Ground reaction force causes a flexion moment. The knee continues to flex until it reaches 20⁰ just after foot flat. The quadriceps control the angle of flexion.

The ankle is in 10⁰ plantarflexion. Ground reaction force causes plantarflexion moment which gets smaller as the body moves forward and the ground reaction force comes close to the ankle joint. The dorsiflexors reduce in action until there is no action.

Fig 10.12

Mid-stance

The knee is in 10⁰ flexion. The ground reaction force causes a small flexion moment. There is no quadriceps action but the soleus muscle may control knee flexion.

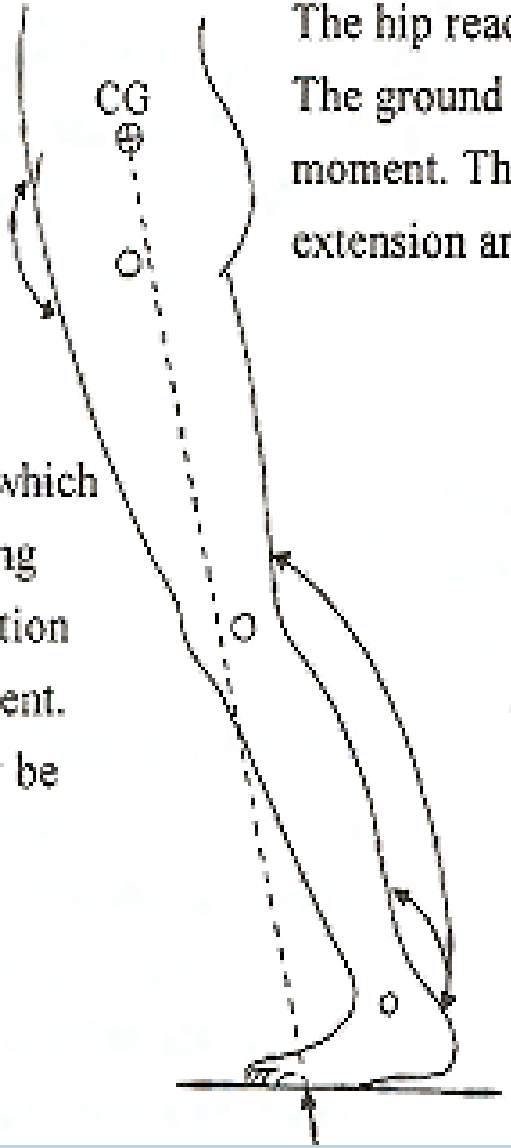


The hip is in 10⁰ flexion. The ground reaction force passes through the joint, therefore there is no moment.
The hip begins to extend as the ground reaction force moves posterior to the hip joint shortly after mid-stance.

The ankle is in 5⁰ dorsiflexion. The ground reaction force causes dorsiflexion moment. Dorsiflexion continues and is controlled by the plantarflexors.

Heel-off

The hip reaches a maximum of about 13° extension. The ground reaction force causes an extension moment. The iliacus and psoas major control extension and initial flexion.

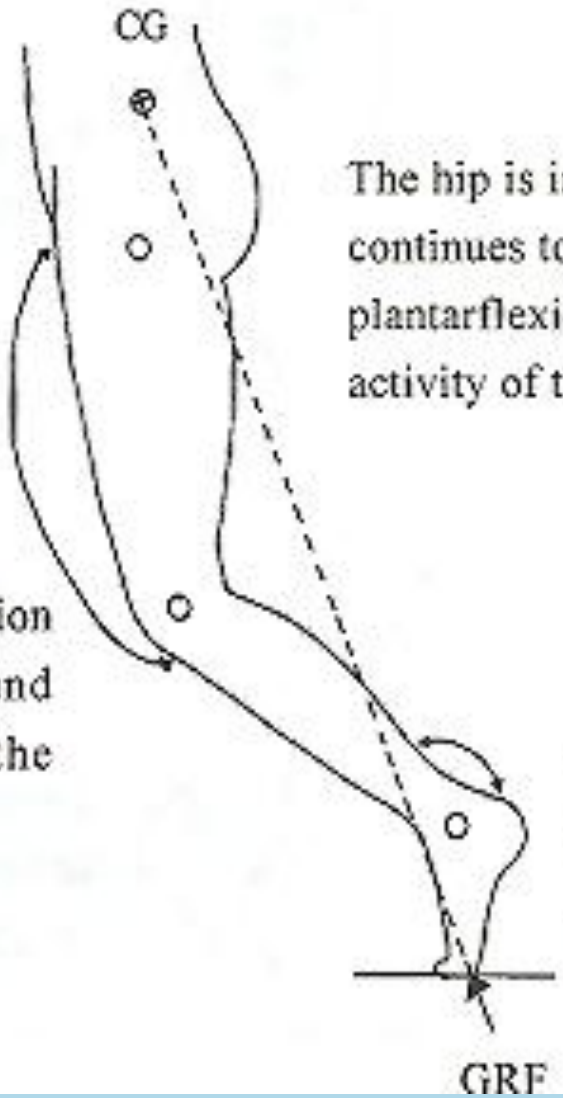


The knee is flexed to about 2^0 which is the maximum extension during the gait cycle. The ground reaction force causes an extension moment. The gastrocnemius muscle may be active in preventing further extension.

The ankle is in 15^0 of dorsiflexion. The ground reaction force causes dorsiflexion moment. The plantarflexors make powerful contractions to "push" the body forward.

Toe-off

The ground reaction force is not significant for all three joints as most of the weight is on the other leg.



The hip is in 10° of extension and continues to flex due to the plantarflexion of the foot and the activity of the rectus femoris.

The knee is in 40° of flexion. Flexion continues due to the small ground reaction force moment and the plantarflexion of the foot.

The ankle is in 20° of plantarflexion. The plantarflexor muscles stop acting as soon as the toes leave the ground.

Acceleration

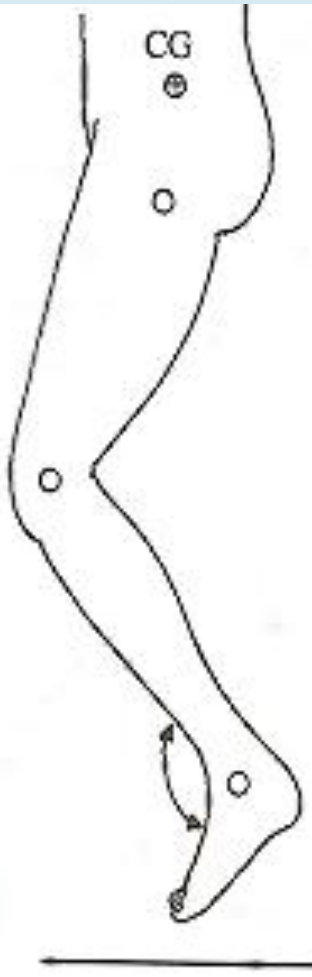


The hip is in 10° of extension and flexes as the hip flexors accelerate the limb forward.

The knee is in 40° of flexion and continues to flex under pendulum action as the limb accelerates.

The ankle is in 20° of plantarflexion directly after toe off. It then begins to dorsiflex under the action of the pretibial group of muscles.

Mid-swing

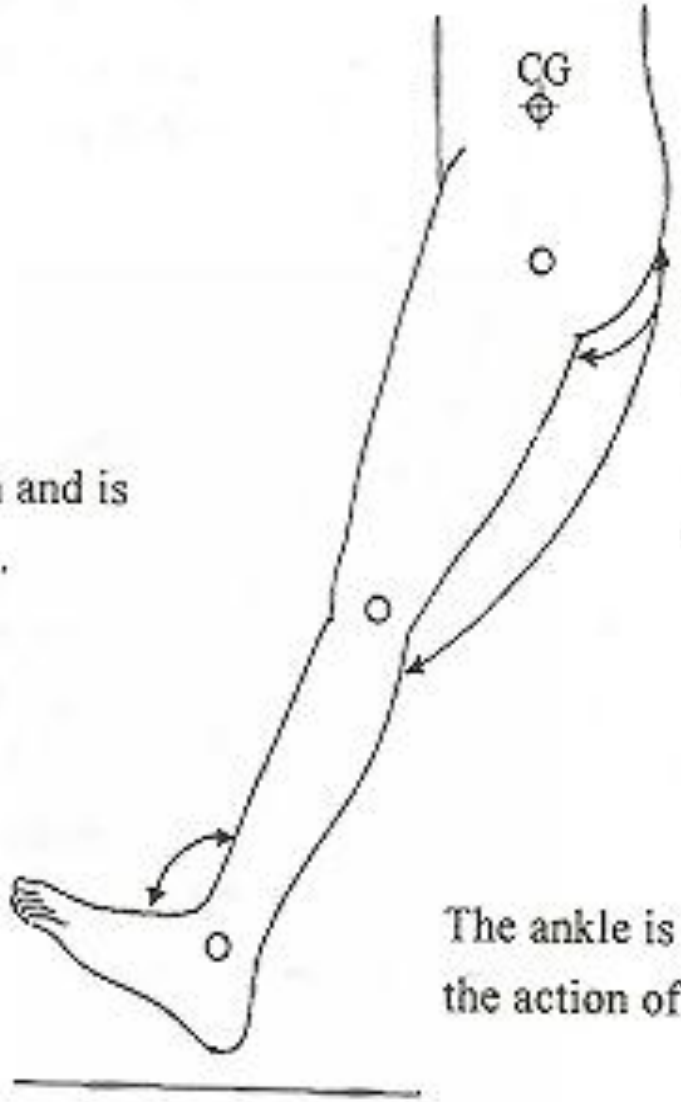


The hip is flexed to about 20° and continues to flex.

The knee reaches about 65° of flexion then begins to extend under pendulum action.

The ankle has reached its neutral position and is held there by slight activity of the pretibial muscles.

Deceleration



The hip reaches 25° of flexion and is restrained by the gluteus maximus and the hamstrings.

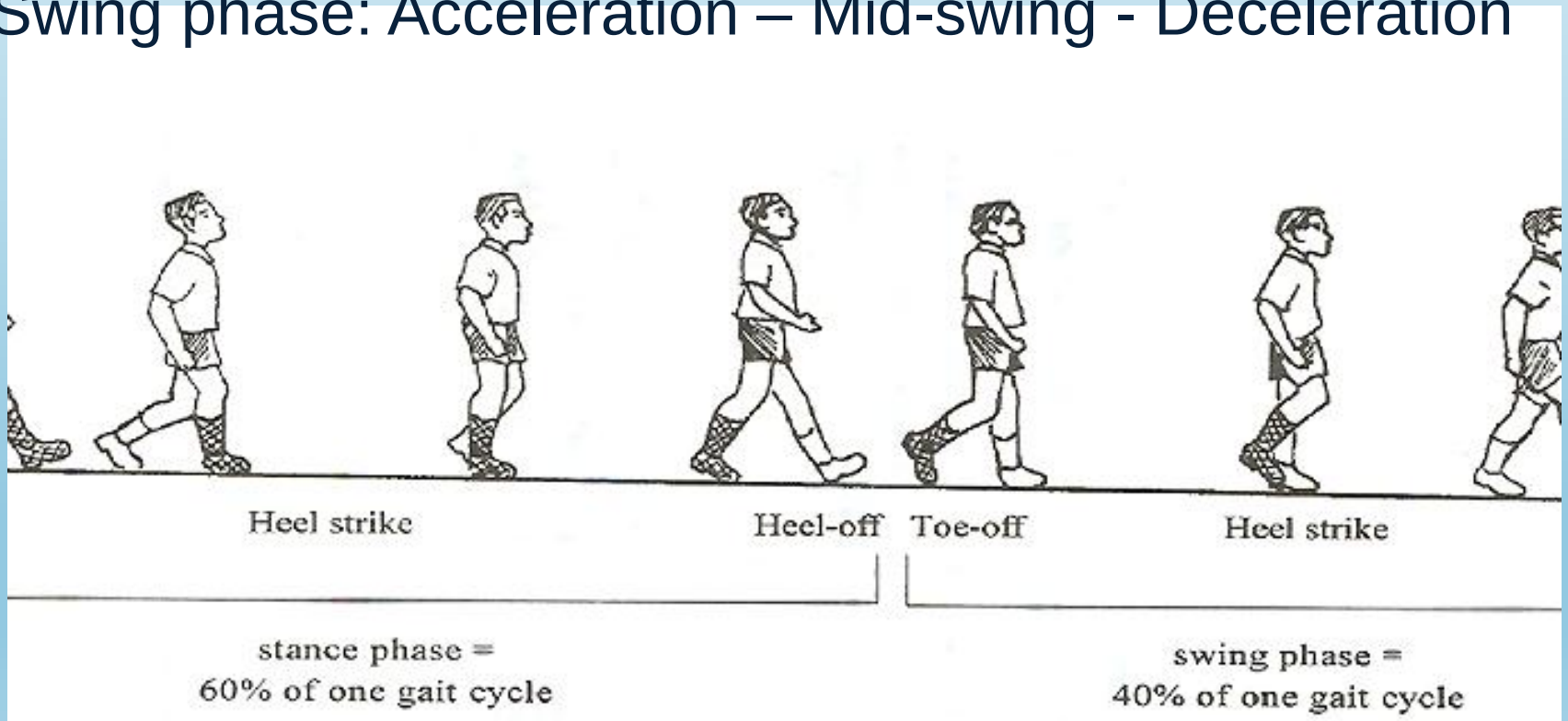
The knee is in full extension and is restrained by the hamstrings.

The ankle is still held in the neutral position by the action of the pretibial muscles.

Summary of Gait

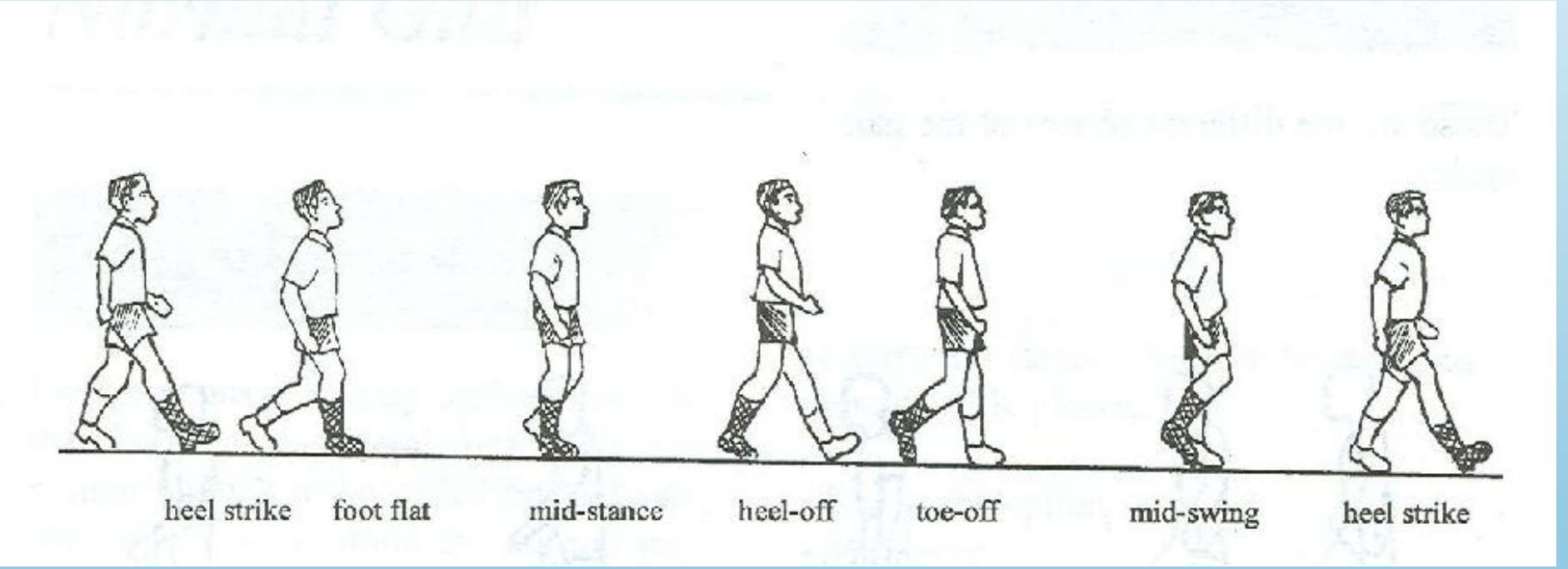
The Normal Gait Cycle

- Stance phase: Shock absorption- Mid-stance – Push-off
- Swing phase: Acceleration – Mid-swing - Deceleration



Summary of Gait cont.

- Time points



Summary of Gait cont.

Characteristics of gait

- Vertical displacement - Lateral displacement - Pelvic dip - Pelvic rotation - Walking base - Double support – Timing - Cadence

Analysis of normal walking motion

- At Heel strike - Shortly after heel strike – Foot flat - Mid-stance - Heel-off - Toe-off – Acceleration - Mid-swing - Deceleration

Any Questions????

Thank you very much