BIOMECHANICAL GAIT CHARACTERISTICS OF UNSUCCESSFUL FOOT CLEARANCE DURING SWING IN INDIVIDUALS WITH CHRONIC STROKE

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Stroke

- Approximately 800,000 strokes occur in the U.S. each year (Go 2013)
- Stroke is a leading cause of impairment and physical disability
- Hemiparesis is a common motor deficit following stroke (Cauraugh 2003)

Falls following stroke

- 70-80% of post-stroke individuals will experience a fall (Forster 1995)
- Most falls occur during walking and transfers
- High incidence of adverse outcomes due to falls in individuals following stroke (Schmid 2013)

Hemiparetic gait

- Alterations in lower limb mechanics (Olney 1996)
  - Joint angle changes throughout the gait cycle
  - Changes in joint moments and powers

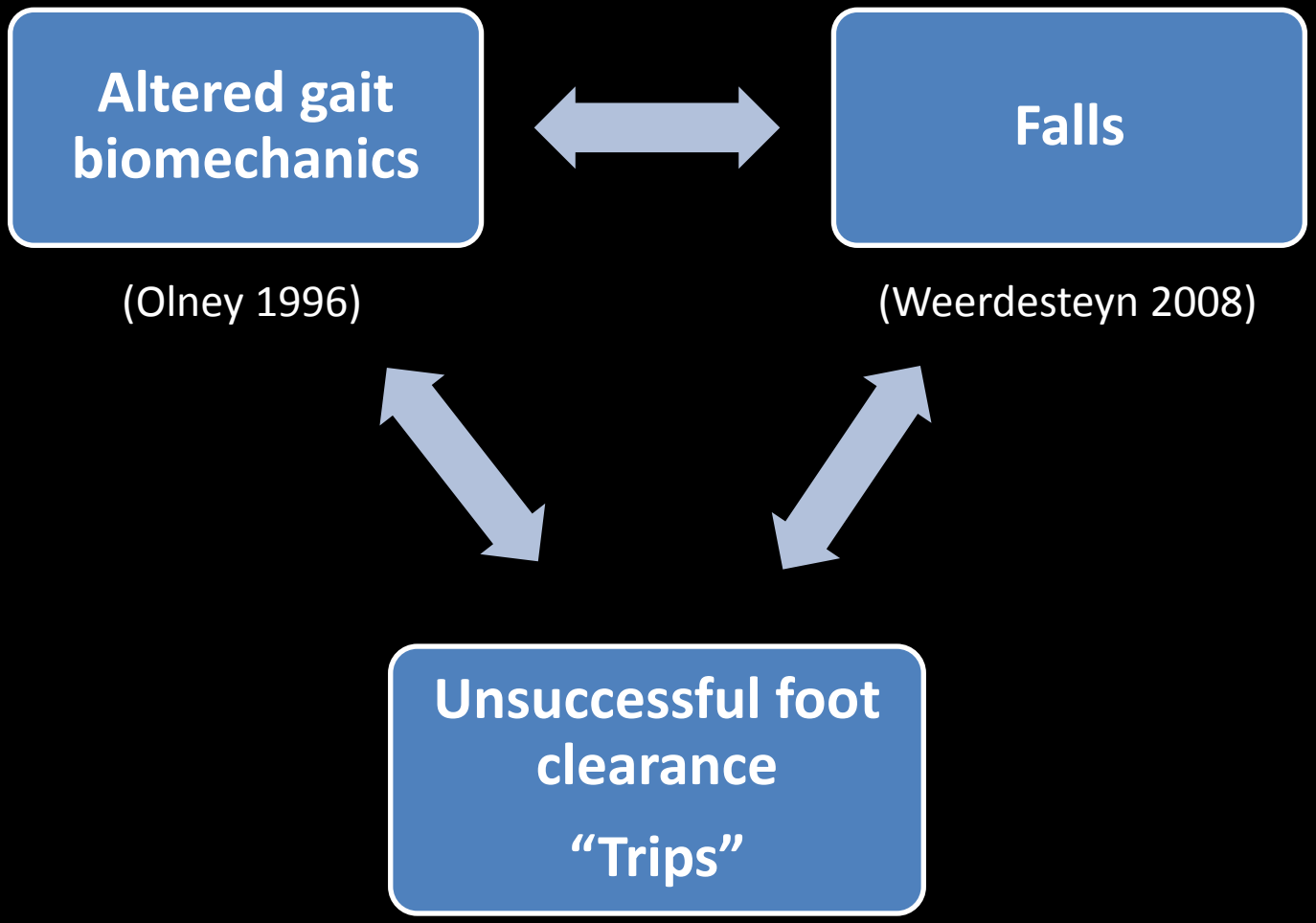
- Resultant gait abnormalities (De Quervain 1996)
  - Reduced walking speed
  - Reduced step length
  - Reduced stance time on the paretic limb
  - Increased double support time

Hemiparetic gait

- The biomechanical patterns that characterize hemiparetic gait negatively affect ambulatory ability (Weerdesteyn 2008)

- Gait impairments result in an increased risk of trips and falls during walking

Hemiparetic gait, trips, and falls



Purpose

- Determine biomechanical characteristics surrounding instances of unsuccessful foot clearance in individuals following stroke

Hypothesis

- During unsuccessful foot clearance, subjects will exhibit biomechanical alterations that result in a functionally longer limb in swing phase

"Trip" Kinematics

↓ Pelvic obliquity ↓ Hip flexion ↓ Knee flexion ↑ Plantarflexion

Subjects n=26

Demographics	Mean	SD	Range
Age (y)	56.0	11.5	(35-81)
Time post stroke (months)	59.5	75.9	(9-333)
Gait speed (m/s)	0.68	0.27	(0.2-1.3)
Fugl-Meyer Motor Function LE	23.9	4.40	(14-31)
Berg Balance Scale	48.8	5.5	(38-56)
	Number of subjects		
Paretic side (Right/Left)	15/11		
AFO	2		
Assistive device	2		

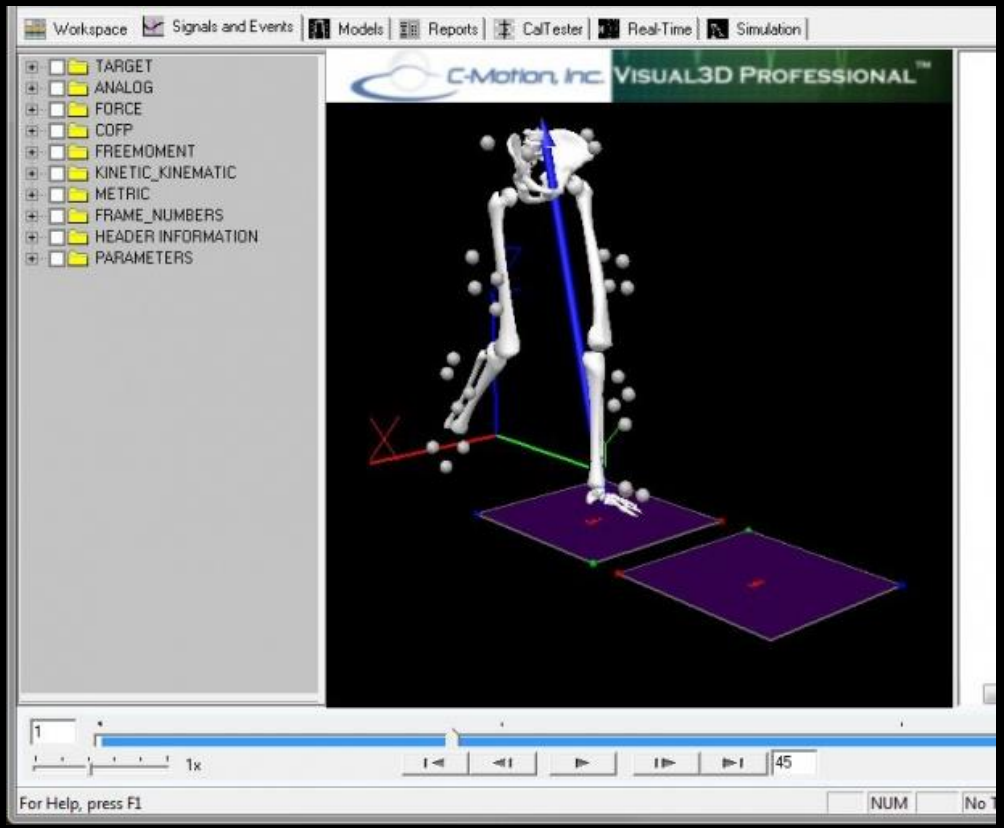
Gait Analysis

- 20 min training session
- Dual-belt ‘instrumented’tre admill (Bertec Corp.)

Gait Analysis

- Limb movement recorded via retro-reflective markers and a motion analysis system (Vicon Corp)
- Collected at 120 Hz

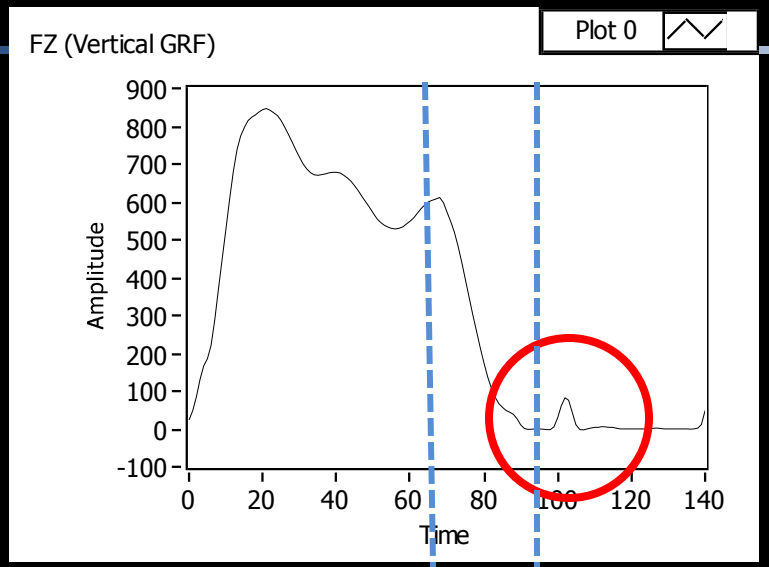
Gait Analysis

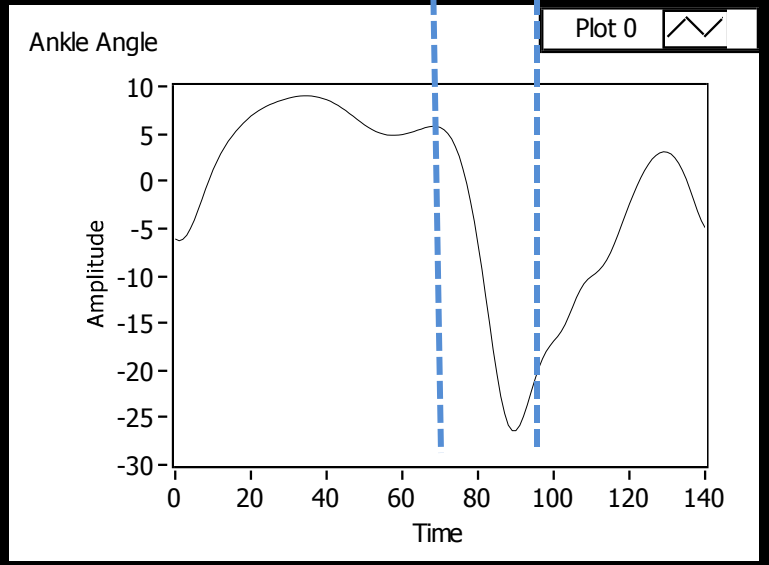


Visual3D (C-Motion, Germantown, MD)

- Sagittal, frontal, and transverse plane angles
- Hip, knee, and ankle joints

Biomechanical parameters during "trips"





Collected measures

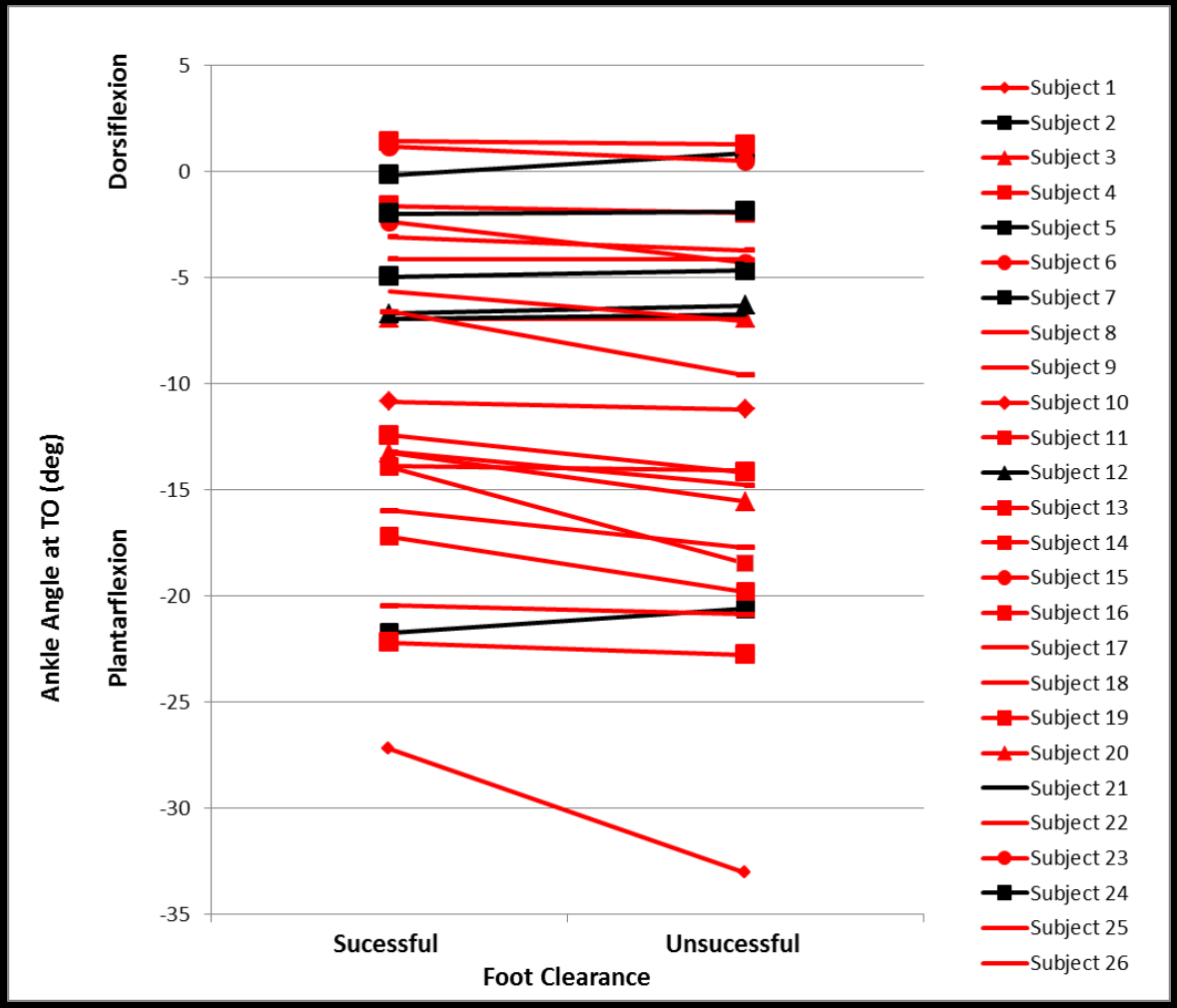
- Spatiotemporal parameters
  - Stance time
  - Double support time
- Kinematic parameters
  - Peak sagittal plane hip, knee, ankle angles
  - Frontal plane pelvis and hip angles
  - Knee angular velocity
- Kinetic parameters
  - Hip, knee, ankle joint moments
  - Max hip and ankle powers
  - Ground reaction forces

Statistics

- Paired samples t-test

$p<0.05$

Successful vs unsuccessful foot clearance

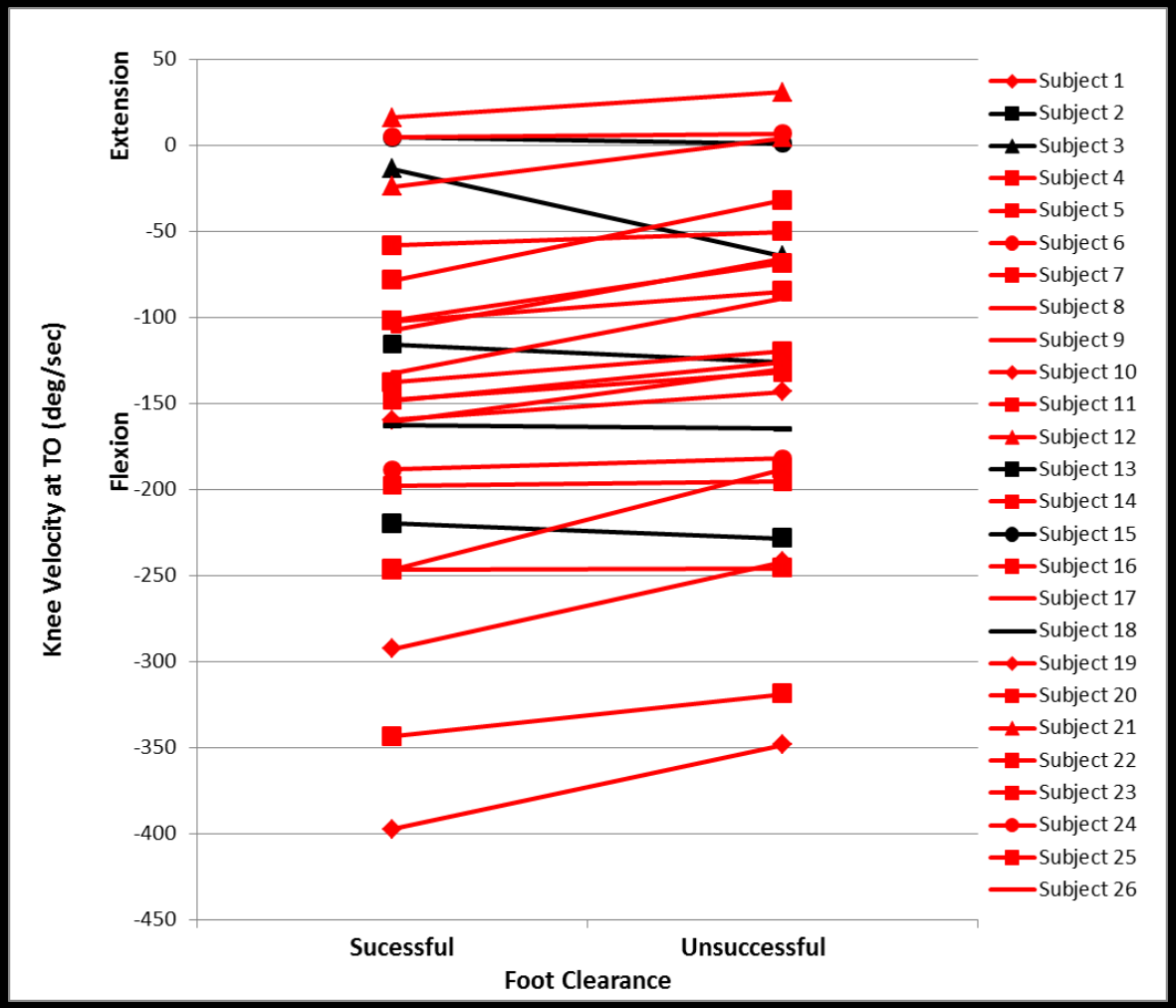


Ankle angle at toe-off

p = .003

Mean difference: 1.1° more plantarflexion

Successful vs unsuccessful foot clearance

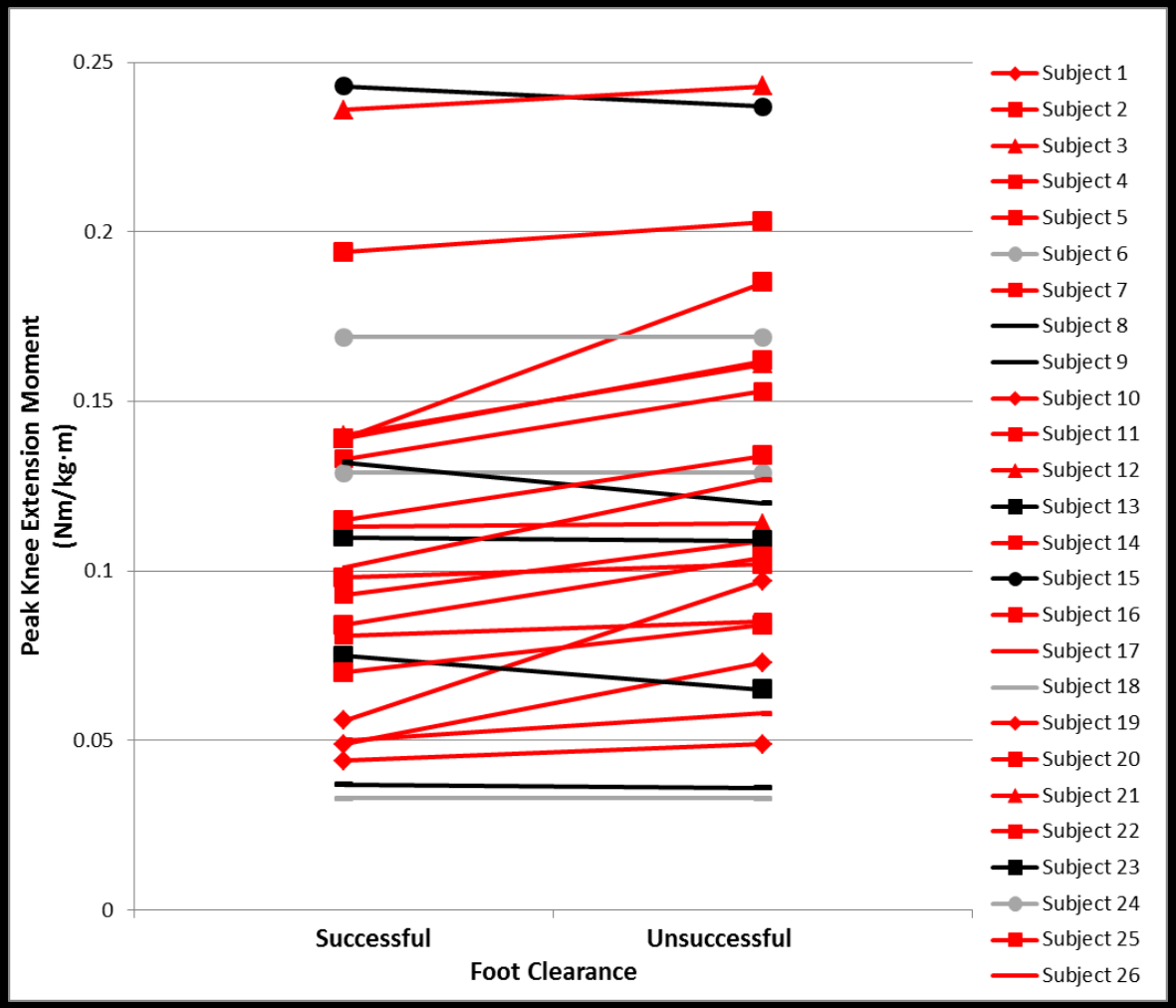


Knee flexion velocity at toe-off

p = .001

Mean difference: 17.5°/sec less knee flexion velocity at TO

Successful vs unsuccessful foot clearance



Peak knee extension moment late stance

p = .001

Mean difference: <u>0.01 Nm/kg·m</u> greater knee extension moment

Conclusions

- Small quantitative differences between successful and unsuccessful foot clearance
- Multi-joint biomechanical changes contribute to unsuccessful foot clearance
- These changes result in a functionally longer paretic limb during swing phase

Clinical Implications

- Minor alterations in movement of the paretic limb can lead to unsuccessful foot clearance and an increased risk for falls

- Multi-joint interventions targeting increased flexion throughout the paretic limb may reduce the risk of unsuccessful foot clearance in hemiparetic individuals

Thank you

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  - Foundation for Physical Therapy, Inc.: Geriatric Endowment Fund
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Biomechanical parameters

Measure	*P* value
Stance phase (sec)	0.36
Double support time (sec)	0.41
Propulsive impulse	0.57
Peak propulsion	0.24
Ankle angle (toe-off)	0.003
Peak DF angle (swing)	0.77
Peak knee flexion angle (swing)	0.19
Knee flexion velocity (toe-off)	0.001
Peak hip extension angle (late stance)	0.87

Measure	*P* value
Hip hike angle (swing)	0.71
Circumduction (mm)	0.52
Plantarflexion moment	0.57
Knee extension moment	0.001
Hip flexion moment	0.50
Plantarflexion power	0.41
Hip flexion power	0.22
Limb length (toe-off)	0.70
Limb length (swing)	0.82