TRANSFEMORAL AMPUTEES PERFORMING SIT TO STAND WITH A POWERED KNEE AND ANKLE PROSTHESIS

INTRODUCTION
Standing up from a seated position is a difficult activity for transfemoral amputees. This task requires a significant amount of power generation at the knee. Since passive prostheses cannot assist users during this movement, amputees tend to stand up bearing most, if not all, of their weight on their sound side (Burger et al. 2005). Although powered prostheses can assist amputees in standing up (Varol et al. 2009; Highsmith et al. 2011), one study with transfemoral amputees using the Power Knee show only small improvements in limb symmetry measures compared to passive, C-Leg knees (Highsmith et al. 2011). This result may be due to the timing or delivery of power generation in these devices or the fact that the prosthetic ankles did not also generate power.

The goal of this study was to develop and test a new control strategy for a powered knee and ankle prosthesis that may encourage amputees to bear more weight through their prosthesis while standing up from a seated position.

METHOD
One 64 year old male (K3 ambulator) and one 22 year old female (K4 ambulator) unilateral transfemoral amputees, both C-Leg (OttoBock) users, were fit with a powered knee and ankle prosthesis (Sup et al. 2009). Both subjects had experience walking with the powered prosthesis. Subjects sat comfortably on a standard height chair with arm rests. Subject training and prosthesis configuration for sitting and standing was as follows:

- **Sitting Down:** The prosthesis provided controlled resistance as subjects sat down in a chair. A therapist focused subjects’ attention on equal weight distribution between legs.
- **Standing Up:** The prosthesis provided knee and ankle joint power to assist subjects in standing from a seated position. The knee and ankle power began when subjects put a small amount of weight through the prosthesis and increased as more weight was shifted onto their prosthetic side. A therapist instructed the subjects on foot placement, upper body positioning, and equal weight distribution.

When subjects could comfortably sit down and stand up without use of the chair arm rests, we collected 10 trials of each movement. Subjects repeated these trials using their C-Leg. Sound side and prosthetic side forces were collected for all movements using two force plates. Force plate data was averaged across all 10 trials and normalized by body weight.

RESULTS
While using the powered prosthesis, subjects displayed a more equal weight distribution between the sound limb and prosthetic side for both standing up and sitting down when with the powered prosthesis than they did with their C-Leg (Figure 1). Between prosthetic devices, there were no differences in movement time for standing up (powered prosthesis, 1.6s ± 0.1s; C-Leg, 1.8s ± 0.4s) or sitting down (powered prosthesis, 2.3s ± 0.4s; C-Leg, 2.3s ± 0.4s).

**Figure 1.** Forces during standing up while using the powered prosthesis and C-Leg for one subject. Solid line indicates prosthetic side, dashed line indicates sound side.

DISCUSSION
Both transfemoral amputees demonstrated more equal weight distribution while using the powered knee and ankle prosthesis compared to using the C-Leg for both standing up and sitting down. Proper foot placement and a forward trunk lean were important positioning tools that helped subjects maintain their balance. While standing up, subjects commented that they felt the power from the prosthesis help them up from the chair.

CONCLUSION
By allowing these transfemoral amputees more control over the power delivered from a knee and ankle prosthesis, they were able to stand up and sit down with their body weight spread more equally between their prosthetic and sound sides.

CLINICAL APPLICATIONS
A powered knee and ankle prosthesis that assists with sit to stand may improve functional mobility in the home and community. In the future, we see this device benefitting lower level (K2) transfemoral amputees to allow improved independence.

REFERENCES