I. Describe joint kinematics and normal muscle function during walking

II. Describe gait through the life span: Pediatric

III. Describe gait through the life span: Geriatric

IV. Explain differences between walking and running

### Terminology Review

**RLA (phases)** | **Traditional (events)**
---|---
Initial Contact | Heel Strike
Loading response | HS $\rightarrow$ foot flat
Midstance | FF $\rightarrow$ midstance
Terminal stance | Midstance $\rightarrow$ heel off
Pre-swing | Heel off $\rightarrow$ toe off
Initial swing | Toe off $\rightarrow$ early accel.
Midswing | Acceleration $\rightarrow$ midswing
Terminal swing | Midswing $\rightarrow$ deceleration

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Levangie and Norkin

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Muscle Function - designed for efficiency

- Muscles contract when body alignment creates a torque antagonistic to weightbearing stability
  - (I.e. the body vector is aligned to create instability)

- The intensity of muscular responses are proportional to the magnitude of the torque demand that must be restrained
  - as soon as alternate means are available the muscles relax

- There is a continual exchange between the external torque demand and the controlling mechanisms (muscle action, momentum, passive tension of ligaments and fascia, etc.) to resist that demand
Determining muscle function via the ground reaction force vector method. Example-

<table>
<thead>
<tr>
<th>Phase</th>
<th>GRFV torque</th>
<th>Muscle torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial contact (the GRFV is anterior to hip)</td>
<td>Attempts to produce hip flexion</td>
<td>This force is resisted by the hip extensors</td>
</tr>
<tr>
<td>Terminal stance</td>
<td>Ankle dorsiflexion</td>
<td>Ankle plantar flexion</td>
</tr>
</tbody>
</table>

* Caution - This method is dynamically inaccurate and can yield wrong results

**SAGITTAL Kinematics:**

* Initial Contact (Heel Strike) (see also pg. 30 of Observational Gait Analysis)
  * HIP: 25° flexion
  * KNEE: 0° - 5°
  * ANKLE: 0° (90°)

**Muscle Function - Initial Contact (Heel strike)**

- Hip stabilized by extensor activity of hamstrings and gluts
- Knee stabilized by co-contraction of quads and hamstrings
- Ankle pre-tibial muscles dorsiflex ankle, positioning foot for initial contact

**SAGITTAL Kinematics:**

* Loading Response Phase (Heel Strike to Foot Flat)
  * HIP: 25° flexion
  * KNEE: 0° → 15° flexion (Lowers CM)
  * ANKLE: 0° → 10° plantar flexion

"1st rocker:"

Calcaneus
Muscle Function – Loading Response (HS to Foot Flat)

- Hip abductors stabilize pelvic drop in frontal plane
- Hip extensors counteract trunk and hip flexion
- Quads control knee flexion providing shock absorption
- Ankle dorsiflexors decelerate foot drop
- Tibialis anterior and posterior eccentrically decelerate pronation

SAGITTAL Kinematics: Midstance Phase (Foot Flat to "midstance event")

- **HIP**: 25° flexion → 0°
- **KNEE**: 15° flexion → 0° flexion
- **ANKLE**: 10° plantar flexion → 5° dorsi flexion

Muscle Function – Mid-stance (FF to Midstance)

- Hip abductors continue to minimize pelvic drop in the frontal plane
- Quads resist knee flexion until COG passes over base of support, then quads are silent
- Soleus and gastroc eccentrically control forward tibial progression

SAGITTAL Kinematics: Terminal Stance Phase ("midstance event" to Heel Off)

- **HIP**: 0° flexion → 20° extension
- **KNEE**: 0°
- **ANKLE**: 5° dorsi flexion → 10° dorsi flexion

Continue “2nd rocker:” ankle
At end of terminal stance, Begin “3rd rocker:” MTP
**Muscle Function - Terminal Stance**
(Midstance to Heel off)

- Brief burst from hip flexors resisting hyperextension of the hip
- Tensor fascia latae active throughout stance to resist pelvic drop
- Minimal to no quad or hamstring activity
- Ankle plantar flexors prevent forward tibial collapse and contribute to heel rise through passive tension

**SAGITTAL Kinematics:**
*Preswing Phase*  
(Heel Off to Toe Off)

- **HIP:** 20° extension → 0°
- **KNEE:** 0° → 40° flexion
- **ANKLE:** 10° dorsi flexion → 20° plantar flexion

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**Muscle Function - Pre-swing**
(Heel to Toe off)

- Femur flexes forward due to gravity and momentum, may be facilitated by adductor longus and rectus femoris
- Adductors stabilize weight shift across midline to other foot
- Rectus femoris may restrain rapid passive knee flexion, otherwise quads silent
- Passive tension in ankle plantar flexors facilitates knee flexion and then decreases to zero in preparation for toe off

**SAGITTAL Kinematics:**
*Initial Swing (Toe Off to early acceleration)*

- **HIP:** 15°
- **KNEE:** 60°
- **ANKLE:** 10° plantar flexion
Muscle Function - Initial Swing
(Toe off to Early Acceleration)

- Hip flexors flex hip
- Adductor longus brings leg toward midline
- Ankle pre-tibials initiate dorsiflexion to clear toes

SAGITTAL Kinematics: Mid-Swing

- **HIP**: 25°
- **KNEE**: 25°
- **ANKLE**: 0°

Muscle Function - Mid-swing

- Hip flexors and momentum flex hip
- Hamstrings begin to decelerate knee extension
  - Knee extension created by tibial forward momentum
- Ankle pre-tibials concentrically contract to clear foot

SAGITTAL Kinematics: Terminal Swing (Mid-swing-deceleration)

- **HIP**: 25°
- **KNEE**: 0°
- **ANKLE**: 0° plantar flexion
**Muscle Function - Terminal Swing**  
(Midswing-Deceleration)

- Hamstrings continue to decelerate forward swing of leg
- Quadriceps may contract to extend knee in preparation for initial contact
- Ankle pre-tibials contract to prepare foot for initial contact

**Appendix A - Muscle Function by muscle group**

1. **Trunk**
   - transversospinalis, erector spinae, quadratus lumborum
     - counterbalance trunk flexion moment
     - coordinate rotating the trunk opposite from pelvis

2. **Abdominals**
   - rotates trunk in opposite direction of pelvis

3. **Hip Flexors**
   - (iliopsoas, TFL, sartorius, rectus femoris, and adductors)
     - brief activity at beginning of swing to initiate hip flexion
     - electrical silence by mid-swing
     - eccentric control of hip extension at terminal stance

4. **Gluteus Maximus**
   - activity begins at TSW, rises sharply to peak during IC through LR
   - function with hamstrings to decelerate forward trunk momentum by preventing closed-chain hip flexion
   - assist with hip extension if resistance

5. **Hip Adductors**
   - stabilize the limb at heel strike
   - from TST to PSW to stabilize the limb during external rotation and assist in hip flexion

6. **Hip Abductors**
   - stabilize pelvis in the frontal plane
     - eccentrically control contralateral pelvic drop
   - active from LR through TST
<table>
<thead>
<tr>
<th>Number</th>
<th>Muscle Group</th>
<th>Actions</th>
</tr>
</thead>
</table>
| 7.     | Quadriceps                         | - active from TSW through MST  
         |         | - extend knee to place foot just prior to IC  
         |         | - absorb shock and provide knee stability during early to mid-stance |
| 8.     | Hamstrings                          | - active from end of swing phase through loading response  
         |         | - primary action is to decelerate the thigh  
         |         | - can assist gluteus maximus in preventing hip flexion at beginning of stance  
         |         | - assist with knee flexion during swing |
| 9.     | Tensor Fascia Latae                | - active at terminal swing along with gluteus maximus to stabilize ITB (pulls anterior while G. Max. pulls posterior)  
         |         | - active at end of stance and beginning of swing to assist hip flexion |
| 10.    | Pre-tibial muscles (Tib. Ant., EDL, EHL) | - active from initial contact through loading response to decelerate ankle plantar flexion  
         |         | - active from pre-swing through swing to clear toes from floor |
| 11.    | Gastroc/soleus                      | - active just after midstance through terminal stance to decelerate forward progression of the tibia  
         |         | - contribute to heel rise (passive tightening of the tendon elevates the heel)  
         |         | - stabilizes knee at terminal stance (pulls femur posteriorly to extend knee) |
| 12.    | Tibialis posterior                  | - support the medial arch, decelerates pronation during stance |
| 13.    | Flexor hallucis longus              | - Controls the amount and rate of first MTP extension from heel off to toe off |
| 14.    | Peroneus longus                     | - Plantar flexes the first ray from heel off to toe off |
| 15.    | Intrinsic foot muscles              | - active throughout stance in effort to stabilize the foot |
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