Normal Gait

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Critical Gait Parameters

- Average walking speed = 2-3 mph (60-80m/min)
- Average cadence = 80-110 steps/min
- Average step length = 30 cm
- Average stride length = 60 cm
- Stance/swing (1 leg) = 60/40
- Single/double limb support = 80/20
- Running has no double limb support
Step or Stride?

R step + L step = stride
Phases of the Gait Cycle (1 leg)
Stance Phase – 60%
Swing Phase – 40%
Comparison of R leg to L leg

80/20 rule

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<tr>
<th></th>
<th>R</th>
<th>L</th>
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<tbody>
<tr>
<td>0–10%</td>
<td>10–30%</td>
<td>10–23%</td>
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<tr>
<td>(10%)</td>
<td>(20%)</td>
<td>(13%)</td>
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<tr>
<td>Initial &amp; loading</td>
<td>Midstance</td>
<td>Initial &amp; loading</td>
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<tr>
<td>30–50%</td>
<td>37–50%</td>
<td>37–50%</td>
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<tr>
<td>(20%)</td>
<td>(14%)</td>
<td>(13%)</td>
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<tr>
<td>Terminal stance</td>
<td>Preswing</td>
<td>Terminal stance</td>
</tr>
<tr>
<td>50–60%</td>
<td>50–60%</td>
<td>50–60%</td>
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<tr>
<td>(10%)</td>
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<td>(10%)</td>
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<tr>
<td>Initial swing</td>
<td>Midswing</td>
<td>Initial swing</td>
</tr>
<tr>
<td>60–73%</td>
<td>60–80%</td>
<td>60–80%</td>
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<td>(13%)</td>
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<td>Terminal swing</td>
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Key: 

- Swing
- Stance
Three Important Gait Factors

- Forward Progression
- Stance Stability
- Conservation of Energy
Methods of Analyzing Gait

- **Kinematics** = observing or measuring the position of joints and segments through each phase of gait (visual gait analysis)

- **Kinetics** = 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
STANCE PHASE

HEEL STRIKE
LOADING RESPONSE
MIDSTANCE
TERMINAL STANCE
PRE-SWING
INITIAL SWING  MIDSWING  TERMINAL SWING

SWING PHASE
Rockers or Pivot Points in Stance

A Heel rocker
B Ankle rocker
C Forefoot rocker
Initial Contact:

- Double Support
- Hip = Flexed 30°
- Knee = Extended
- Ankle = Neutral
- Goal = Begin Stance
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 = Flexed 5-10°
- Ankle = Dorsiflexing

Goal = Advance body over stationary foot, ankle rocker
Terminal Stance:

- **Single Support**
- Hip = Extending 15-30°
- Knee = Extend, then Flex
- Ankle = 15° DF to Neutral
- Goal = Advance body over forefoot rocker
Pre Swing:

- Double Support
- Hip = Flexing
- Knee = Flexing 30-40°
- Ankle = Plantarflexing 20-30°

Goal = Prepare for Swing, transfer load to other limb
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
Terminal Swing:

- **Single Support**
- **Hip = Flexed 30°**
- **Knee = Extending**
- **Ankle = Neutral**
- **Goal = Advance limb**
Initial Contact:

- Double Support
- Hip = Flexed 30°
- Knee = Extended
- Ankle = Neutral
- Goal = Begin Stance
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

Energy Expenditure During Walking
cal/min/kg

2.9 km/h

4.4 km/h

Angle of Knee Flexion

B
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.
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