

What's New in Amputee Rehabilitation?

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Objectives

1. Epidemiology UPDATE!!
2. Review “normal” biomechanics of gait
3. Analyze the FLAG Assessment as a clinical outcome measure
4. Perform observational gait analysis using the FLAG Assessment
5. Develop PT interventions designed to restore gait biomechanics
6. Identify problem solving solutions for prosthetic-related concerns in PT



Epidemiology of Amputation

Estimating the Prevalence of Limb Loss in the United States: 2005 to 2050

- 185,000 individuals have an amputation annually (UE or LE)

	2005 Estimate	2050 Estimate
Persons living with limb loss	1.6 million	3.6 million
Dysvascular related amputations	<1 million	2.3 million

Outdated

Estimating the Prevalence of Limb Loss in the United States: 2005 to 2050

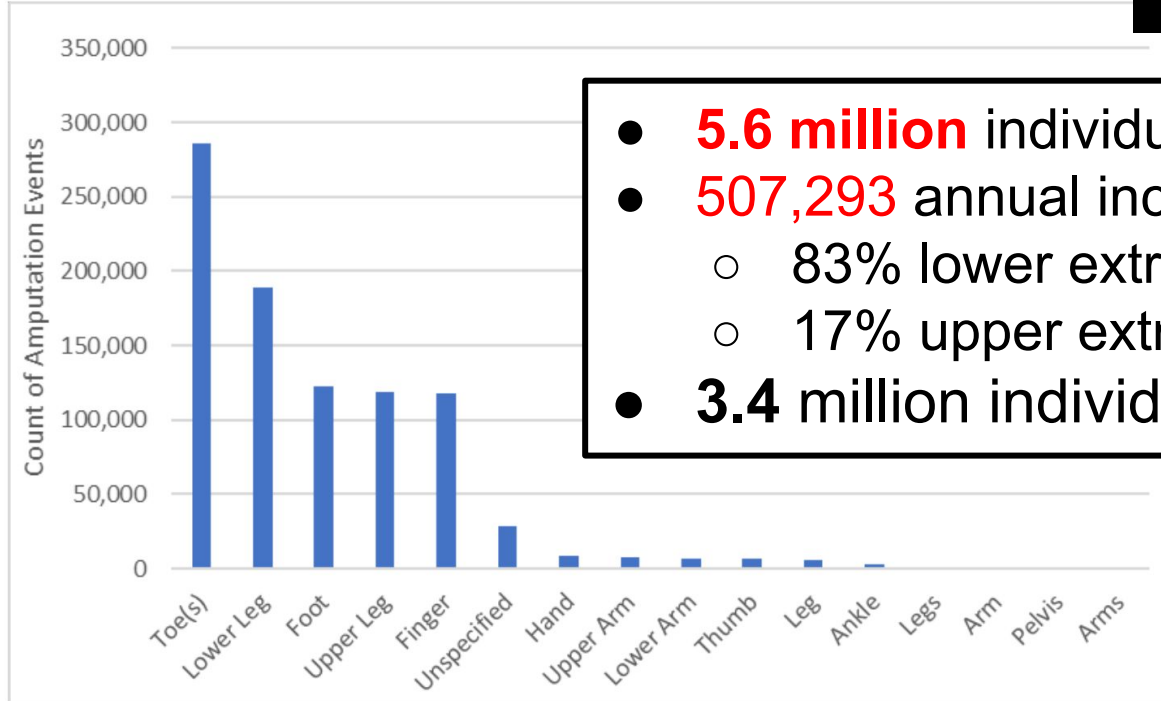
- **No** national database existed to monitor limb loss (LL)
- 1st study since 1996 to provide estimated prevalence on LL.
- Estimations based on data from National Inpatient Sample (NIS) from **1988-1999**
 - **Included** major and minor amputations
 - **Excluded** congenital limb loss & amputations at federal facilities

Outdated

Prevalence of Limb Loss and Limb Difference in the United States: Implications for Public Policy

Figure 1: Annualized Incidence of Limb Loss by Body Part, 2016–2021

HOT OFF THE PRESS



- **5.6 million** individuals living with LL/LD
- **507,293** annual incidence
 - 83% lower extremity
 - 17% upper extremity
- **3.4 million** individuals with congenital LD

Note that these are counts of amputation, individuals may experience multiple amputations so counts will be higher than incidence of individuals with limb loss.

Caruso & Harrington (2024)

Prevalence of Limb Loss and Limb Difference in the United States: Implications for Public Policy

- **Toes** = most common
 - 57.6% had diabetes comorbidity
- **Common comorbidities:**
 - Infection (42.8% of individuals)
 - Vascular conditions (39.3%)
 - Ulcer (37.7%)
 - Osteomyelitis (26.5%)
- **Trauma: 12.9%**
- **Age:**
 - 44.6% \geq 65 years old
 - 41.7% aged 45-64

Prevalence of Limb Loss and Limb Difference in the United States: Implications for Public Policy

Megan Caruso and Shelby Harrington | 2.14.24



Limb Loss and Preservation Registry (LLPR)

- Launched by Mayo Clinic in May 2022
 - Until now, **NO** national database existed for measuring quality outcomes for patients with a limb loss or limb difference.
- **Goal is to gather data from:**
 - Hospitals regarding amputations
 - Providers regarding care given
 - Patient outcomes



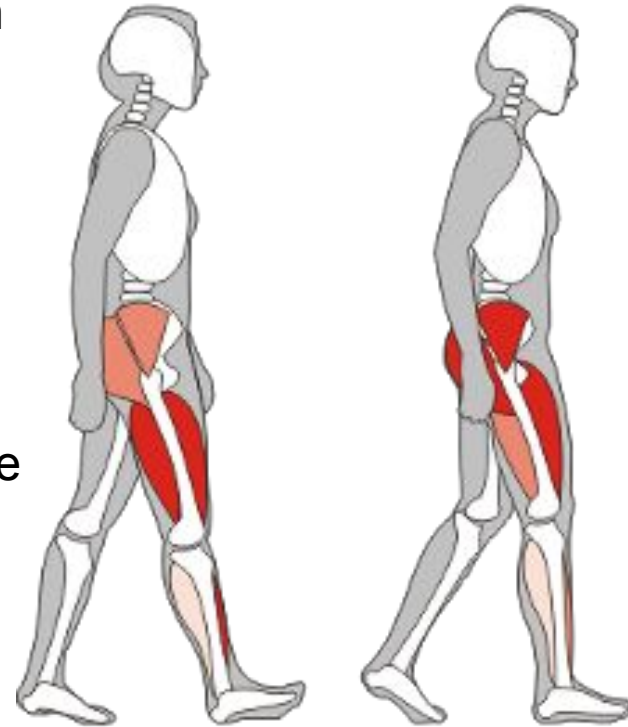
LIMB LOSS *and*
PRESERVATION
REGISTRY®

Activity is health.®

Review of anatomical gait

Task 1: Weight Acceptance

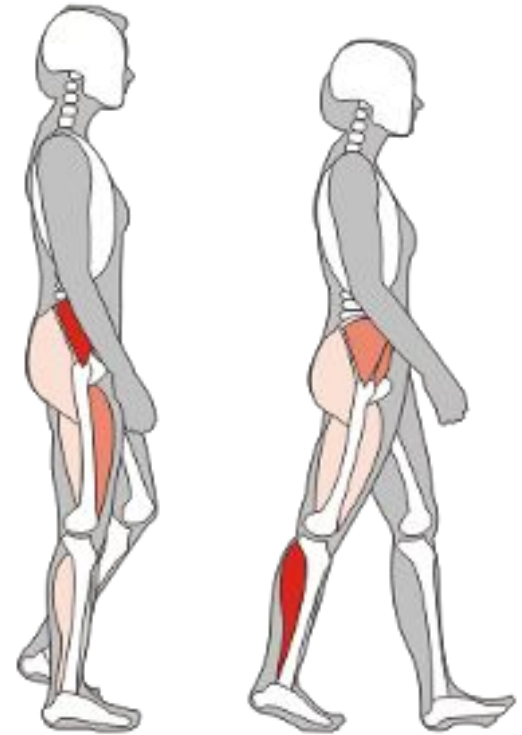
- **Task:** transfer of body weight onto the limb as soon as it makes contact with the ground
- **Functional Demands:**
 - Shock absorption
 - Initial limb stability
 - Maintain forward progression
- **Occurs during:** Initial Contact & Loading Response
 - Most demanding task in the gait cycle



Winfred (2020)

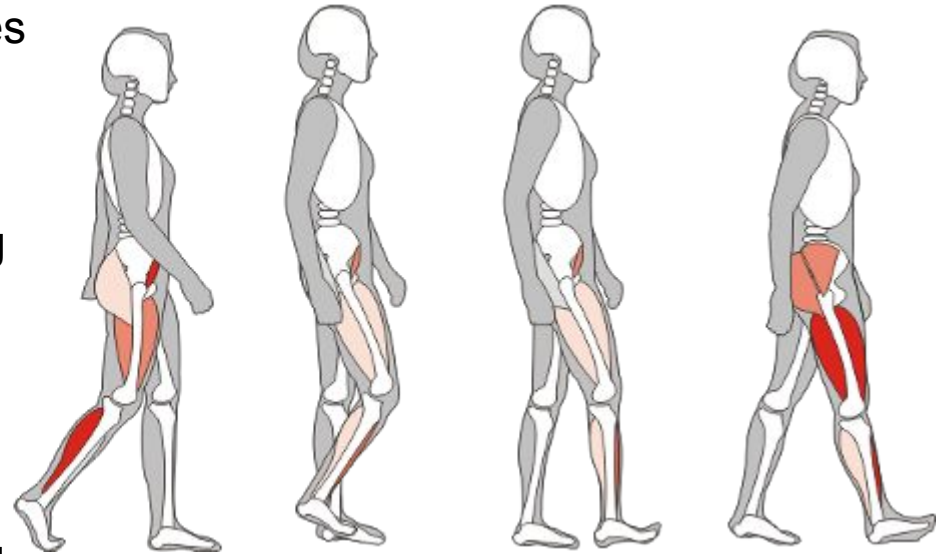
Task 2: Single Limb Support (SLS)

- **Task:** Progression of the body over the fixed foot
- **Functional Demands:**
 - Limb and trunk stability
 - Progression of the body beyond the stationary foot
- **Occurs during:** Midstance & Terminal Stance
 - Begins with lifting of the other foot for swing



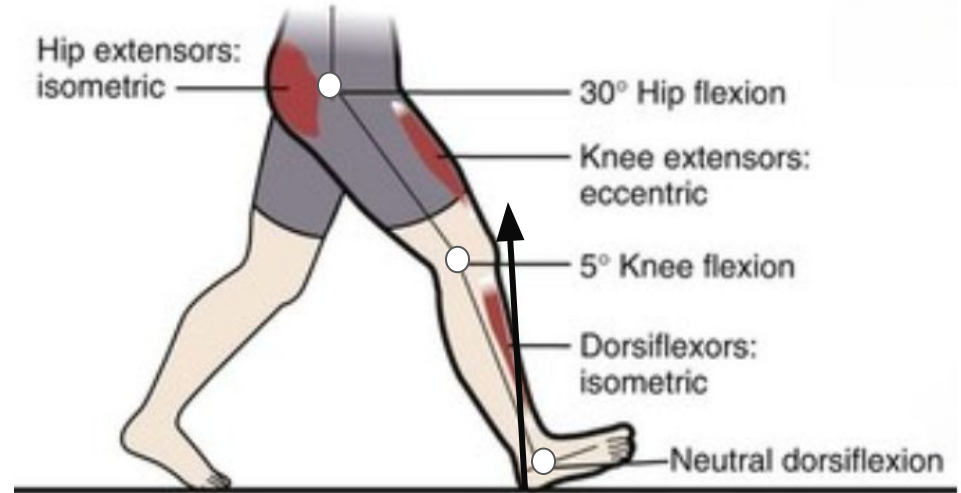
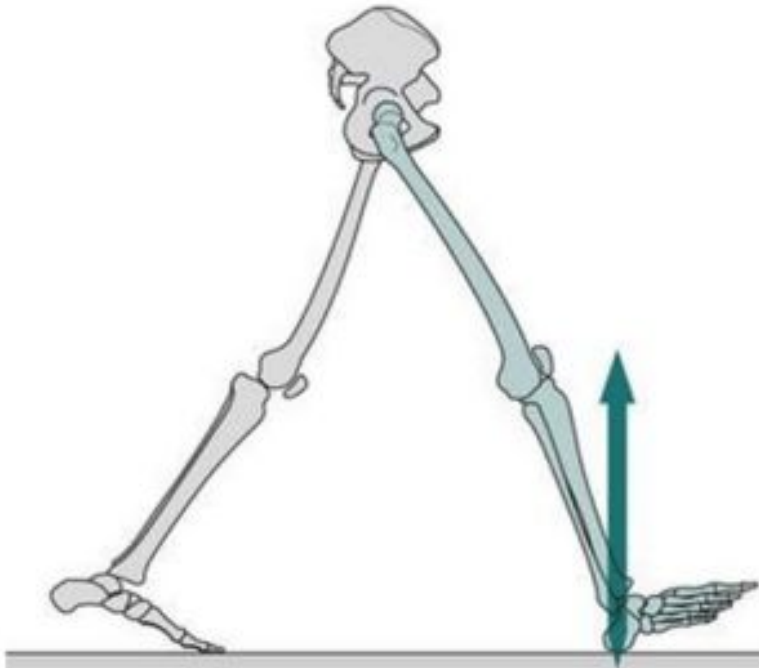
Task 3: Single Limb Advancement (SLA)

- **Task:** Preparatory posturing for swing, then limb clears the ground, advances forward
- **Functional Demands:**
 - Preparation of the limb for swing
 - Accelerate progression
 - Limb advancement
 - Foot clearance
- **Occurs during:** Pre-swing, Initial swing, Mid-swing and Terminal swing



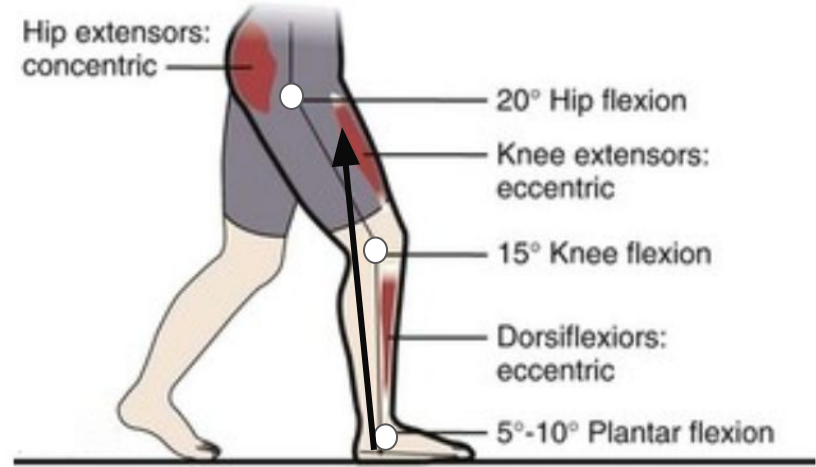
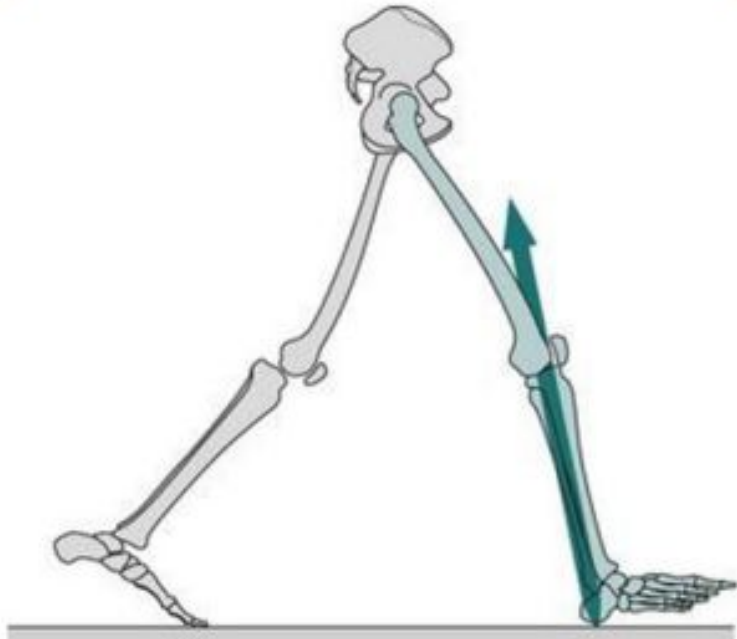
Winfred (2020)

Initial Contact: initiates weight acceptance, shock absorption



Joint	GRFv Location	EXTERNAL Moment
Ankle	Posterior	Plantar Flexion
Knee	Anterior	Knee Extension
Hip	Anterior	Hip Flexion

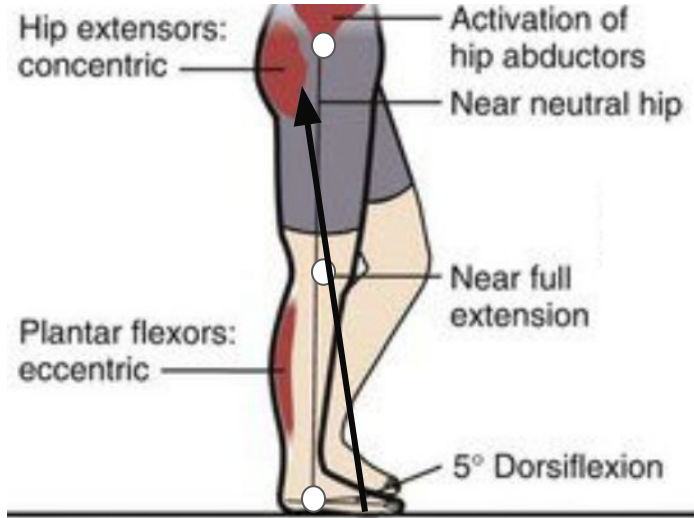
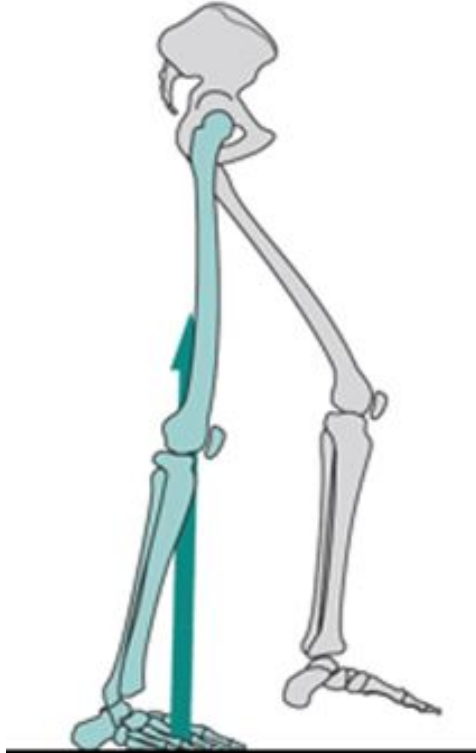
Loading Response: “foot flat”, controlled foot descent, shock absorption



Joint	GRFv Location	EXTERNAL Moment
Ankle	Posterior	PF
Knee	Posterior	Flexion
Hip	Anterior	Flexion

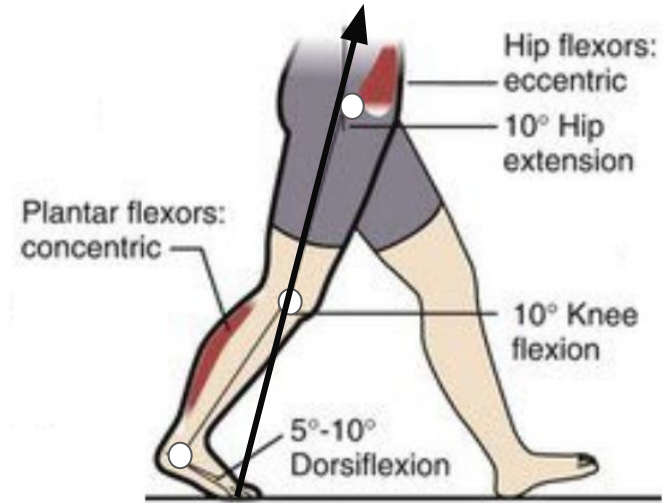
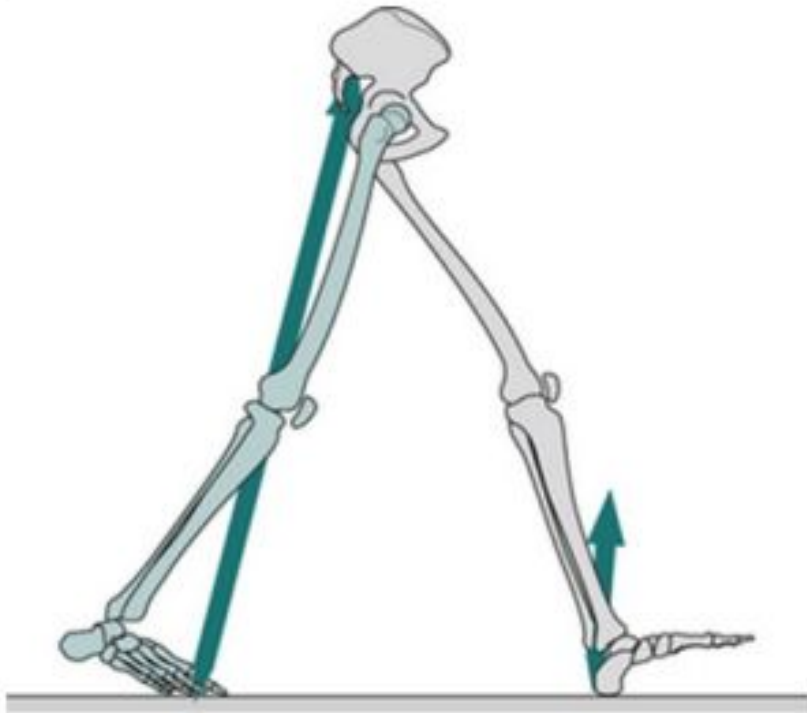
Midstance: tibial advancement over fixed foot

Transition from shock absorption to propulsion



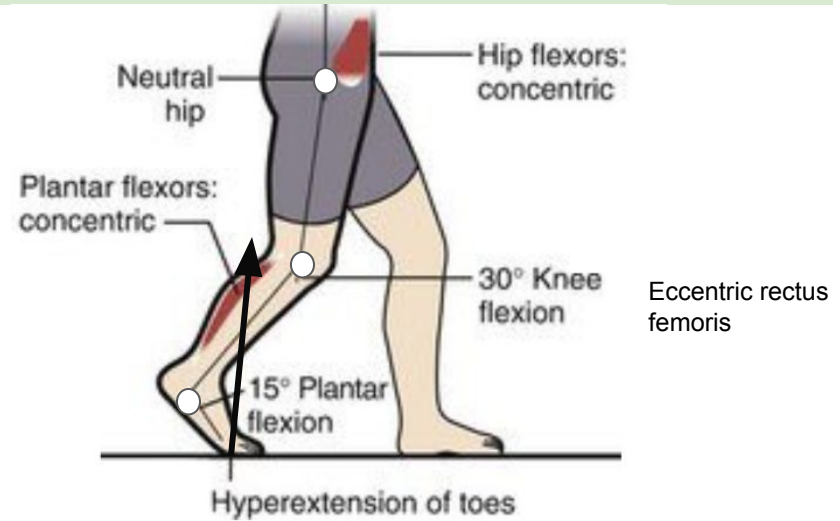
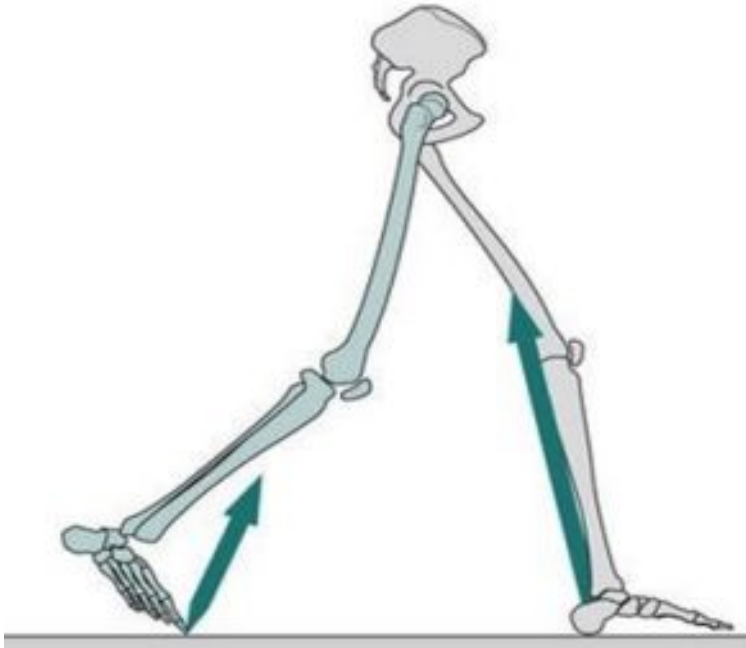
Joint	GRFv Location	EXTERNAL Moment
Ankle	Anterior	DF
Knee	Anterior	Extension
Hip	Posterior	Extension

Terminal Stance: “heel rise”, progression beyond supporting limb



Joint	GRFv Location	EXTERNAL Moment
Ankle	Anterior	DF
Knee	Anterior	Extension
Hip	Posterior	Extension

Pre-Swing: “toe off”; propulsion

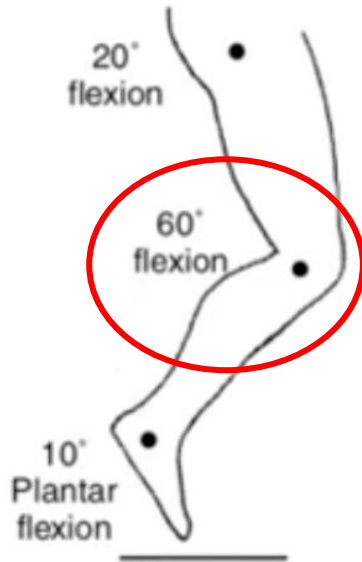


Joint	GRFv Location	EXTERNAL Moment
Ankle	Anterior	DF
Knee	Posterior	Flexion
Hip	Posterior	Extension

Swing Phase

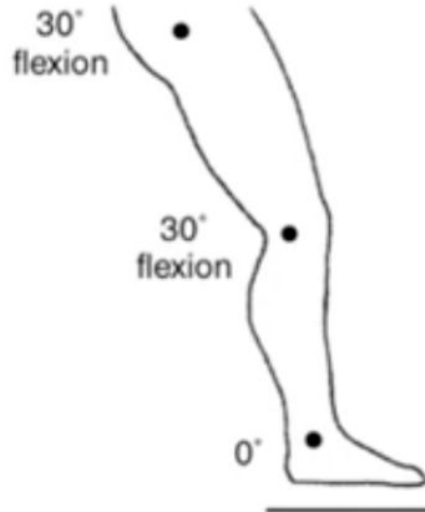
Initial Swing (ISw)

- Foot clearance
- Advancement of limb



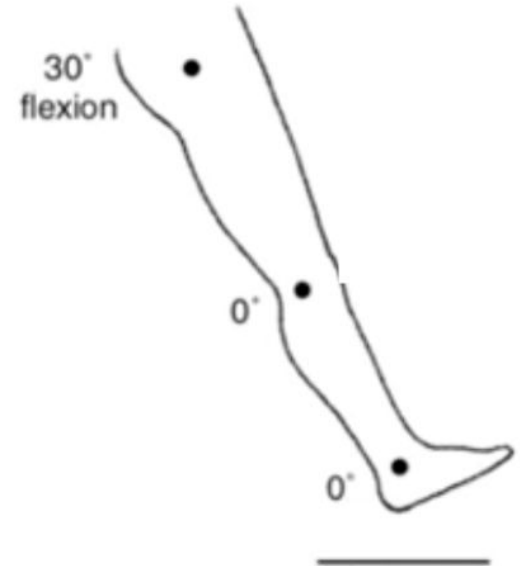
Mid Swing (MSw)

- Advancement of limb



Terminal Swing (TSw)

- Advancement of limb
- Prepare for stance

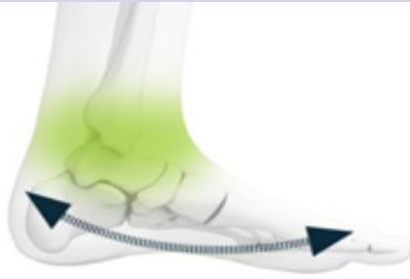


Rockers

Blatchford Biomimicry Philosophy



Heel Rocker



Ankle Rocker



Forefoot Rocker



Determines time until foot flat (soft vs. firm heel).

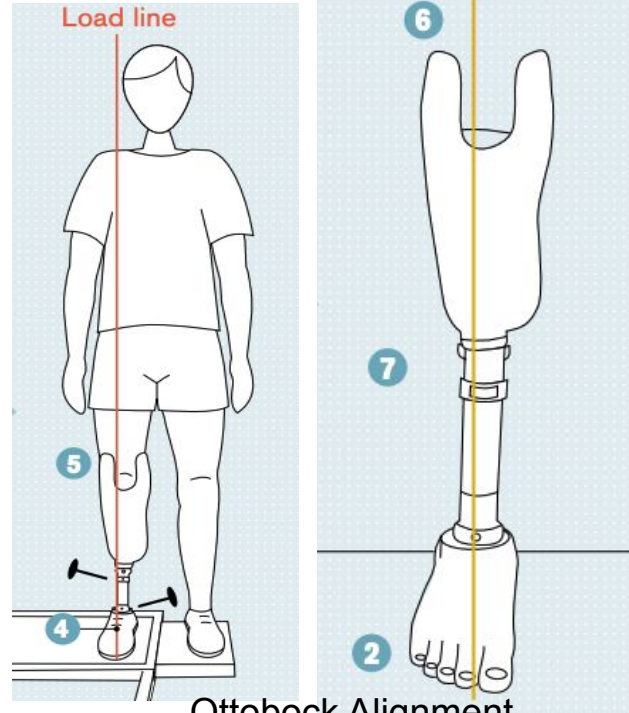
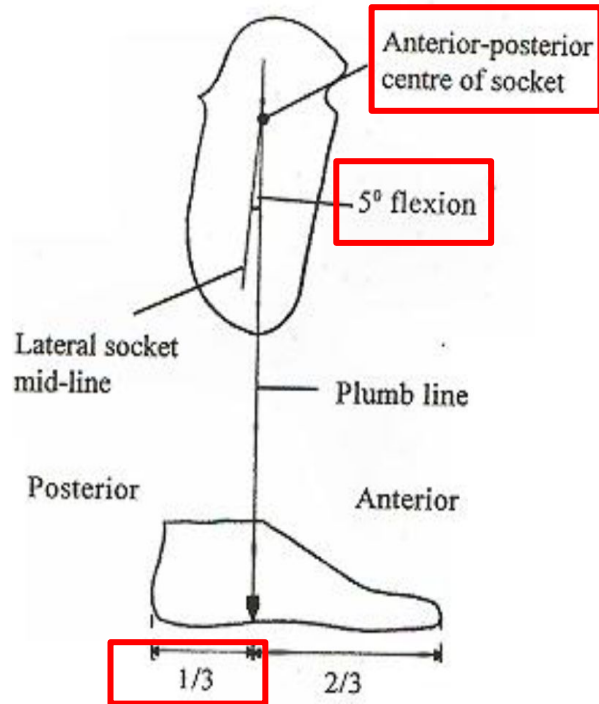


Tibial Advancement:
Keel offers resistance to tibial advancement until toe break

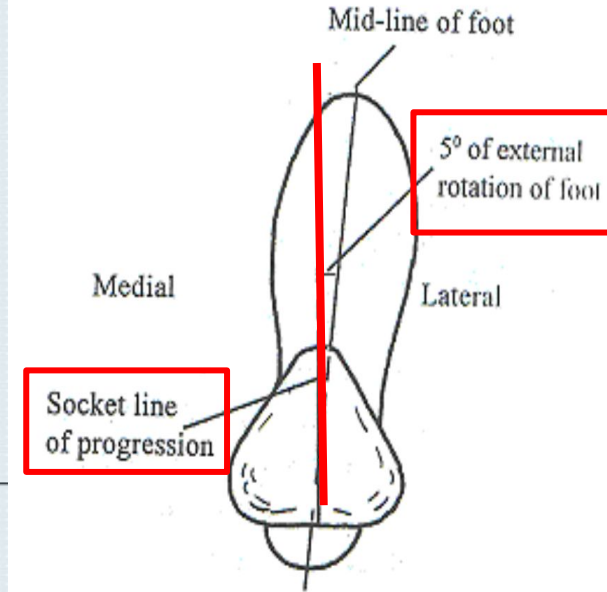


Forefoot dynamics (stiffness) determines rate of heel rise / energy return

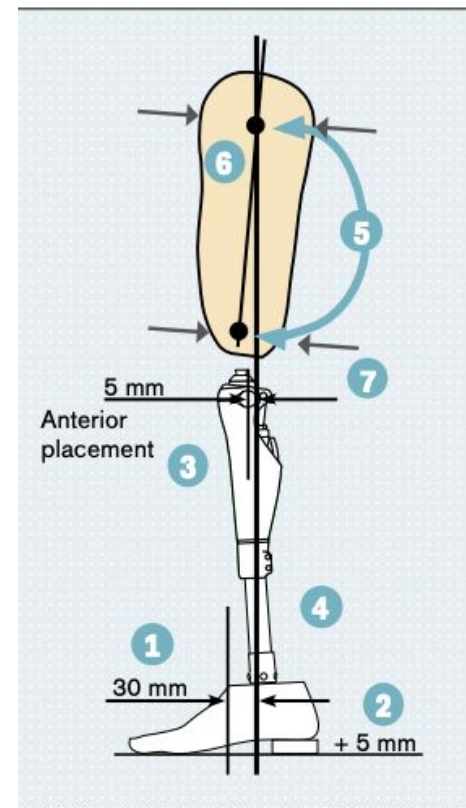
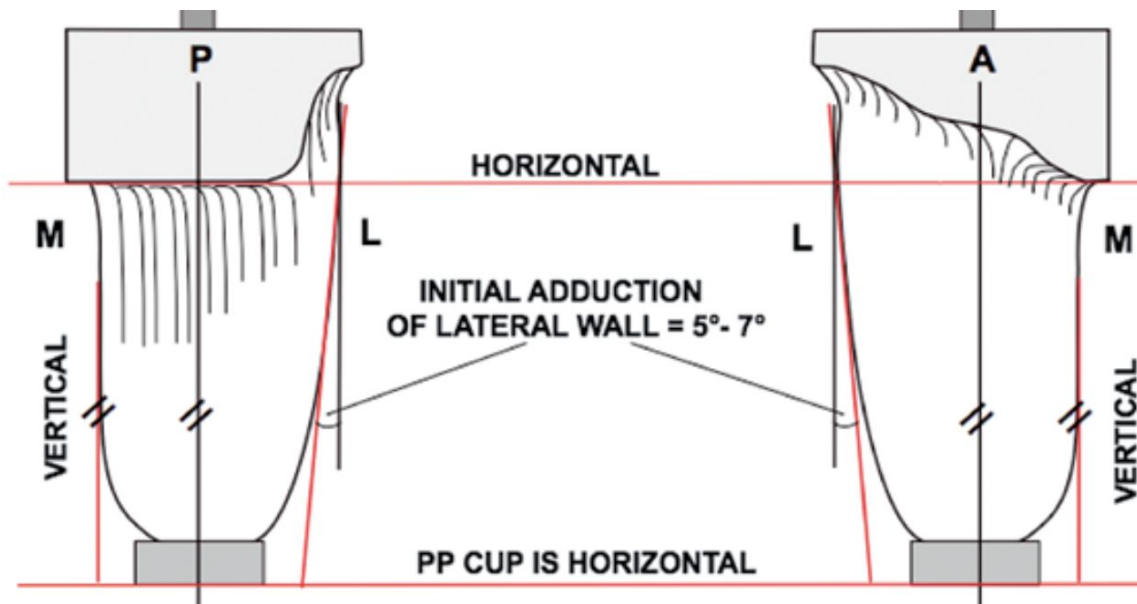
BKA Bench Alignment



Ottobock Alignment Recommendations

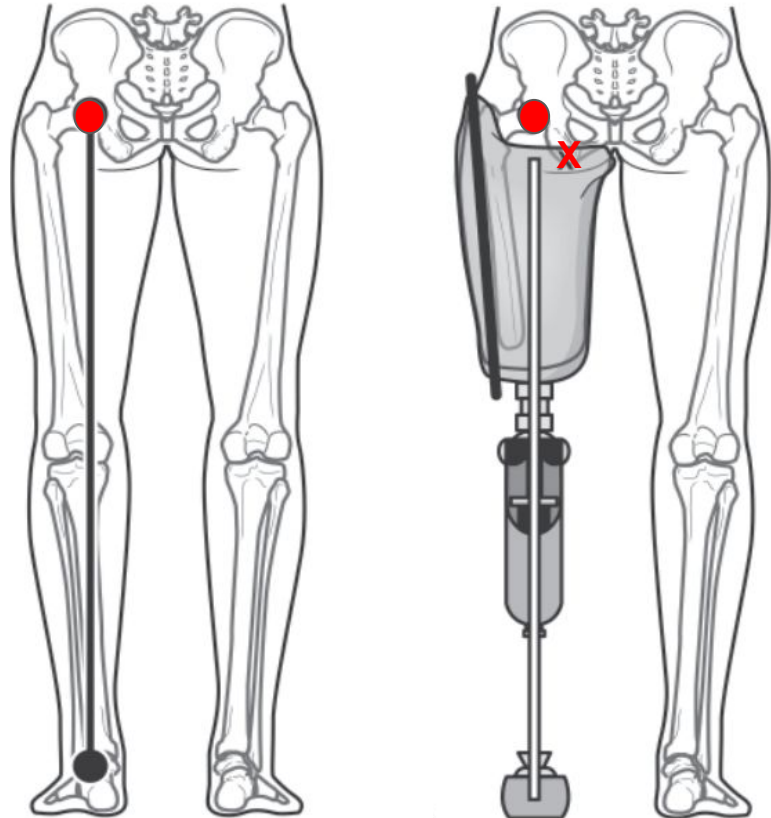


Transfemoral BENCH Alignment



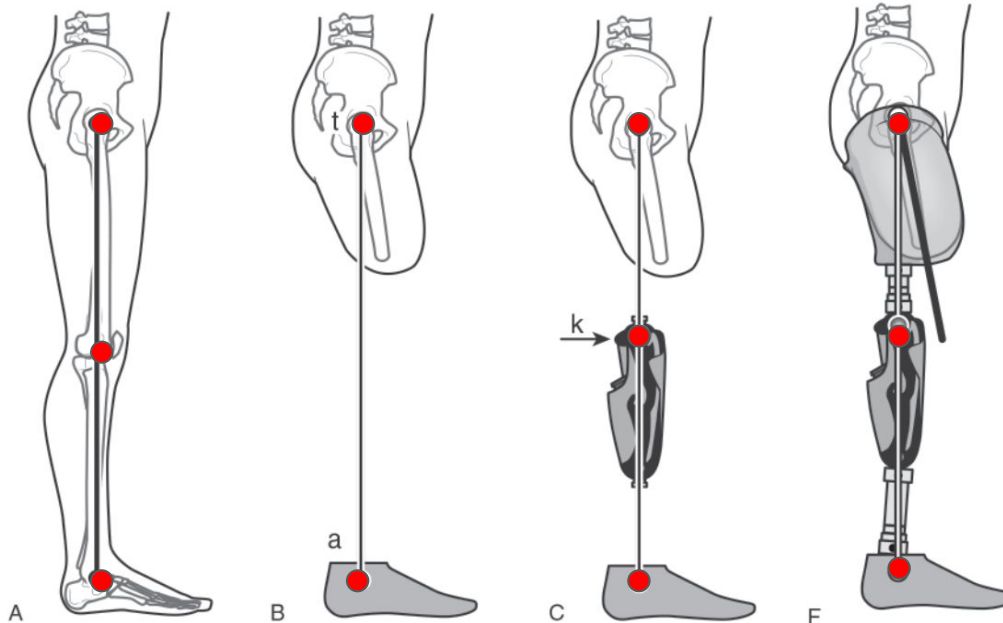
Transfemoral Alignment (posterior view)

- Hip joint cannot be used as a reference point since it does not fall inside of the socket.
- APPROXIMATE: Locate a point on the socket brim that is **1" lateral to the location of the ischium**
- Plumbline bisects heel
- Foot slightly inset



Sagittal Plane Alignment Sequence

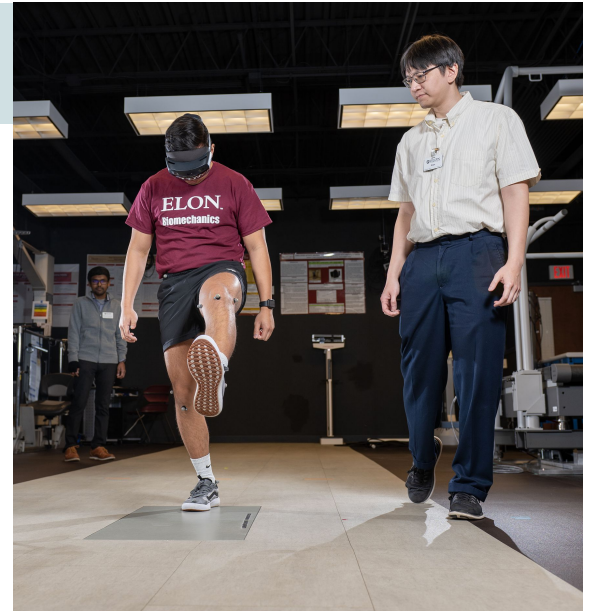
- Approximate hip joint (greater trochanter)
- Identify T-A line
- Place knee center for voluntary vs. involuntary control.



Gait Analysis

Instrumented Gait Analysis (IGA)

- **3D motion capture:**
 - kinematic parameters (e.g., knee flexion angle)
- **Electronic walkways:**
 - spatiotemporal parameters (e.g., step length, stance time)
- **Inertial measurement unit (IMU):**
 - Accelerometer
 - Gyroscope (angular rotation/velocity)
 - Magnetometer (compass)



Observational Gait Analysis (OGA)

- Primary method in clinical setting to identify presence/absence of gait deviations and help to determine what is the cause.
 - **Familiar OGAs**
 - New York University (NYU)
 - Ranchos Los Amigos (Rancho)
 - Prosthetic Observational Gait Assessment (POGA)
 - Prosthetic Observational Gait Score (POGS)



NYU OGA Tool (1980)

Chapter 14 - Atlas of Limb Prosthetics: Surgical, Prosthetic, and Rehabilitation Principles (1992)

- Describes abnormal motion or spatial asymmetry by LEA level
- **BKA**: only list deviations at knee joint during stance phase
- **AKA**: did not include temporal asymmetries, arm, or knee motion.
- Prosthetic alignment heavy
 - Few functional impairments / patient causes
 - Dated terminology (Pre-ESAR feet)

FOOT SLAP

Description: The foot plantar-flexes too rapidly and strikes the floor with a slap (Fig 14-10.).

When to observe: Just after heel strike.

How to observe: From the side. Listen for slap.

Cause: The plantar-flexion bumper is too soft and does not offer enough resistance to foot motion as weight is transferred to the prosthesis.

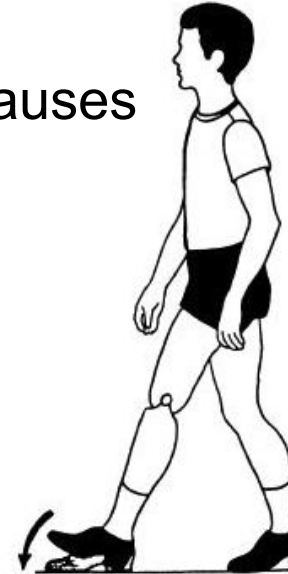


Fig 14-10. Foot slap.

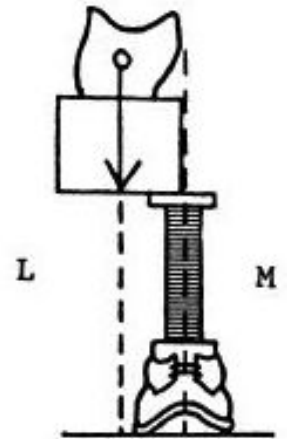


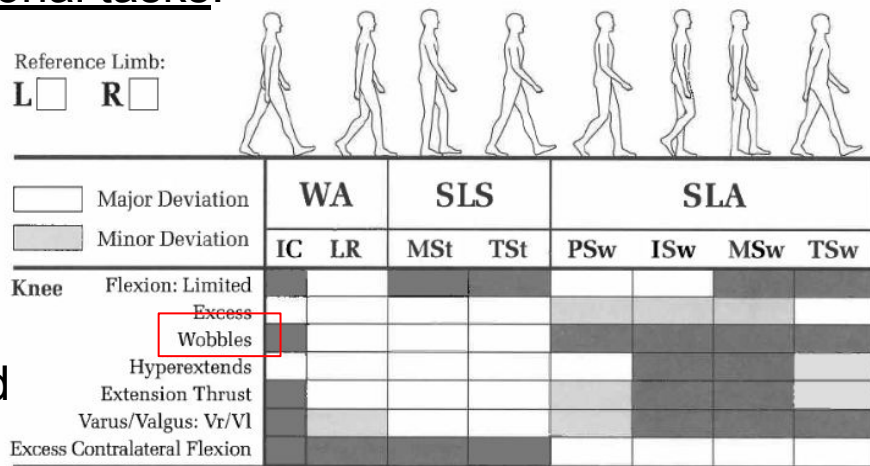
Fig 14-3. Excessive medial placement of the prosthetic foot.

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Ranchos Los Amigos (Rancho) OGA

- Perry et al. (1993)
- 8 phases of gait classified into 3 functional tasks:
 - **Weight acceptance (WA)**
 - **Single limb support (SLS)**
 - **Single limb advancement (SLA)**
- **178** gait deviations
- Not LLA specific
 - No prosthetic-related issues noted



<i>Major Problem</i>	<i>Task</i>	<i>Most Likely Cause</i>	<i>Significance</i>
WOBBLES	WA SLS	<ul style="list-style-type: none"> • Impaired proprioception • Quadriceps hypertonicity • Plantar flexor hypertonicity 	<ul style="list-style-type: none"> • Decreases forward momentum • Decreases limb stability and balance

Assess spastic CP: **Fair to moderate inter-rater reliability, Fair to moderate concurrent validity**



Prosthetic Observational Gait Analysis (POGA)

- **1997:** Dr. Robert Gailey developed an amputee specific OGA
- Established **47** gait deviations from the 178 on the Rancho OGA tool
 - Includes body function impairment, prosthesis and patient related causes. classified by amputation level.

Prosthetic Observational Gait Assessment Form

Sagittal View	Weight Acceptance	Single-Limb Support	Swing
Foot/Ankle	foot flat	vaulting (excessive plantarflexion)	
	foot slap	increased dorsiflexion	
	external rotation		
Knee	hyperextension	decreased knee flexion	increased flexion or (excessive heel rise)
	increased flexion or (knee instability)		terminal impact
Hip		flexed	
Pelvis		posterior rotation	posterior rotation
Trunk		anterior rotation	
		lordosis	
Arm Swing	uneven		uneven
	decreased		decreased
Stride Length			increased
			decreased
Stance Time		increased	
		decreased	
Toe Clearance			increased
			decreased

Reliability and validity not reported

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Prosthetic Observational Gait Score (POGS)

- **2010:** Susan Hillman and colleagues (Anderson Gait Analysis Lab - Scotland)
 - **16** gait deviations
 - Scoring permits comparison of ipsilateral to contralateral side

3. Lateral Trunk Lean/Side Flexion

The subject flexes or tilts the upper body in the coronal plane. This would normally be a tilt to the prosthetic side.

Score 1 for moderate, (e.g. displacement of the head up to, and in line with, the supporting foot).

Score 2 for marked, (e.g. displacement beyond the supporting foot).

Possible causes include:

- Short prosthesis.
- Insufficient lateral support in socket.
- Socket set in abduction.
- Pain or discomfort, especially on lateral distal aspect of residual limb.
- Weak abductors.
- Abducted gait.



Hillman et al. 2010

Table 1
Prosthetic observational gait score sheet.

		2	1	0	1	2
	Trunk					
1 (s)	Arm swing	–	Asymmetric - contralateral ipsilateral	Normal and symmetric	Asymmetric - ipsilateral > contralateral	Absent or negligible bilateral arm swing
2 (s/c)	Vaulting in stance	Visible heel lift on ipsilateral side	Negligible heel lift on ipsilateral side	Normal	Negligible heel lift on contralateral side	Visible heel lift on contralateral side
3 (c)	Lateral trunk lean/side flexion in stance	Marked to swing side	Moderate to swing side	Normal	Moderate to stance side	Marked to stance side
4 (s)	Peak sagittal position	–	Moderately backward	Normal	Moderately forward	Markedly forward

Validity not reported, fair inter-rater reliability, Good Intra-rater reliability



Functional Lower-Limb Amputee Gait Assessment

- **Purpose:** create a tool enabling PTs and CPs to communicate and collaborate using common language when describing observable gait deviations.
- **Structure:** lists **11** of most common gait deviations with the expected patient and prosthesis cause.
- Pilot study to establish a reliable and valid OGA tool to assess the gait of people with unilateral LLA
 - Only POGS reports on reliability



The Functional Lower-Limb Amputee Gait Assessment (FLAG Assessment): An Observational Gait Analysis Tool for People with Unilateral Lower Limb Amputation

Kristal, Anat

<https://scholarship.miami.edu/esploro/outputs/doctoral/The-Functional-Lower-Limb-Amputee-Gait-Assessment/991031573186702976/filesAndLinks?index=0>



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Functional Lower-Limb Amputee Gait Assessment

APPENDIX E: THE FUNCTIONAL LOWER-LIMB AMPUTEE GAIT ASSESSMENT (FLAG ASSESSMENT)

1
2
3
4
5
6

Gait Action	Observed Deviation	Expected Normative Observation	Possible Causes
Step Width	<input type="checkbox"/> Intact limb foot at midline <input type="checkbox"/> Prosthetic limb abducted	5 to 10 cm (2 to 4 inches)	- Poor balance on the prosthesis - Habit of relying more on the intact limb - Balance because of intact limb foot at midline - Weak or poorly trained prosthetic side musculature
Step Length & Time	<input type="checkbox"/> Intact limb step shorter <input type="checkbox"/> Intact limb step faster <input type="checkbox"/> Prosthetic limb step shorter	Minimum 30 cm (12") from toes of trailing limb to the heel of leading limb Temporal symmetry between the prosthetic and intact step time	- Poor balance on the prosthesis - Pain or discomfort - Decreased confidence - Habit of spending too much time on the intact limb
Forefoot Load	<input type="checkbox"/> Decreased prosthetic forefoot load	Forefoot break or rocker	- Poor balance over prosthetic forefoot
Knee Flexion	<input type="checkbox"/> Less than expected knee flexion	30 - 40° at PSw 60° at ISw	- Decreased pelvic rotation - Prosthesis too short - Too much knee flexion resistance
Pelvic Rotation	<input type="checkbox"/> Lack prosthetic limb forward pelvic rotation	5° forward and backward both sides	- Inadequate pelvic and hip mechanics - Prosthesis too short
Trunk & Arm Motions	<input type="checkbox"/> Decreased trunk rotation <input type="checkbox"/> Asymmetrical arm swing <input type="checkbox"/> Lateral Trunk Lean	5° in opposition to the pelvis Symmetrical arm swing Neutral, upright alignment	- Poor balance - Use of an assistive device - Prosthesis too short - Weak or poorly trained prosthetic side musculature - Habit
All	<input type="checkbox"/> No Deviation		



Youtube Video: Ottobock - Dynion 3R85

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FLAG: Reliability ($K \geq .41$)

Table 5.2: Gait Deviations that Achieved Inter-rater Reliability

PTs Group		CPs Group	
1	Prosthetic limb abducted	1	Prosthetic limb abducted
2	Prosthetic limb step shorter	2	Intact limb step faster
3	Lack prosthetic limb forward pelvic rotation	3	Prosthetic limb step shorter
4	Lateral trunk lean	4	Less than expected knee flexion
		5	Asymmetrical arm swing
		6	Lateral trunk lean

Table 5.1: Gait Deviations that Achieved Intra-rater Reliability

PTs Group		CPs Group	
1	Prosthetic limb abducted	1	Prosthetic limb abducted
2	Intact limb step shorter	2	Intact limb step shorter
3	Intact limb step faster	3	Intact limb step faster
4	Prosthetic limb step shorter	4	Prosthetic limb step shorter
5	Less than expected knee flexion	5	Less than expected knee flexion
6	Lack prosthetic limb forward pelvic rotation	6	Asymmetrical arm swing
7	Decreased trunk rotation	7	Lateral trunk lean
8	Asymmetrical arm swing		
9	Lateral trunk lean		



FLAG: Validity

- **Criterion-concurrent** validity of **prosthetic limb step shorter** was established in community ambulators with unilateral LLA ($\geq 80\%$)
- **Construct validity:** lack prosthetic limb forward pelvic rotation, asymmetrical arm swing, and lateral trunk lean
 - Present = lower balance confidence scores (ABC)
 - Present = slow gait speeds (10MWT)

Takeaway: FLAG Assessment provides an important first step towards establishing a reliable and valid OGA tool to assess the gait of people with unilateral LLA.



Functional Lower-Limb Amputee Gait Assessment

Gait Action	Gait Deviations
1. Step Width	Intact limb foot at midline Prosthetic limb abducted
2. Step Length and Time	Intact Limb Step SHORTER Intact Limb Step FASTER Prosthetic limb step SHORTER
3. Forefoot Load	Decreased prosthetic forefoot load
4. Knee Flexion	Less than expected knee flexion
5. Pelvic Rotation	Reduced PROSTHETIC limb forward rotation
6. Trunk & Arm Motion	Decreased Trunk Rotation Asymmetrical Arm Swing Lateral Trunk Lean



1st Gait Action: Step Width

- **Observe:** Frontal plane
- **Gait Task:** Weight Acceptance
- **Expected norm:** 2-4”
- **Observed gait deviations:**
 - Intact foot at midline
 - Prosthetic limb abducted

Gait Action	Observed Deviation	Expected Normative Observation	Possible Causes
Step Width	<input type="checkbox"/> Intact limb foot at midline <input type="checkbox"/> Prosthetic limb abducted	5 to 10 cm (2 to 4 inches)	- Poor balance on the prosthesis - Habit of relying more on the intact limb - Balance because of intact limb foot at midline - Weak or poorly trained prosthetic side musculature

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1st Gait Action: Step Width

Let's consider this patient...



Step Width: Intact Foot at Midline

- **Observable Signs:**
 - **Primary:** heel placed under intergluteal cleft
 - **Secondary:** Intact limb in ER
- **Possible Causes:**
 - Poor balance on prosthesis
 - Habit of relying on sound limb for stability



Step Width: Prosthetic Limb Abducted

- **Observable Signs:**
 - Prosthesis abducted beyond natural line of progression
 - Step width >2-4"
- **Possible causes:**
 - Poor balance / increase stability
 - Weak / Improperly trained prosthetic side hip abductors



2nd Gait Action: Step Length & Time Symmetry

- **Observe:** Sagittal
- **Expected norm:** >12" (step length) & symmetrical timing of steps
- **Observed Gait Deviations:**
 - Sound limb step faster
 - Sound limb step shorter
 - Prosthetic limb step shorter



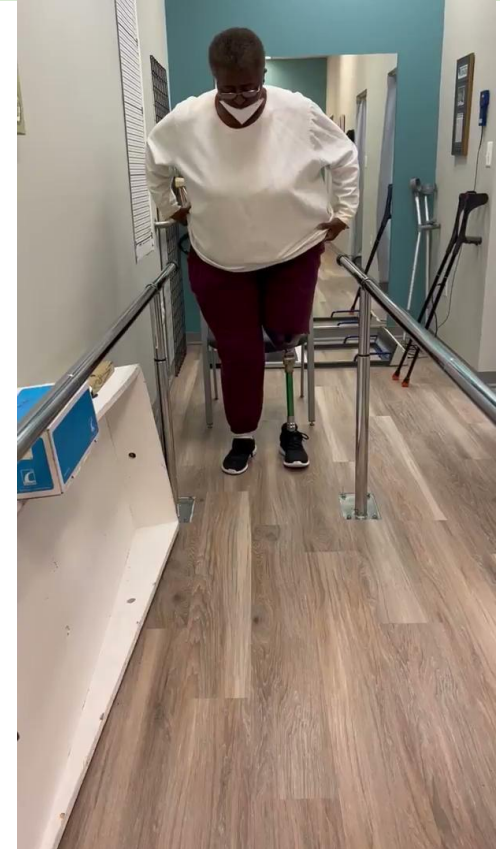
Step Length and Time: Sound Limb Step Faster

- **Gait Task:** Single limb support
- **Observable Signs:** Temporal
 - Duration of prosthetic SLS is shorter than sound limb SLS.
- **Causes:**
 - Poor balance over prosthesis
 - Pain/discomfort
 - Decreased confidence in prosthesis



Step Length and Time: Sound Limb Step Shorter

- **Gait Task:** Weight Acceptance
- **Observable Signs:**
 - Distance between prosthetic toes and intact heel <12"
 - Sound limb step length shorter than prosthetic step length
- **Possible Causes:**
 - Poor balance over prosthesis
 - Pain/discomfort
 - Decreased confidence in prosthesis



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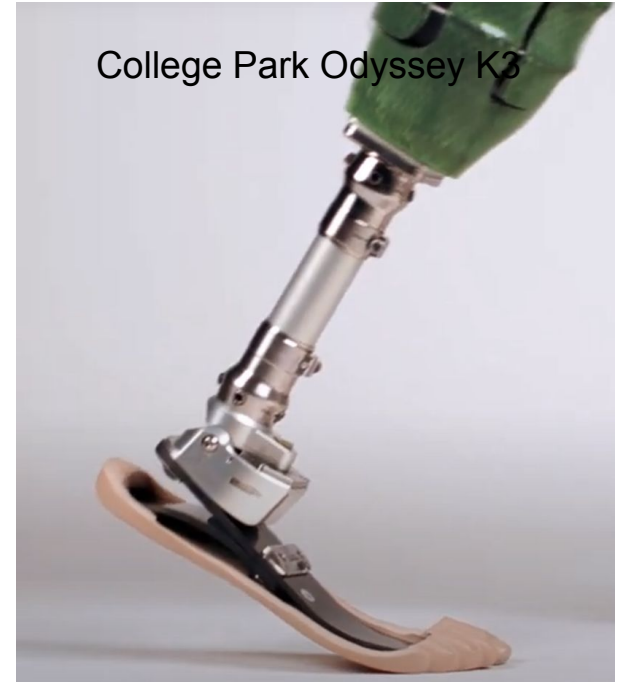
Step Length and Time: Prosthetic Limb Step Shorter

- **Gait Task:** Weight Acceptance
- **Observable Signs:**
 - Distance between intact toes and prosthetic heel <12”
 - Prosthetic step length is shorter than sound limb step length
- **Possible Causes:**
 - Habit of spending longer time on sound limb



3rd Gait Action: Forefoot Load

- **Observe:** Sagittal
- **Gait Tasks:**
 - Single Limb Support (late)
 - Single Limb Advancement (early)
- **Expected norm:** heel off the ground, MP joints in extension
- **Observed gait deviation:**
 - Decreased loading of the prosthetic forefoot



Forefoot Load: Decreased prosthetic forefoot load

- **Observable Signs:**

Primary

- Insufficient time spent on forefoot
- Absence of forefoot crease (MPJ extension)

Secondary (Prosthetic):

- “Lift” and “Kick”
- Circumduction
- Hip Hike

Secondary (Intact):

- Shorter step length
- Vaulting

- **Possible Causes:** Poor balance over prosthetic forefoot



4th Gait Action: Knee Flexion

- **Observe:** Sagittal
- **Gait Task:** Single Limb Advancement
- **Expected norm:**
 - *Pre-Swing:* 30-40°
 - *Initial Swing:* 60°
- **Observed gait deviation:**
 - Less than expected knee flexion



Knee Flexion: Less than expected knee flexion

- **Observable signs:**

Primary

- $<30^\circ$ flexion at PSw
- $<60^\circ$ flexion at ISw

Secondary (intact)

- Vaulting

Secondary (Prosthetic)

- Circumduction
- Hip Hiking

- **Possible Causes:**

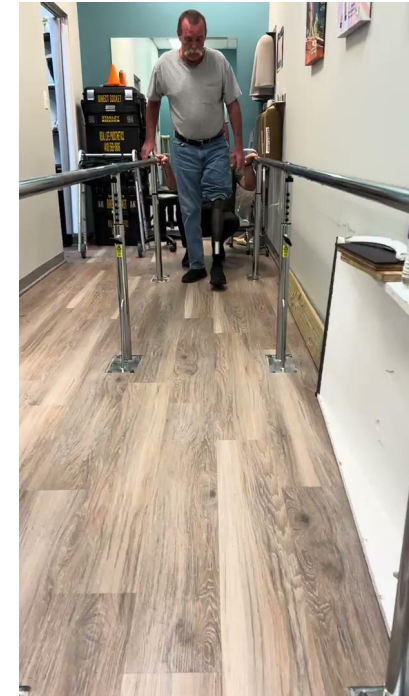
- Decreased pelvic rotation on prosthetic side
- Prosthesis too short
- Excessive knee flexion resistance

Kristal, A. (2021)



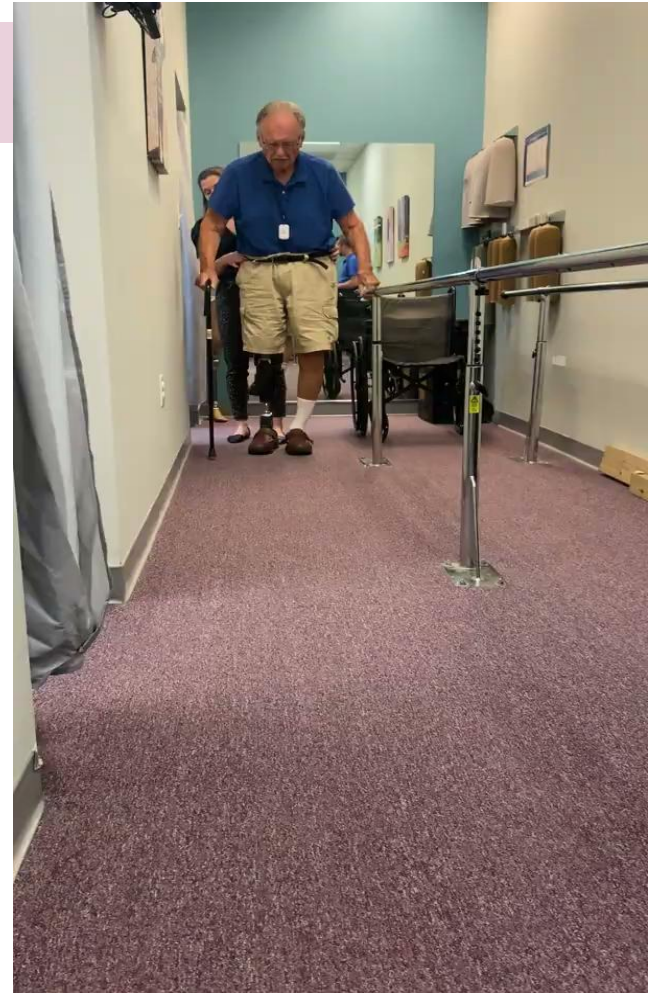
Reduced knee flexion: Prosthetic Causes

- **Swing Phase Control:** flexion resistance set too high
- **Too stable of alignment:** TKA too anterior to knee center
- **Prosthesis too short:** loss of CKC



5th Gait Action: Pelvic Rotation

- **Planes to observe:** Frontal & Sagittal
- **Gait Task:** SLA
- **Expected Norm:** 5° FWD and BWD pelvic rotation
- **Observed gait deviation:**
 - Reduced prosthetic limb forward rotation (transverse)



Pelvic Rotation: Reduced transverse pelvic rotation

Observable Signs:

Primary:

- Decreased forward motion of ASIS

Secondary (intact):

- Weight remains on heel
- Toe extension during prosthetic SLA
- Toe flexion during WA
- Vault

Possible causes:

- Inadequate pelvic/hip biomechanics
- Prosthesis too short

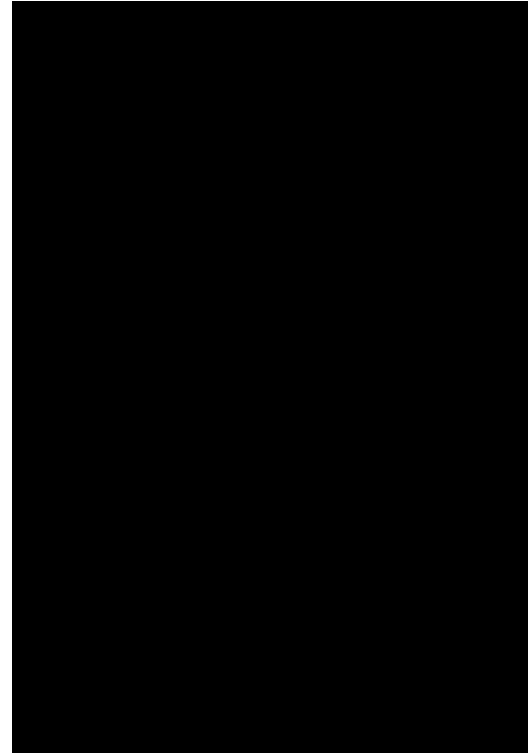
Secondary (prosthetic)

- “Lift” and “kick”
- Circumduction
- Hip Hiking



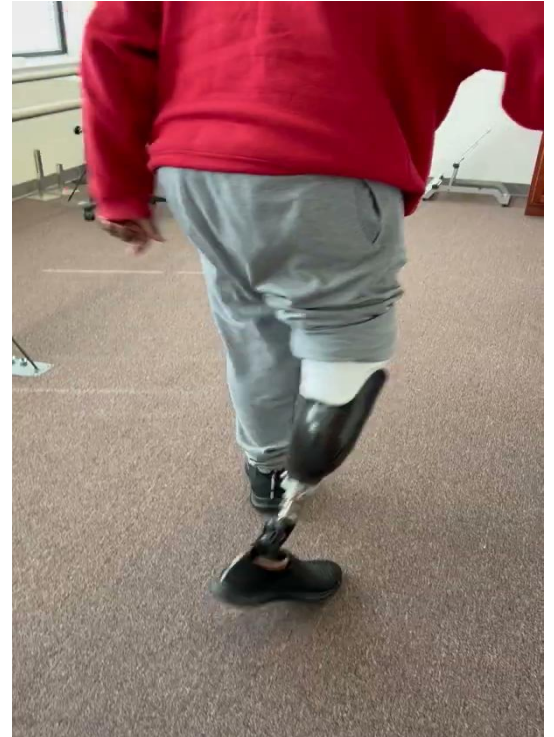
6th Gait Action: Trunk & Arm Motion

- **Trunk Expected Norm:**
 - **Transverse plane:** 5° rotation in opposition of pelvis
 - **Frontal Plane:** maintain a neutral, upright trunk alignment.
- **Arms Expected norm:** symmetrical swing
 - Arms are an extension of trunk rotation
- **Expected deviations:**
 - 1. Decreased trunk rotation
 - 2. Asymmetrical arm swing
 - 3. Lateral trunk lean



Trunk Motion: Decreased trunk rotation

- **Observe Sagittal**
- **Gait task:** Single limb advancement
- **Observable signs:**
 - **Primary:** lack of shoulder rotation in opposition to pelvis
 - **Secondary:** Abducted arms
- **Possible causes:**
 - Poor balance
 - Use of an assistive device



Trunk Motion: Lateral trunk lean

- **Observe:** Frontal
- **Gait task:** Weight acceptance & Single limb support
- **Observable signs:** Trunk shifts laterally beyond prosthesis
- **Possible causes:**
 - Prosthesis too short
 - Weak or poorly trained prosthetic side hip abductors
 - Pain/discomfort
 - Habit of passively shifting the trunk towards the prosthesis.



Arm motion: Asymmetrical arm swing

- **Observe:** Sagittal & Frontal
- **Gait Task:** Single limb advancement
- **Observable signs:** Asymmetrical arm swing (abducted arm)

- **Possible causes:**
 - Poor balance
 - Use of an assistive device



Interventions



Gait Action: Step Width

Equal WB'ing

- **Deviation(s):** Intact foot at midline and prosthesis abducted
- **Intervention:** Identify new location of CoM to promote equal weight distribution between limbs.
- **How:** Place patient in normal alignment (rotate pelvis)



Gait Action: Step Length & Timing

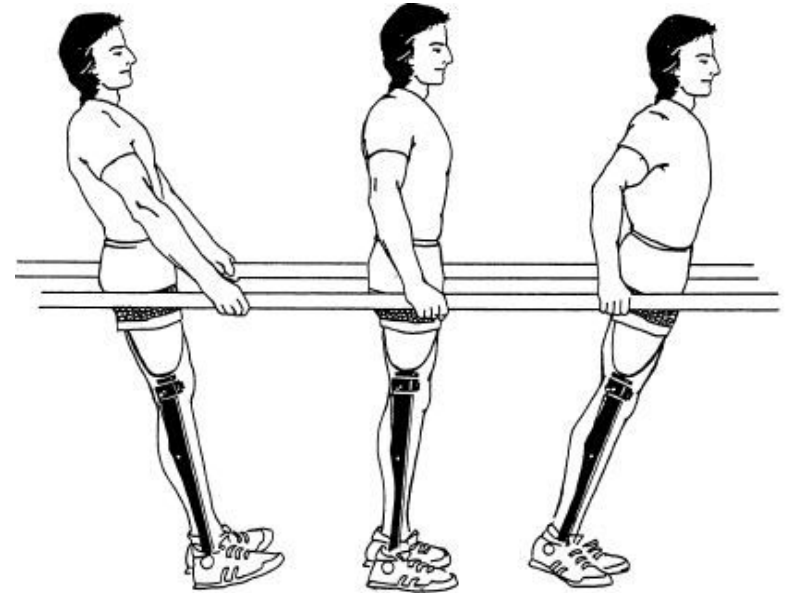
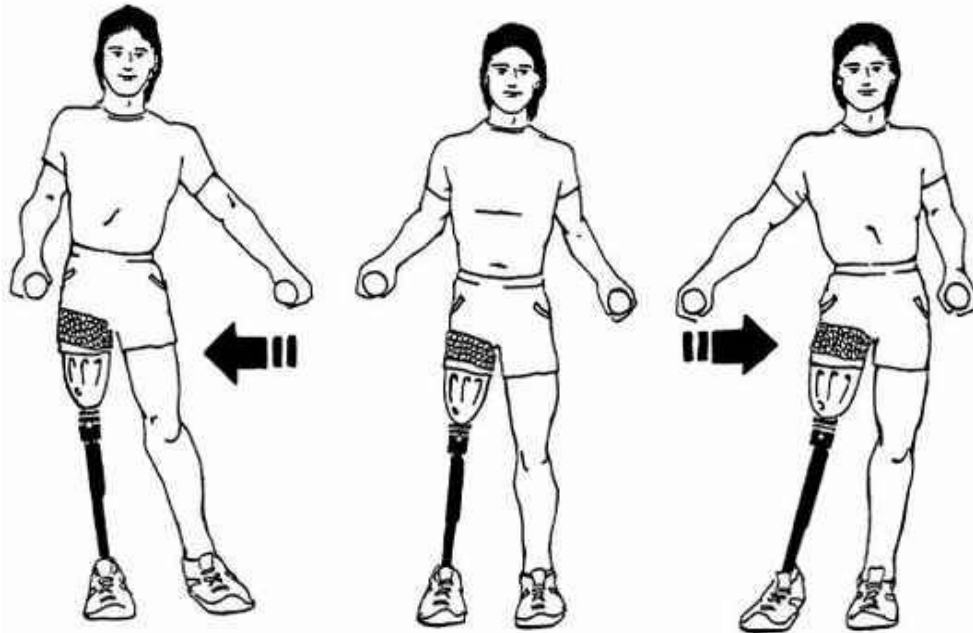
Foot-Floor Interface

- Orientation of CoM
 - Using a reflex hammer, tap big toe, little toe, heel
- Cue patient to shift weight to each part of the foot
- Enhances proprioception using the foot as a reference point
 - “roll over the toe”
 - “keep weight over big toe”



Gait Action: Step Length & Timing

Weight shifting



F. AUGILO

Gailey, 1992



Pelvic Control Exercises:

- Ball Rolls
- Perform quickly and in all planes to train muscles inside the socket how to respond to multi-directional perturbation



Gait Action: Step Length & Timing

Step Taps



Gait Action: Pelvic Rotation

Sound Limb Stepping



Flex-Foot Exercise - Spotstepping - Ossur Academy

Gait Action: Pelvic Rotation

Rhythmic Initiation



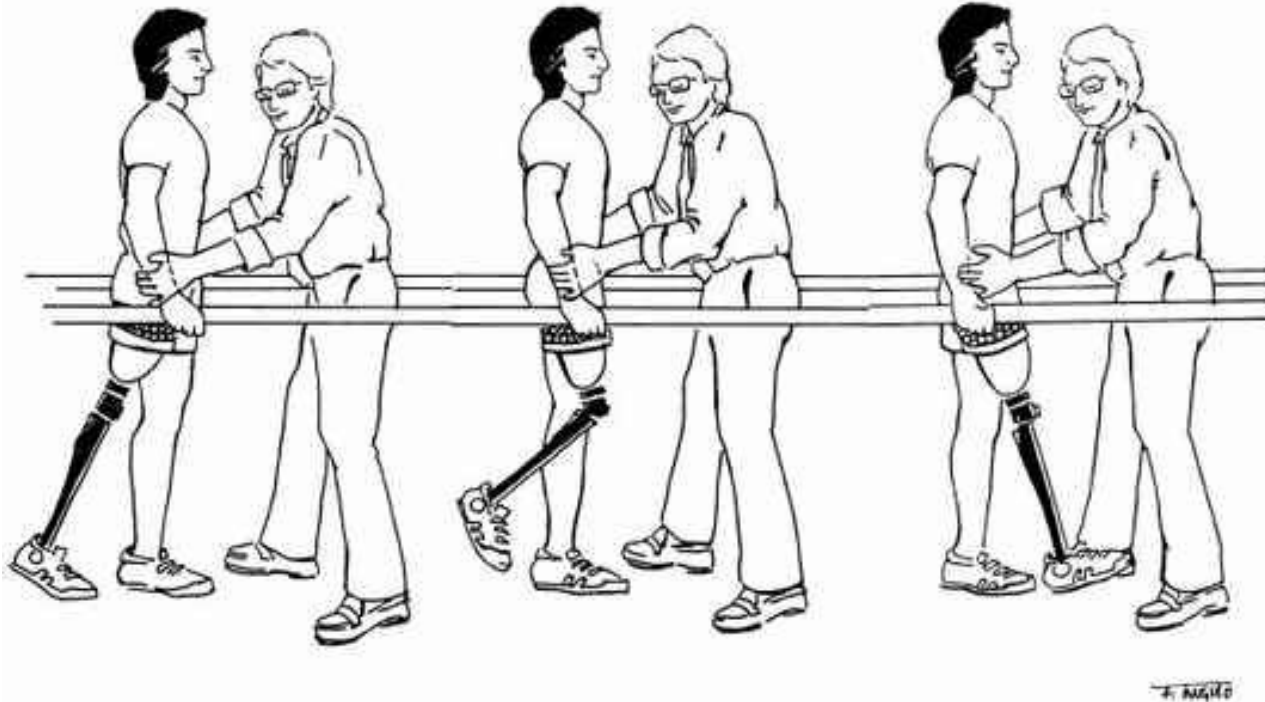
***Prosthetic
Step
Training***

Mission Gait Foundation



Gait Action: Pelvic Rotation

Resistive Gait Training



Gailey, 1992



*Prosthetic
Step
Training*





*Prosthetic
Step
Training*



Gait Action: Trunk & Arm Motion

Ball Roll Progressions

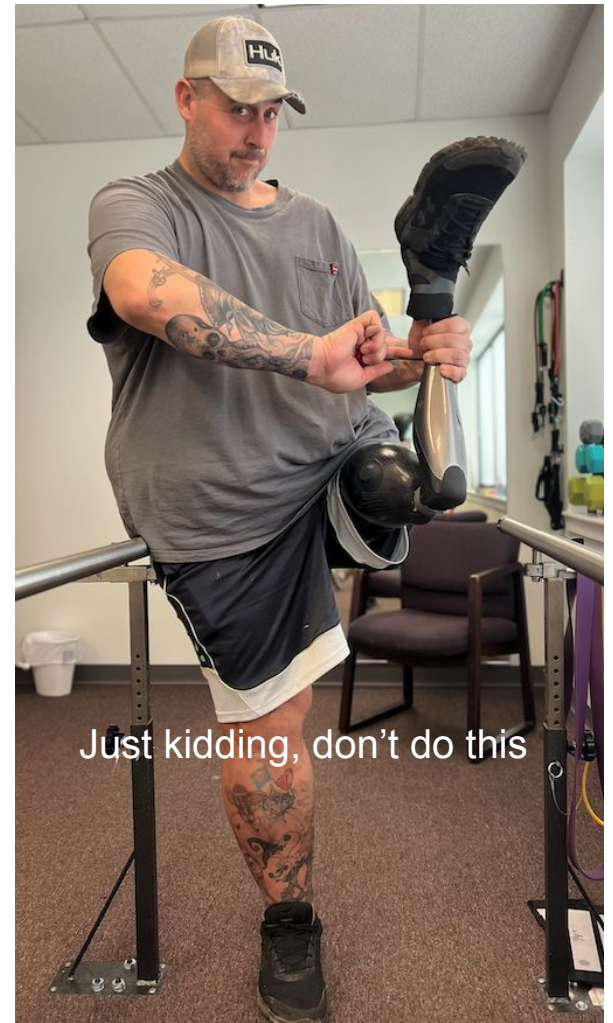
- **Deviation:** Lateral Trunk Lean
- **Possible Cause:** Weak / Poorly trained Hip Abductors
- Loss of proprioceptive input = Decreased speed of contraction



- **Deviation:** Decreased prosthetic forefoot load
- **Intervention:** Resisted Ambulation
 - **Technique:** Resist slightly when weight is over the prosthetic forefoot and sound limb advances



How can PTs address prosthetic related concerns in the clinic?



Signs of a long prosthesis

- Vaulting gait (contralateral side)
- Pistoning / poor suspension
 - Prosthesis functionally long in swing
- Wide base gait (Abducted)
- Circumduction

Signs of Poor Suspension

- Abducted gait
- Socket rotation
- Pistoning



Summary

1. FLAG enables communication between PTs and CPs using a shared language of the 11 most common gait deviations
2. PT interventions must train hip strategies, pelvic stability, and ability to displace CoM over BoS.
3. Poor balance and lack of confidence over prosthesis can result in 1 or all 11 of the presented gait deviations



Questions?

Thank you!

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