STAIR AMBULATION WITH A LIGHTWEIGHT POWERED KNEE AND ANKLE PROSTHESIS ACROSS FUNCTIONAL CLASSIFICATION LEVELS: A CASE SERIES

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INTRODUCTION

Most individuals living with an above-knee amputation cannot walk at variable speeds and safely negotiate environmental barriers with their prescribed passive prostheses (Schmalz et al., 2002). This limited functional mobility severely affects their health and independence (Gailey, 2008). Powered prostheses have the potential to address these limitations by providing energy for climbing up stairs, standing up from a seated position, improving walking stability, and increasing foot clearance. However, available powered protheses are designed for young, strong individuals, who lost their limb due to trauma and can already achieve full community ambulation with available passive prostheses. We aim to make powered prostheses viable for elderly and dysvascular individuals who are limited community ambulators with their prescribed passive prostheses.

METHOD

Apparatus: We developed the first powered knee and ankle prosthesis (Cempini et al., 2017; Tran et al., 2019) to combine the lightness of a passive device (~5.5 lbs.) with the power generation capability of a powered prosthesis (~400 W). A novel control framework automatically synchronizes the movement of the powered prosthesis joints with the movements of the residual leg for intuitive user interaction.

Subjects: We recruited two individuals with unilateral above-knee amputation. One dysvascular K2 subject (60 yr. old male, 195lbs, 5'7'') and one traumatic K3 subject (26 yr. old male, 150 lbs, 5'10'').

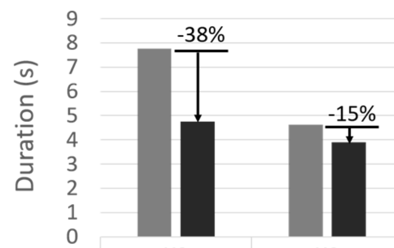
Procedures: Subjects were asked to ambulate on a 4-step staircase five times with each prosthesis. Both subjects used a step-by-step gait pattern with their prescribed prostheses and a step-over-step gait pattern with the lightweight powered prosthesis.

Data Analysis: A stopwatch was used to measure the time necessary for the subjects to ascend the 4-step staircase. Averages and standard deviations were computed for each subject separately.

The University of Utah Institutional Review Board approved this study and informed consent was obtained from the subjects prior to participation.

RESULTS

The time required to ascend the 4-step staircase with the prescribed passive prosthesis was 7.76 s and 4.63 s for the K2 and K3 subject, respectively. The time required to ascend the 4-step staircase with the lightweight powered prosthesis was 4.76 s and 3.89 s for the K2 and K3 subject, respectively. Ascending stairs was 38.5% and 15.2% faster with the powered prosthesis than the passive prosthesis for the K2 and K3 subject, respectively.



	K2	K3
Passive	7.8 ± 0.5	4.6 ± 0.3
Powered	4.8 ± 0.3	3.9 ± 0.2

Figure 1. Averages and standard deviations of the time required by the subjects to ascend the 4-step staircase.

DISCUSSION

Both subjects were faster with the powered prosthesis than their prescribed passive prosthesis. However, the improvement was much higher for the K2 subject than the K3 subject (i.e., -38% vs. -15%). Most importantly, when using the lightweight powered prosthesis, the K2 subject climbed the staircase at the same speed as the K3 subject with his prescribed passive prosthesis. Our results agree with a previous study with K3 subjects (Ledoux and Goldfarb, 2017). To the best of our knowledge, this is the first study on the effect of a powered prosthesis on a K2 subject.

CONCLUSION

A lightweight powered knee and ankle prosthesis has the potential to improve stair ambulation in dysvascular individuals with above-knee amputations.

CLINICAL APPLICATIONS

Novel lightweight and intuitive protheses have the potential to lower the strength and balance currently required for full-community ambulation.

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