Crossover and energy storing prosthetic feet in adults with transtibial amputation: a comparative effectiveness study

Hafner, BJ; Halsne, EG; McDonald, CL; Morgan, SJ; Kramer, PA
University of Washington; Seattle, WA USA

INTRODUCTION
People with transtibial amputation (TTA) demonstrate increased energy expenditure, reduced walking speed, compromised balance, and decreased endurance compared to people without amputation (Waters, 1999; Genin, 2008). Contemporary energy storing feet (ESF) promote users' mobility, but do not fully restore their functional capabilities (Hsu 2006). Crossover feet (XF) combine features of ESF (carbon fiber heel, split keel, foot shell) and running-specific prostheses (extended keel, posterior attachment) to facilitate greater energy return and performance across a wide range of functional activities.

The goal of this study was to determine if use of an XF could decrease users' energy required for walking, increase endurance, enhance walking performance, or improve self-report health, relative to using an ESF.

METHOD
Participants: People with TTA due to non-dysvascular causes were recruited from local prosthetics clinics.

Interventions: Participants were tested in a prosthesis with an XF (Ossur Cheetah Xplor) and an equivalent prosthesis (duplicate socket and suspension) with an ESF (Ossur Vari-flex with EVO foot).

Procedures: A randomized crossover study was conducted to assess changes in energy expenditure, walking performance, endurance and reported health. Participants wore an activity monitor (Orthocare Innovations Stepwatch 3) for 1 month before testing. Energy expenditure was measured with a portable metabolic analyzer (Cosmed K4b2) while participants walked at 3 speeds (self-selected slow, comfortable and fast) on a treadmill (Landice L7). Endurance was measured with the 6-min walk test (6MWT). Walking performance was measured with an electronic walkway (CIR Systems GAITRite) while participants performed the 6MWT. Self-reported mobility, fatigue, balance confidence, activity restrictions, and satisfaction were measured with standardized surveys (PLUS-M, PROMIS-Fatigue, ABC, and TAPES).

Analysis: Mean mass-adjusted metabolic rates were calculated from the last 3 minutes of each 6-minute treadmill trial (slow, comfortable, and fast). Overall 6MWT distance was measured; mean speed, cadence, and step length, width, time were computed using the GAITRite software; mean daily steps were calculated. Surveys were scored according to developers’ instructions. All outcomes were compared across conditions using a Wilcoxon Signed-Rank test and a threshold of α=.05.

RESULTS
Participants: 14 participants have completed the study to-date; 2 people were dropped due to extrinsic factors that affected data Integrity. 12 participants (83% male, age = 41±10 years, time since amputation = 12±12 years) were included in this analysis.

Metabolic energy: Participants showed significantly reduced mean mass-adjusted metabolic rates at comfortable (p=.0499) and fast (p=.0499) walking speeds in the XF compared to the ESF (Fig. 1). No significant differences in metabolic rates were seen at slow speed (p=.638).

DISCUSSION
Results indicate that XF may reduce users' metabolic energy at comfortable and fast walking speeds. Indoor walking performance and endurance may not reflect performance under real-world conditions, as users perceived significant benefits and were highly satisfied with the XF’s function. However, not all participants experienced the same outcomes. Thus, future work is needed to refine prescription criteria.

CONCLUSION
XF are a promising alternative to traditional ESF, as they may reduce energy expenditure during walking and improve users’ perceived functional outcomes.

CLINICAL APPLICATION
Crossover feet may be an effective solution for people with TTA who wish to engage in a range of activities, particularly those that require walking at fast speeds.

REFERENCES