AN AUTO-ADJUSTING SOCKET TO ACCOMMODATE CHANGES IN LIMB VOLUME

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Short Video Presentation at: http://depts.washington.edu/jsweb/video/AutoSocket_presentation_v1.mp4

Objectives of This Research

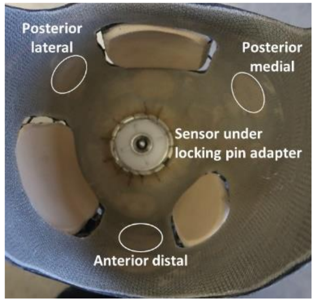
Compare performance of three socket configurations for people with transtibial limb amputation in their free-living environments:

- Auto-adjusting
- Manual-adjusting (using a phone app)
- Locked (control)

Test Sockets

The same socket was used for all tests on a participant.

Each socket had three panels (anterior medial, anterior lateral, posterior) that were moved radially inward or outward using a motor mounted to a frame supporting each panel. For the auto-adjusting configuration, an on-board proportional-integral controller adjusted panel position according to data collected from limb-socket distance sensors positioned in the socket wall and a pin depth sensor. For the manual configuration, participants adjusted panel position using a mobile phone app. For the locked configuration (control), adjustment was disabled.



Sensor locations in the socket. A sensor to detect pin depth is under the locking pin adapter.

Test socket with three motor-driven adjustable panels.

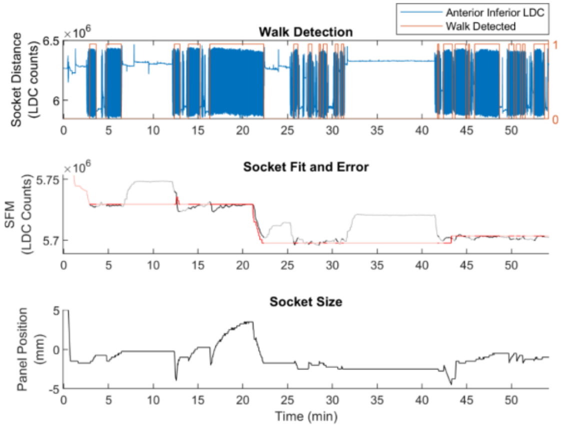
Protocol

Participants used each socket for up to 2 weeks in their free-living environment. A socket fit metric (SFM), mean of the posterior medial and lateral mid-limb sensor channels, was recorded, and socket wear time (hours per day) was monitored. Participants were asked their socket comfort score (SCS) 3 times per day and were interviewed after each test configuration was completed.

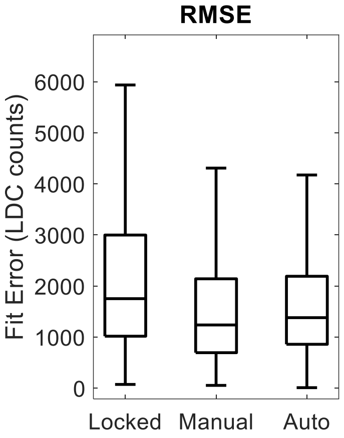
Results

Five male participants took part in this study. They all had their limb amputation as a result of trauma. Age ranged from 45 to 60 years, and time since amputation from 7 to 36 years.

Auto-adjustment was active only during walking, detected using the anterior inferior socket sensor (top graph). In the middle graph, the match between the SFM (black line) and the set point (red line) demonstrates proper controller performance (gray line = controller inactive). Changes in panel radial position, indicative of socket size, are shown in the bottom graph.



The root mean square error (RMSE) between the SFM and the set point was less for the manual and auto modes than the locked mode.



Participants preferred the manual or auto-adjusting modes over the locked mode. One participant preferred the auto mode because he did not need to doff his socket as often throughout the day, like he would with his traditional prosthesis. He had an upper limb amputation and found it inconvenient to take his phone out to make an adjustment. His median SCS was 8 for auto and 6 for manual. Another participant had a slight preference for manual mode because he liked having control over the socket size. While driving, he was concerned that the socket may automatically adjust size. His median SCS was 8 for auto and 8 for manual.

Discussion

- Limb-socket distance measurements may effectively monitor small changes in limb size that are precursors to a deterioration in socket fit
- Automated socket size adjustment may be an appropriate strategy for regular clinical use
- Controller algorithms that operate during activities other than walking may enhance application of the technology in clinical care

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