



# Stair Ascent and Descent with Genium and C-Leg Knees

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## INTRODUCTION

Unilateral lower limb pathologies commonly lead to a step-to (ST) gait pattern during stair walking. However, the C-Leg has enabled transfemoral amputees (TFAs) to descend stairs using a step-over-step (SOS) gait pattern. This study presents gait patterns used by TFAs in a randomized cross-over study of the Genium and C-Leg prosthetic knees. Gait patterns were classified for each knee using 3D motion capture data to identify the leading foot and the gait style as ST or SOS.

## METHOD

**Subjects:** 5 Non-amputee controls & 20 TFAs (19 Male, 6 Female). Study protocols were approved by the University of South Florida's IRB, and informed consent was obtained prior to data collection.

**Apparatus:** Randomized experimental A-B crossover. 8 camera Vicon (Oxford, UK) motion analysis system.

**Procedures:** Control subjects' gait was recorded for reference prior to recording TFAs. TFAs were randomized to C-Leg or Genium knee for phase A testing. After an accommodation period, subjects were asked to demonstrate a step-over gait (if able) and their normal gait (if different) for stair ascent and descent. Amputee subjects switched knee type, and re-accommodated, prior to returning for phase B testing. While accommodating to the Genium knee, subjects were trained to utilize novel features of the knee (Highsmith et al., 2014).

**Data Analysis:** Motion analysis data were filtered using a weighted moving average to remove noise. Markers positioned superior to the 2<sup>nd</sup> metatarsal head (or approximate location on prosthetic side) were used to track footsteps. Knee flexion data were calculated based on marker clusters placed on the thigh and shank of each subject.

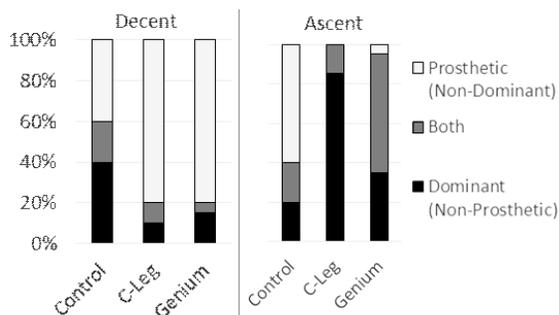


Figure 1. Percent of subjects leading with; only the Prosthetic (Non-Dominant) side (White); both sides (Gray); and only the Dominant (Non-Prosthetic) side (Black) for stair descent & ascent: Controls, C-Leg, Genium.

## RESULTS

Subjects demonstrated several gait patterns. Controls had symmetric steps, always used SOS gait, and did not show a strong preference for leading foot in either ascent or descent. TFAs were more variable when deciding the leading foot. TFAs tended to prefer to lead with their prosthetic foot during descent, and the contralateral side for ascent. During ascent while using the Genium knee subjects were more likely to lead with the prosthetic foot. (Figure 1) During descent, most TFAs led with their prosthetic side, placed the heel on the step's edge and rode the knee resistance down, regardless of knee.

On ascent, TFAs either used ST gait, with little change in knee flexion, or SOS gait. Within SOS TFA gait, several variations were observed. Some used SOS without using pronounced knee flexion. This was the primary pattern used 5/20 TFAs able to use SOS with C-Leg. While using Genium, 18/20 TFAs could activate knee flexion and demonstrate an ascent pattern similar to controls. However, many TFAs also exhibited exaggerated knee flexion and heel rise with Genium use during ascent.

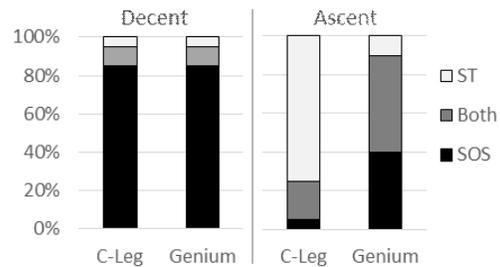


Figure 2. Gait style of TFAs during stair descent & ascent.

## DISCUSSION

Genium significantly ( $p < 0.001$ , McNemar's) increased the number of amputees able to ascend stairs using a SOS gait pattern, but did not show significant difference during stair descent. Results agree with previous studies evaluating the C-Leg and X2 knees, that found improvement in gait parameters with use of the X2 knee (Whitehead et al., 2014) for stair ascent.

## CONCLUSION

Genium knee use seems to decrease TFA movement impairment during stair ascent.

## CLINICAL APPLICATIONS

Genium knee use may be beneficial for users who want or need to ascend stairs regularly.

## REFERENCES

Highsmith et al., Technology & Innovation, 15, 349-358, 2014.  
Whitehead et al., Clin. Orthopaedics., 472, 3093-3101, 2014