Gait

- An individual's style or way of walking –
  - may change slightly with mood
    - Happy - bounce
    - Depressed - heavy step

Gait

- Normally, walking is a very efficient biomechanic process, requiring relatively little use of energy
- Walking is a complex & high-level motor function
- The ability to walk safely often determines when a patient can be D/C home
Gait Cycle

- Refers to all activity that occurs between two successive heel contacts of the same foot
- It is broken up into stance phase and swing phase

Stance Phase

- Activity that occurs when the foot is in contact with the ground
  - begins with heel strike, ends with toe off of same foot
    - accounts for 60% of the gait cycle

Swing Phase

- Occurs when the foot is not in contact with the ground
  - begins when the foot leaves the floor and ends with heel strike of the same foot
    - accounts for 40% of the gait cycle
Stance

That period of time when one foot is in contact with the ground.

Stance has Several phases

A. Heel strike (HS)
B. Foot flat (FF)
C. Mid-stance (MS)
D. Heel off (HO)
E. Toe off (TO)

Heel Strike

- When the heel comes in contact with floor
  - Ankle - neutral position
  - Knee – slightly flexed
    - provides shock absorption
  - Hip - approx. 30° of flexion
  - Trunk - rotated to opposite side, opposite arm forward, same arm back
    - body weight begins to shift onto stance limb
Heel Strike

- Muscle activity:
  - Ankle - dorsiflexors isometric to keep ankle neutral
  - Knee – eccentric knee extensors to allow slight give to flexed knee
  - Hip – isometric hip extensors to prevent trunk from “jackknifing”
  - Trunk - erector spinae active

Foot Flat

- When entire foot is in contact with floor
  - Ankle - moves into approx. 5-10° plantarflexion
  - Knee - moves into approx. 15° of flexion
  - Hip - moving into extension which allows trunk and rest of body to “catch up” to the limb
  - Weight shift onto stance limb continues
Foot Flat
- Muscle activity
  - Ankle - eccentric contraction of dorsiflexors
  - Knee - eccentric contraction quads
  - Hip - isometric extensor contraction changes to slight concentric, guiding the hip toward extension

Mid-Stance
- Point at which body passes over the stance limb
- The leg is approaching the vertical position
- The leg is in Single-limb support, as the other limb is freely swinging forward

Midstance
- Ankle - moves into slight dorsiflexion
- Knee - extends
- Hip - continues to extend
- Trunk - neutral position of rotation - arms are parallel to body
Mid-Stance

- **Muscle activity:**
  - **Ankle**: dorsiflexors inactive; plantarflexors eccentrically contract to control the rate at which the limb moves over the foot
  - **Knee**: knee locked in extension, very little contraction needed
  - **Hip**: concentric extensors, concentric hip abductors to prevent opposite side of pelvis from dropping in frontal plane

Heel Off

- **Period when heel just begins to rise off floor**
  - **Ankle**: dorsiflexion initially (to 10 degrees), and then plantar flexion begins concentrically = push off phase
  - **Knee**: extended knee prepares to flex
  - **Hip**: hyperextension
  - **Trunk**: rotate to same side

Heel Off

- **Muscle activity**
  - **Ankle**: concentric plantar flexors (push off)
  - **Knee**: eccentric quads
  - **Hip**: isometric extensors, eccentric hip flexors
**Toe Off**

- Period just before, and including when the toes leave the floor
- Opposite foot begins its foot flat phase
- Signals *End of stance phase, and the beginning of swing phase*
  - Toes - hyperextension
  - Ankle – plantar flexion to approx. 10-15°
  - Knee - moving into flexion (30 degrees)
  - Hip – at the end of the phase, it starts to flex

---

**Muscle activity:**

- Ankle - concentric plantar flexion
- Knee - eccentric quads
- Hip - concentric hip flexors
Swing Phase, “the NWB phase”

- A. Acceleration
- B. Mid-swing
- C. Deceleration

**Acceleration**

- Limb behind body and moving to catch up
  - Ankle - moves into dorsi-flexion
  - Knee/Hip - continue to flex
- Muscle activity:
  - Ankle - concentric dorsi-flexion
  - Knee - eccentric quads
  - Hip - concentric flexors

**Mid Swing**

- “Shortening of limb to clear ground as swings through”
- Joint activity:
  - Ankle – maintained in neutral
  - Knee - max. flexion approx. 60°
  - Hip - continued flexion approx. 25°
Mid Swing

- Muscle activity:
  - Ankle - isometric dorsiflexion
  - Knee - eccentric quads then quick concentric to initiate acceleration of the tibia
  - Hip – concentric hip flexors

Deceleration

- Ankle – maintained in neutral, preparing for heel strike
- Knee – moves to almost full extension
- Hip – in flexion

Deceleration

- Muscle activity
  - Ankle - isometric dorsiflexion
  - Knee - eccentric hams
  - Hip - eccentric extensors
Let's Take a Look…

- http://www.youtube.com/watch?v=GV6CAZiv5Zo&feature=related

Other factors

Double Support
- When both feet are in contact with the floor
  - occurs when one limb is ending stance phase and the contralateral limb begins stance phase
  - 10% of the gait cycle is spent in double support
    - faster gait → less double support time
    - slower gait → more time in double support
Single Support
- When only one foot is in contact with the ground
  - 2 periods of single support
    - right stance
    - left stance
    - each accounts for approximately 40% of gait cycle

Non-Support
- Occurs when *neither* foot is in contact with the floor
  - DOES NOT OCCUR DURING WALKING
  - RUNNING: biggest difference between running and walking is non-support

Stride Length
- The distance traveled in one stride (between two consecutive heel strike of the same foot)
Step
- The events that occur between successive heel strikes of opposite feet
- Includes a period of double support (DS) and single support (SS)
- **Step length**: distance between heel strike of one limb and heel strike of the other limb
  - Step length should remain equal despite walking speed

Step Width
- Distance we keep our feet apart when we walk
- The distance between the heel centers of two consecutive foot contacts
- Normally 2 - 4 inches

Cadence
- Walking speed, or number of steps taken per minute
  - VARIES GREATLY
  - Regardless of speed all phase relationships are the same
Vertical Displacement of COG

- Highest at mid-stance
- Lowest at heel strike
- Normally 2 inches

Horizontal Displacement of COG

- Occurs as body weight shifts side to side
- Greatest at single support phase of mid-stance
- Normally 2-4 inches

Lateral Pelvic Tilt

- Occurs when weight is taken off the limb at toe off
- Hip ABDuctors on contra-lateral side work to keep pelvis level
Trunk Rotation/Arm Swing

- Arms swing is the opposition of trunk rotation to control the amount of trunk rotation by providing counter-rotation.

Gait Analysis

- Lateral
- Anterior
- Posterior
- Always start at feet and work to head or vice-versa

Non-pathological Gait Patterns

- Child
  - Wider BOS
  - Faster cadence
  - Shorter stride length
  - Initial contact with floor is with flat foot
  - Knees remain mostly extended during stance phase

- Elderly
  - Walk slower
  - Spend more time in stance phase
  - Longer periods of double support
  - Shorter steps
  - Less vertical displacement
  - Wider BOS
  - Greater horizontal displacement
Questions???

- Mansfield, P.J., Newmann, D.A., (2009), Essentials of Kinesiology for the Physical Therapist Assistant, Mosby: St. Louis, MO.