INTRODUCTION
Lower limb prostheses that provide power at the knee and/or ankle joints may allow amputees to ambulate with a more normal gait. These devices have the capability to aid transfemoral amputees in walking and ascending stairs (Sup et al. 2009; Lawson et al. 2013). We further investigated the configuration of and training for a powered knee and ankle prosthesis across multiple users and multiple ambulation modes.

METHOD
Seven unilateral transfemoral amputees (5 male, 2 female, mean age 44±15 years, K3/K4 ambulators) were fit with a powered knee and ankle prosthesis (Sup et al. 2009). Subjects were educated on the powered device’s capabilities and differences from their currently prescribed passive prosthesis. After the prosthesis was configured for each subject’s body weight, they were trained in five ambulation modes:

- **Level Ground Walking:** Subjects initiated swing with a forward weight shift over the prosthesis. In late stance, subjects experienced powered plantar flexion to aid in push off. The prosthesis was configured to have proper alignment at heel strike, an adequate amount of powered plantar flexion and sufficient ground clearance during swing.
- **Ramp Ascent:** Subjects walked up the ramp with a slight forward posture to allow propulsion provided by the powered plantar flexion to assist them. Prosthesis parameters were similar to walking.
- **Ramp Descent:** Subjects were instructed to allow stance phase knee flexion by “riding” the knee down the ramp. The prosthesis was configured to ensure that it had high enough resistance to support subjects throughout stance phase.
- **Stair Ascent:** Subjects climbed a 4-step staircase using a reciprocal gait. The prosthesis was configured such that the knee and ankle power was large enough to assist subjects in ascent rather than subjects pulling themselves up with the handrails. Prosthesis parameter adjustments were made to ensure adequate swing phase clearance.
- **Stair Descent:** Subjects descended the staircase using a reciprocal gait and were instructed “ride” the knee down the stairs. The prosthesis was configured to ensure that it had high enough stance phase resistance and adequate swing phase clearance.

Prosthetic joint angles were recorded for each mode. Averaged kinematic data across subjects were reported from heel strike to heel strike.

RESULTS
An average of 10-20 minutes was needed for a given subject to become comfortable with each mode. The kinematics of all modes closely resembled non-amputee gait (Figure 1).

DISCUSSION
The initial configuration of the powered prosthesis allowed subjects to quickly gain confidence in loading the prosthesis during stance. Because of this, they were able to rapidly learn the key aspects of each mode and successfully perform them in the lab. An interesting result to experimenters and amputees was that the subjects were able to comfortably ascend stairs in a reciprocal pattern having not attempted this activity post-amputation.

CONCLUSION
Multiple subjects with varying demographics (e.g., reasons for amputation, residual limb lengths, and body sizes) were able to use the powered knee and ankle prosthesis for all five in-lab ambulation modes.

CLINICAL APPLICATIONS
As powered lower limb prostheses become commercially available, it will become increasingly important to develop prosthetic configuration guidelines and patient training strategies. This will allow amputees to quickly take advantage of the benefits a powered prosthesis provides and improve their functional mobility in the home and community.

REFERENCES

![Figure 1. Powered prosthesis knee and ankle angles averaged across all seven subjects for five different ambulation modes.](image-url)