INTRODUCTION
We have developed a passive mechanical prosthetic ankle-foot system that is able to adapt to surface slopes on every step of walking (Fig. 1).

METHOD
One highly active 29 year old male veteran with unilateral transtibial amputation provided informed consent to test the prototype. Kinematic and kinetic data were collected while the subject walked at 1.0 m/s on a split-belt instrumented Bertec treadmill. The subject’s movements were tracked using an 8-camera Qualisys motion analysis system. The subject walked on the treadmill at five different slopes: level, uphill, and downhill at angles of five and ten degrees using both the prototype and his usual foot (Otto Bock 1C62 Triton with Harmony). After walking at each slope condition, the subject reported his socket comfort and exertion using the Socket Comfort Score and Rating of Perceived Exertion respectively. Ankle torque and angle were examined to verify slope adaptation.

RESULTS
The subject reported increased comfort and reduced exertion for downhill slopes when using the prototype compared with his usual prosthesis. The subject also expressed that when walking downhill on the prototype, it was the most comfortable he has ever been in a prosthesis. The prosthetic ankle torque-angle relationship shifted toward dorsiflexion for uphill and toward plantarflexion for downhill slopes when using the prototype, indicating slope adaptation. Shifting of the ankle torque-angle curve did not occur when the subject walked with his usual prosthesis, indicating no slope adaptation.

DISCUSSION
The prototype adapts on every step, as evidenced by the return to a consistent swing phase ankle angle on every step regardless of slope. Unlike some existing adaptive microprocessor controlled feet on the market, there is no delay between encountering a new surface and adapting the ankle alignment.

CONCLUSION
The prototype demonstrated evidence of passive slope adaptation on every step and use of the prototype improved socket comfort and perceived exertion when walking downhill.

CLINICAL APPLICATIONS
Future refinement of the prototype into a commercial product could provide a robust system for lower-limb prosthesis users.

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Figure 1: Cut-away CAD rendering of EquiFoot™ adaptable ankle-foot system

Figure 2: Subject reported superior socket comfort (left) and reduced exertion (right) when walking downhill with the prototype, relative to the same conditions when wearing his usual prosthesis (Otto Bock 1C62 Triton with Harmony)