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INTRODUCTION

- Standard of care for individuals with a transfemoral amputation is an ischial containment (IC) socket
- Proximal brim of IC socket can cause
 - Discomfort
 - Increased pressure
 - Limited hip range of motion (ROM) [1,2]
- Limited hip ROM during walking can lead to unhealthy compensatory strategies [1]
- Advancements in socket suspension have allowed prosthetists to design sub-ischial (SI) sockets that eliminate ischial containment. Vacuum-assisted socket suspension aims to reduce motion between the residual limb and socket [2]. With improved coupling, the proximal brim of a socket can be lowered below the ischial tuberosity.

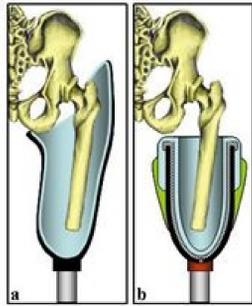


Figure 1. Ischial containment socket on left and sub-ischial socket with vacuum-assisted socket suspension on right. Sub-ischial socket has a lower proximal brim eliminating ischial containment. Image courtesy of NUPOC.

- Potential benefits of SI socket and vacuum-assisted socket suspension
 - Less motion between socket and limb [2]
 - Greater hip ROM
 - Increased comfort during sitting [1,3]
- Potential concern
 - May affect socket stability (frontal plane relative motion between the socket and the residual limb) during walking [4]
- Purpose:** To compare walking biomechanics and patient satisfaction with IC and SI sockets in individuals with unilateral transfemoral amputation

METHODS

- Inclusion Criteria:**
 - 18-45 years old
 - Unilateral transfemoral amputation
 - Residual limb length minimum of 4 inches
 - No prior experience with vacuum-assisted socket suspension
- Each subject wore an IC socket at enrollment and an SI socket was fabricated for the study

Subject Demographics & Sub-Ischial (SI) Accommodation

Subject	Gender	Age (yrs)	Height (m)	Mass (kg)	Time in SI socket
P01	M	35	1.86	95	8 weeks
P02	M	33	1.72	77	3 days*
P03	M	30	1.85	94	9 weeks

* Quick return to duty

- Prosthetic components
 - IC - passive suction suspension
 - SI - vacuum-assisted suspension
 - Gel liner with both sockets
 - X3 microprocessor knee, Ottobock, USA
 - Energy storage and return prosthetic foot
- Assessment of hip and trunk biomechanics during gait at a self-selected walking speed
 - Level over ground (OG) walking
 - Ascending 16 step staircase (STA)



Figure 2. Ischial containment socket with passive suction suspension on left and sub-ischial socket with vacuum-assisted socket suspension on right. Both sockets worn with a gel liner, X3 microprocessor knee and energy storage and return foot.

- Mean differences compared between sockets
 - Hip and trunk ROM during OG walking
 - Hip ROM during STA
 - Differences during OG walking were compared to minimal detectable change values (MDC) [5]

RESULTS

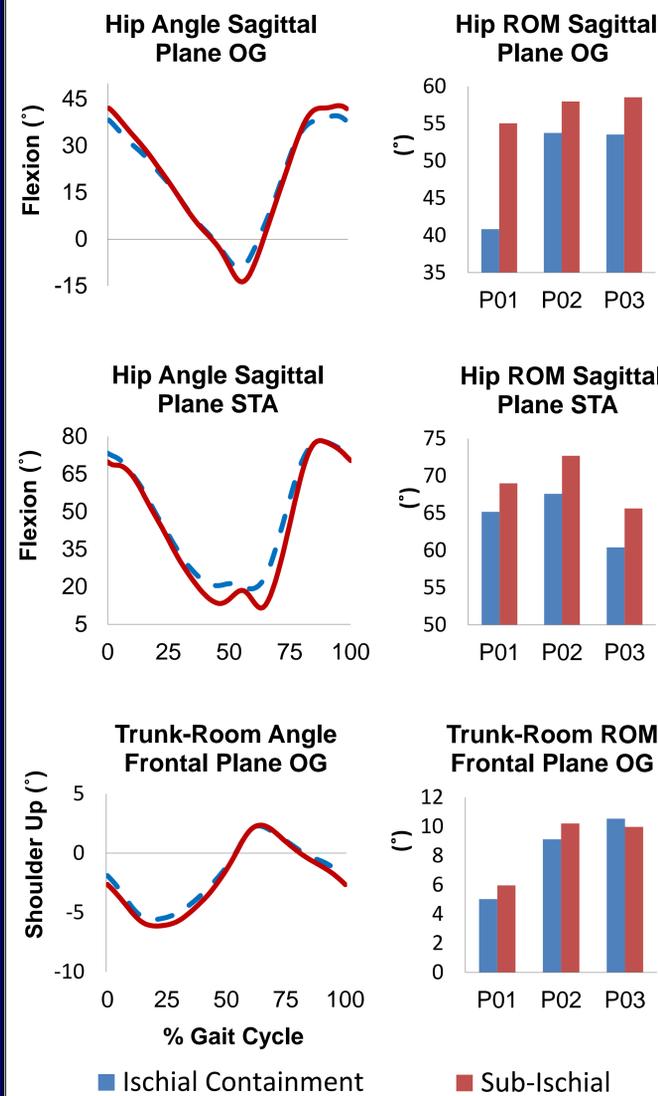


Figure 3. Left column: mean data during gait cycle of sagittal plane hip angle during over ground (OG) walking (top) and stairs ascent (STA) (middle) and frontal plane trunk-room angle during OG walking (bottom). Right column: individual subject ranges of motion (ROM) for same activities and joint/segment.

- There was an average 7.8° increase in sagittal plane hip ROM during OG walking in the SI socket as compared to the IC socket. Each subject's increase in sagittal plane hip ROM was greater than the MDC (3.2°).
- There was an average 4.7° increase in hip ROM during STA in the SI socket compared to the IC socket. MDC not available.
- For all subjects, hip extension increased during both OG walking and STA in the SI as compared to the IC socket.
- There was no consistent change in frontal plane trunk ROM between the IC and SI sockets in OG walking and the difference for all subjects was below the MDC (1.1°).

Self-Selected Walking Speed (m/s)

Subject	Overground (OG)		Stairs Ascent (STA)	
	Ischial Containment (IC)	Sub-Ischial (SI)	Ischial Containment (IC)	Sub-Ischial (SI)
P01	1.23	1.18	0.33	0.32
P02	1.24	1.18	0.38	0.40
P03	1.42	1.39	0.45	0.40

- Self-selected walking speed was overall faster while walking in the IC socket compared to the SI socket. All differences per activity were less than 0.1 m/s.

Socket Preference

Activity	Sub-Ischial (SI)	Ischial Containment (IC)	No Preference
Daily use	P01	P02, P03	
Cycling, Squats	P01, P02, P03		
Sitting	P01, P03		P02

CONCLUSIONS

- Walking with a SI socket resulted in greater sagittal plane hip ROM during OG walking and STA compared to walking with an IC socket.
- The difference in hip ROM during OG walking was greater than the MDC [5] indicating a true difference exists between the sockets.
- Hip extension increased during both OG walking and STA in the SI as compared to the IC socket. However, self-selected walking speed was overall faster in the IC socket indicating increased hip extension did not result in increased walking speed.
- During OG walking the SI socket did not increase frontal plane trunk ROM relative to an IC socket. When socket stability is compromised, individuals may compensate with increased lateral trunk displacement [6]. Therefore, this suggests lowering the proximal brim may not affect frontal plane socket stability.
- There was a consistent preference for the SI socket for activities such as cycling and squats but overall preference for daily use was mixed.
- The results of this study indicate a SI socket may have hip ROM and comfort advantages compared to an IC socket without affecting socket stability. However, an increase in sample size is necessary to determine a clear preference for comfort and daily use.

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