Feasibility Testing a Robotic Prosthetic Leg and an Articulated Prosthetic Ankle Joint

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Introduction

The Loma Linda University Health Robotic Prosthetic Leg (LLUH-RPL) and Articulated Prosthetic Ankle (APxA) were designed and prototyped to provide persons with amputation, regardless of ambulation cadence, the ability to walk on level and sloped ground. These devices have been tested on a non-disabled male subject [1] and found to be feasible for testing on subjects with amputation.

Purpose

The purpose of this graduate student research study was to test the feasibility and safety of the LLUH-RPL and APxA, by evaluating the performance of these devices on level-ground on two subjects with amputation of the right leg.

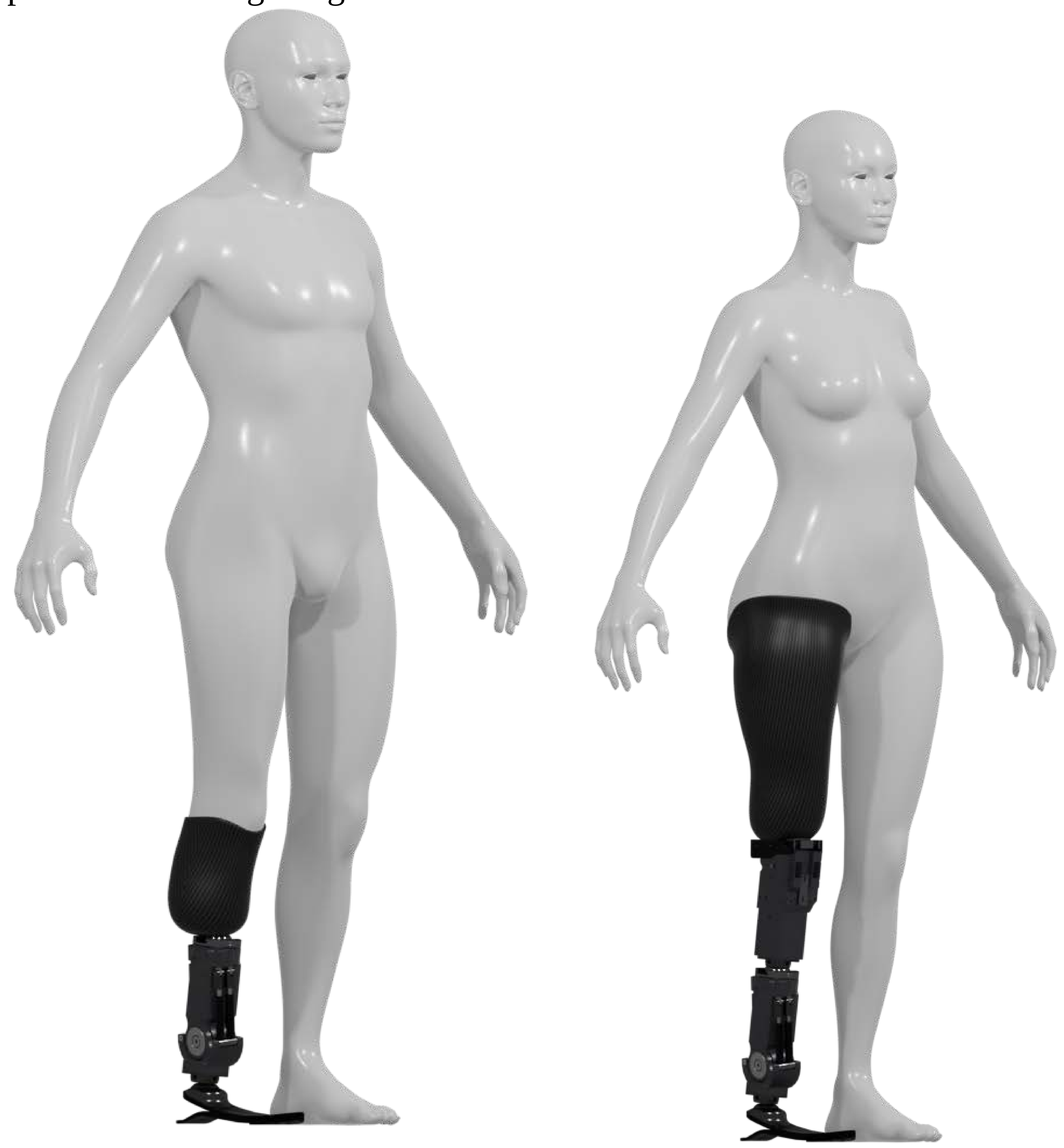

FIGURE 1. Initial design of LLU-Ankle and LLUH-RPL on persons with BKA and AKA

Methods

We recruited two subjects, one male, 183cm (6'0") tall, with below-the-knee amputation (BKA) and one female, 162cm (5'4") tall with above-knee amputation (AKA). Both subjects had the ability to walk with a variable cadence and on uneven terrain (functional level K3). The subjects gave written informed consent. This research protocol was approved by Loma Linda University Office of Sponsored Research Institutional Review Board.

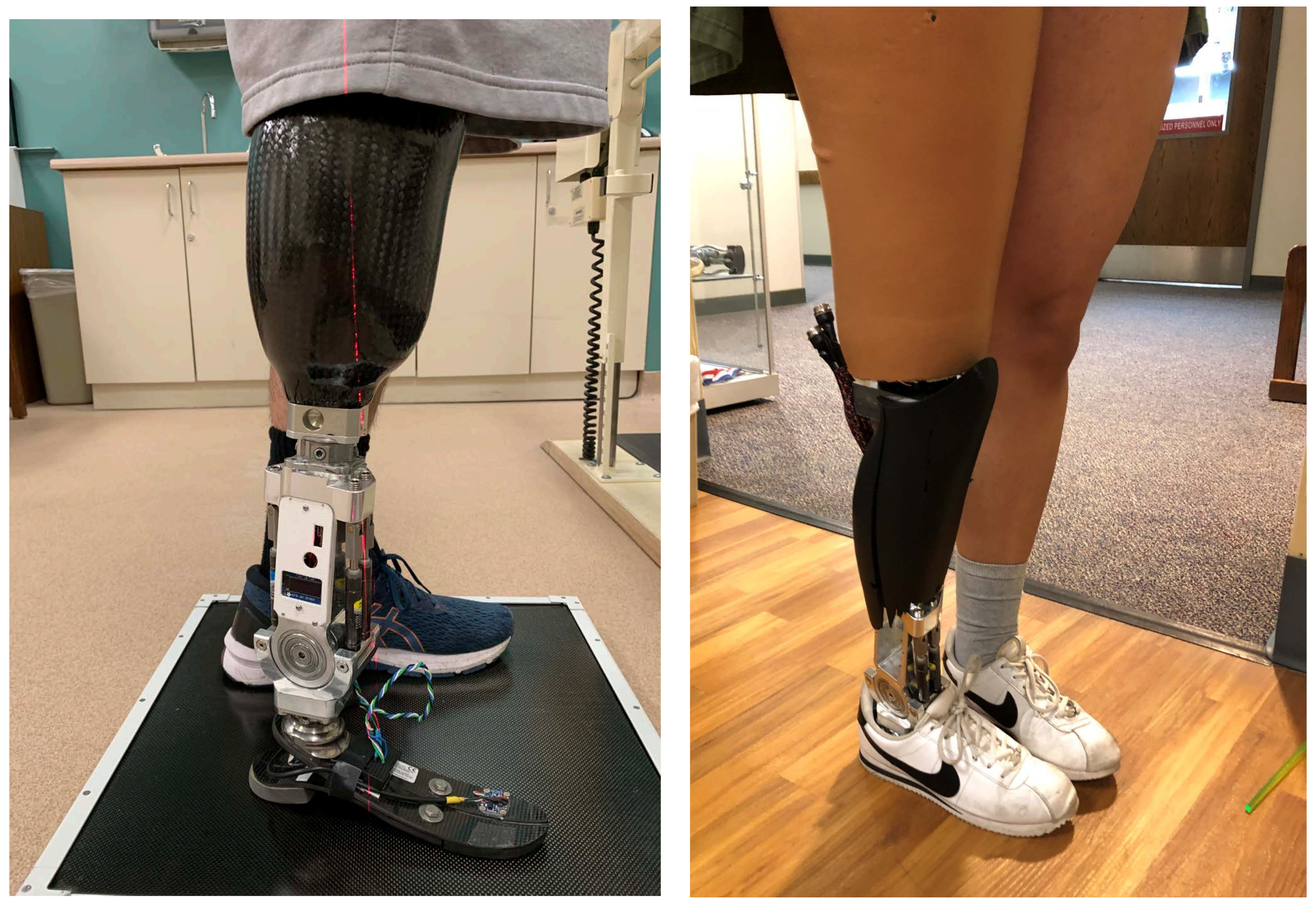

FIGURE 2 - LLU-APxA on a person with BKA (left) the LLUH-RPL with APxA on a person with AKA

Protocol: Subjects performed the 10-meter walk test (10MWT), and the 6-minute walk test (6MWT) while wearing the LLUH-RPL.

Equipment: 1) LLUH-RPL (AKA only) 2) APxA with Passive Hydro-pneumatic Assists (BKA and AKA) 3) Mobile Phone 4) Heart Rate Monitor 5) inertial measurement units (IMUs) 6) 24-camera Motion Capture System 7) In-floor force-plates

Both the APxA and LLUH-RPL+APxA were tested in parallel bars; then tested in an open indoor environment under various cadences and velocities. Then the LLUH-RPL was tested in a motion capture lab to assess kinetics and kinematics.

FIGURE 3 - LLU-APxA on a person with BKA while walking with improved gait symmetry.

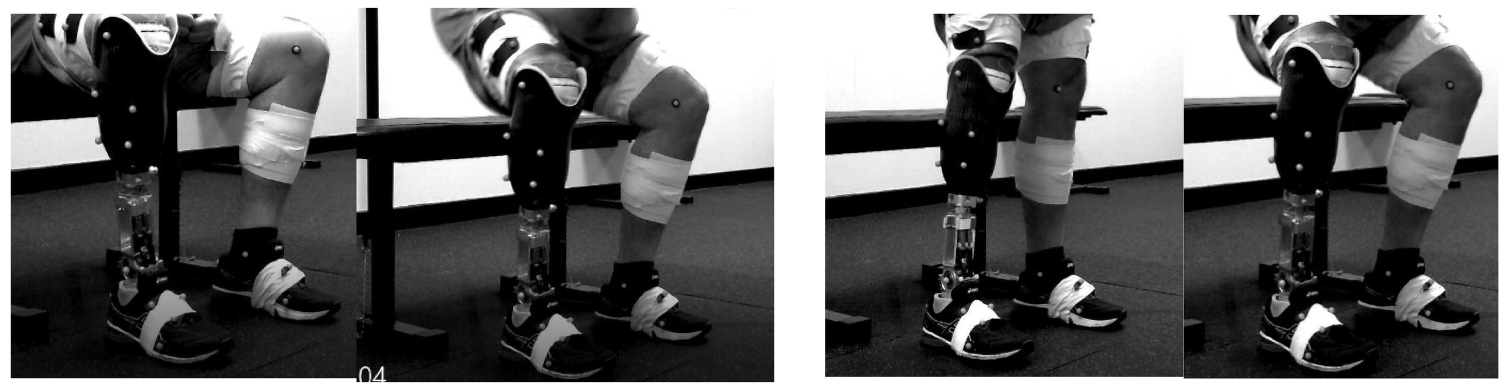

FIGURE 4 - LLU-APxA on a person with BKA while standing then sitting, demonstrates improved ankle motion

FIGURE 5 – From left to right Initial Contact, Loading Response, Midswing, Terminal Swing shows improved joint motions knee and ankle of the LLUH-RPL+APxA still provides stance stability

FIGURE 6 – From left to right Preswing, Initial Swing, Midswing, Terminal Swing shows that knee and ankle motion of the LLUH-RPL+APxA positions the foot to safely clear the floor

Results

	Subject 1 (APxA)	Subject 2 (RPL + APxA)
Intervention	APxA	LLUH-RPL + APxA
Mass and height of device	2.91 kg, 26.5cm	4.11 kg, 43cm
Height of subject	183 cm	162cm
Walking velocity	1.34 m/s	0.77 m/s
Distance traveled (estimated)	2 km	2 km
Falls, stumble events, toe drags	0,0,0	0,5,1

Conclusion

The LLU-APxA and LLUH-RPL was demonstrated to be safe and feasible in ambulation tasks on a male with BKA and a female with AKA, while walking on level ground indoors. These results demonstrate that these prosthetic devices were safe in a controlled environment and are feasible for further testing on ramps, in sit-to-stand, stand-to-sit conditions, and in walking tasks outdoors.

Disclosure

Michael Davidson is the inventor of the claimed technology in this study. Loma Linda University Health owns the rights to this patent. This study was funded by Loma Linda University Health.

References

[1] Davidson, M, Daher, N, Fryer, T, Schaepper, J, & Tran, D. "Design, Prototyping, and Testing of a Robotic Prosthetic Leg Preliminary Results." *Proceedings of the ASME 2021 International Mechanical Engineering Congress and Exposition. Volume 5: Biomedical and Biotechnology*. Virtual, Online. November 1–5, 2021. V005T05A062. ASME. https://doi.org/10.1115/IMECE2021-68786