

Prosthetic Gait Deviations

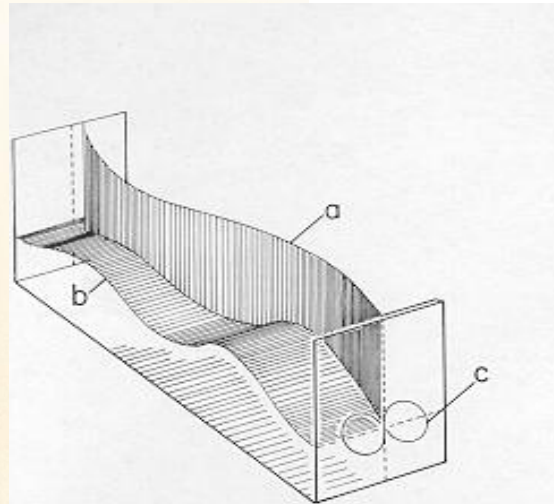
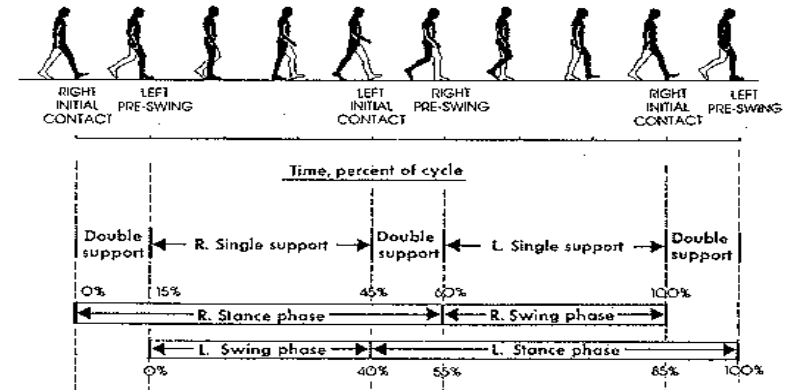
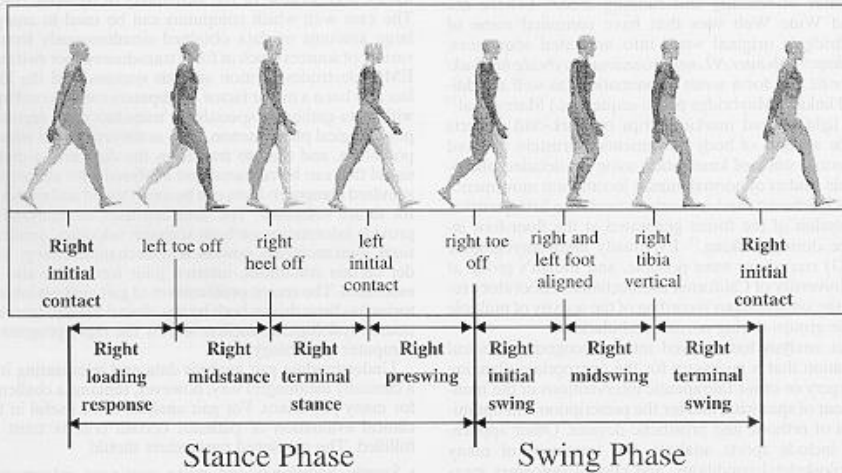
Joseph Burris, MD
Professor of PM&R

Medical Director, Rusk Rehabilitation Hospital

**Department of Physical Medicine and Rehabilitation, University of Missouri
Health Care**



Gait and Biomechanic Implications



Six Determinants of Gait (Inman)

- 1. Pelvic rotation**
- 2. Pelvic tilt (Trendelenburg)**
- 3. Knee flexion**
- 4. Ankle plantar/dorsiflexion mechanisms**
- 5. Knee, ankle, and foot rotation**
- 6. Lateral displacement of pelvis**



What is lost with amputation?

-Muscles

-Joint position

-Load sensation

The more lost and replaced by prosthesis the greater the loss of the major determinants of gait. Thus the greater the energy cost of ambulation.



Energy Cost and Comfortable Walking Speed by Amputation Level

Downey: Physiologic Basis of Rehabilitation Medicine

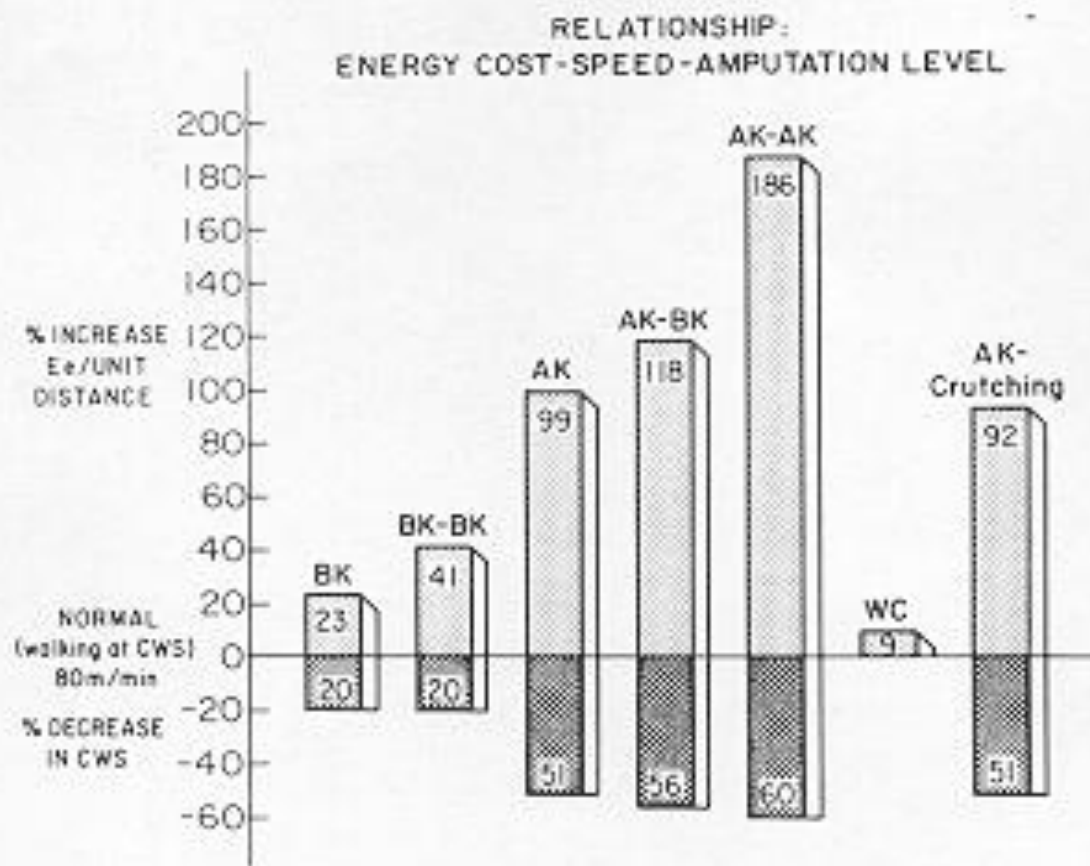


Figure 16-10. Summary of increase in E_e per unit distance and reduction of velocity among amputees as compared to normal subjects at the comfortable walking speed of 80 m/min. The values have been derived from various studies performed by the authors and other collaborators.^{48,63,69}



Pedobarography

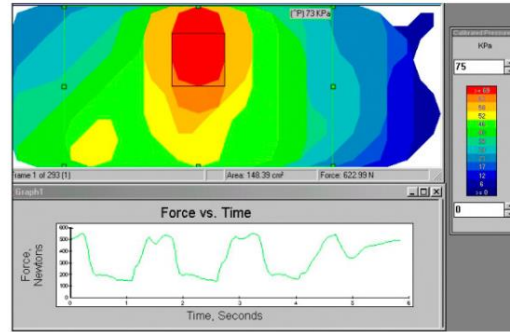
- <https://www.tekscan.com/products-solutions/human-gait-analysis>



Quantitative Prosthetic Socket Analysis



F-Socket system in action



F-Socket Software provides information on peak pressures, force vs. time graphs and center of force (CoF).



Gait Deviations & Assessment

Gait Deviation Definitions

Static Alignment

- Stationary alignment to establish:
 - Height
 - Foot rotation
 - Socket position
 - Flexion/extension
 - Abd/adduction
 - Sagittal position
 - Frontal position



Gait Deviation Definitions

Dynamic Alignment

- During gait or other mobility activities
- Stance phase
- Swing phase



Gait Deviation Definitions



TKA

**Trochanter-Knee-
Ankle Line**

- Hip (socket) rotation point
- Knee rotation point
- Ankle rotation point



AK Gait Deviations

- Prosthetic device etiology
- Amputee/patient etiology
- Common cause^{***}



Medial Whip

Prosthetic Cause

- External rotation of the knee, shank, or foot*

Amputee Cause

- Socket donned in external rotation*
- Gait habit—external rotation of hip at toe off



Lateral Whip

Prosthetic Cause

- Internal rotation of the knee, shank, or foot*

Amputee Cause

- Socket donned in internal rotation*
- Gait habit—internal rotation of hip at toe off



Abducted Gait

Prosthetic Cause

- Prosthesis too long - functional or anatomic*
- Excessive knee friction
- Posterior TKA
- Excessive plantarflexion
- Medial wall too high*
- Lateral wall insufficient to stabilize femur—loss of lateral containment*

Amputee Cause

- Abduction contracture
- Weak hip flexors, abductors, adductors*
- Patient insecure, increase base of support will increase stability*



Circumducted Gait

Prosthetic Cause

- **Prosthesis too long-functional or anatomic***
 - Excessive knee friction
 - Posterior TKA

Amputee Cause

- **Lack of confidence in flexing knee***
- **Abduction contracture**
- **Weak hip flexors***
- **Habit, using entire hip and pelvis to initiate gait**



Vaulting

(sound limb side)

Prosthetic Cause

- **Prosthesis too long-functional or anatomic***
 - **Excessive knee friction**
 - **Posterior TKA**
- **Poor suspension***

Amputee Cause

- **Gait habit, fear of catching toe***
- **Improper initiation of hip flexors on residual limb**



Heel Rise

Prosthetic Cause

- Insufficient knee friction
- Improper knee selection*

Amputee Cause

- Excessive use of hip flexors to initiate swing phase, overpowering knee unit



Knee Instability

Prosthetic Cause

- **Insufficient socket flexion***
- **Anterior TKA***
- **Heel too firm**

Amputee Cause

- **Weak hip extensors***
- **Hip flexion contracture***



Uneven Timing

Short Prosthetic Step

Prosthetic Cause

- Residual limb pain*
- Unstable knee*
- Excess socket flexion
- Excess ankle dorsiflexion
- Poor suspension
- Short or weak toe lever

Amputee Cause

- Patient insecurity*
- Weak hip muscles
- Poor balance



Uneven Timing

Long Prosthetic Step

Prosthetic Cause

- Excessive ankle plantarflexion*
- Insufficient socket flexion
- Long or excessively stiff toe lever

Amputee Cause

- Hip flexion contracture*
- Pain on sound limb side*



Lateral Shift

Prosthetic Cause

- Loss of frontal plane containment*
- Prosthetic foot too far inset*
- Excessive socket adduction

Amputee Cause

- Weak hip abductors on residual limb side*
- Narrow gait base



Lateral Trunk Bend

Prosthetic Cause

- Prosthesis too short*
- Foot too far outset*
- Ineffective lateral socket containment*
- High medial wall*
- Aligned in abduction

Amputee Cause

- Inadequate balance
- Abduction contracture
- Short residual limb*
- Painful residual limb*



Toe Drag

Prosthetic Cause

- **Prosthesis too long-functional or anatomic***
 - Excessive knee friction
 - Posterior TKA
 - Poor suspension
 - Excessive plantarflexion

Amputee Cause

- **Fatigue***
- **Toe lever load to unlock knee does not occur**
 - Weak hip extensors
 - Hip flexion contracture
- **Weak hip abductors on sound side**



Long Prosthesis

Observations

- Patient reports lower back pain**
- Patient reports they feel like they are walking up a hill
- Noticeable rise and drop of shoulder on the prosthetic side
- Uneven arm motion to accommodate uneven stride length



Short Prosthesis

Observations

- Patient reports lower back pain**
- Patient reports they feel like they are stepping into a hole
- Noticeable rise and drop of shoulder on the prosthetic side
- Uneven arm motion to accommodate uneven stride length
- Appears like the patient may be vaulting



BK Gait Deviations

- **Prosthetic etiology**
- **Amputee/patient etiology**
- **Common cause “*”**



Drop Off

Prosthetic Cause

- Short toe lever
- Foot too posterior
- Excessive dorsiflexion*
- Incorrect foot type—keel too soft*

Amputee Cause

- Knee extensor weakness*
- Hip extensor weakness*



Vaulting

Prosthetic Cause

- **Long prosthesis***
 - **Anatomic or functional**
- **Poor suspension**

Amputee Cause

- **Gait habit, fear of catching toe***
- **Weak hip flexors on residual limb**



Wide Gait

Prosthetic Cause

- Prosthetic foot too far outset*
- Loss of frontal plane control*
- Excessive socket adduction

Amputee Cause

- Insecurity, wants to widen base in attempt to increase stability*



Lateral Shift

Prosthetic Cause

- Loss of frontal plane containment*
- Foot too far inset*
- Insufficient socket adduction
- Short prosthesis*

Amputee Cause

- Inadequate balance
- Weak hip abductors*
- Narrow gait base



Long Prosthesis

Observations

- Patient reports lower back pain**
- Patient reports they feel like they are walking up a hill
- Noticeable rise and drop of shoulder on the affected side
- Hesitation in gait timing from prosthetic mid-stance to sound side heel strike



Short Prosthesis

Observations

- Patient reports lower back pain**
- Patient reports they feel like they are stepping into a hole
- Uneven arm motion to accommodate uneven stride length
- Appears like the patient may be vaulting



External Foot Rotation

Observations

- Patient wants foot to match sound side*
- External rotation of hip/knee at toe off
- Induces “medial whip”
- Drop off at end of stance phase*
- Low back pain



Internal Foot Rotation

Observations

- Patient wants foot to match sound side*
- Internal rotation of knee at toe off
- Induces “lateral whip”
- Drop off at end of stance phase*
- Low back pain



THANK YOU