Measurable Skin Differences Between the Contralateral and Residual Limb of Persons with Unilateral Transtibial Amputation

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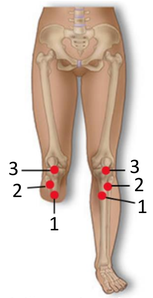
Introduction

- High activity prosthesis users, e.g., Service Members (SM), are prone to skin breakdown, which can hinder their ability to use a socket and preform daily duties[1].
- Quantitative, non-invasive measures of **skin barrier, biomechanica**l, and **pigment properties** can potentially be used to assess the overall health of the skin and have potential to predict breakdown prior to occurrence[2,3].

Purpose: Evaluate the ability of these measures to differentiate between residual limb (RL) and contralateral limb (CL) skin in SM with unilateral transtibial amputation.

Methods and Materials

- One female and eleven male (**n=12**) past/present SM with unilateral transtibial amputation participated (37.9±6.2y; 4.5±3.9y since amputation; 12.3±4.4hrs/day in socket; 11 traumatic amputations, 1 cancer).
- All measures were taken at three locations on both legs:



1. The distal end of the tibia (DT)
2. The interosseous space between the tibia and fibula (IO)
3. The mid section of the patellar tendon (MPT)

Fig. 1: Illustration of anatomical measurement sites on the RL and CL; Adapted from M. Dauenheimer, *ChoosePT.com*

- Barrier function was measured as transepidermal water loss over 30s (TEWL) (g/m^2/h), and surface electrical capacitance (SEC) (Tewameter TM Hex, Corneometer CM 825; Courage+Khazaka [C+K] Electronic, Koln, Germany).
- Skin biomechanics were measured using a suction skin displacement device (Cutometer Dual MPA 580, C+K) and reported as: skin displacement under suction (R0=B)(mm), percent recovery (R2=D/B), net elasticity (R5= C/A), and elastic recovery percent (R7=C/B) (***Fig. 2***).
- Skin pigment was measured as broadscale melanin and erythema content (a.u.) (Mexameter MX18, C+K).

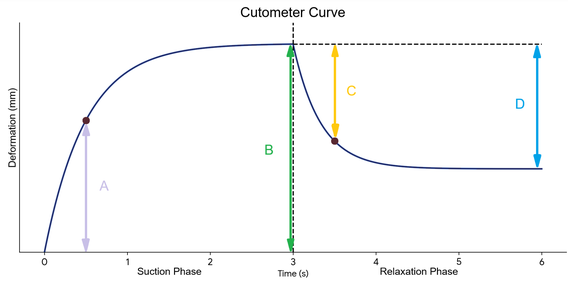
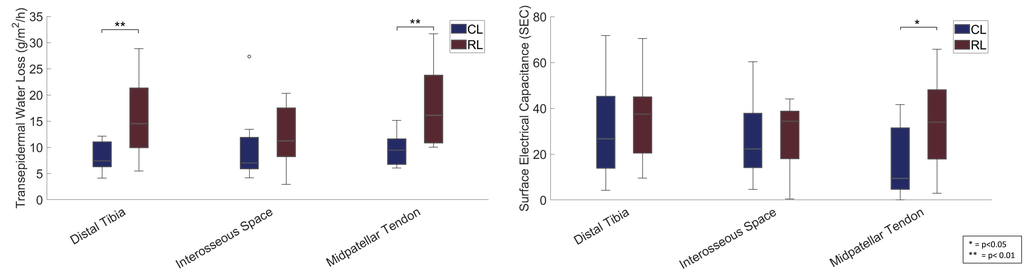


Fig. 2: Example Cutometer displacement curve showing skin deformation (mm) under suction (t=0-3s) followed by relaxation (t=3-6s).

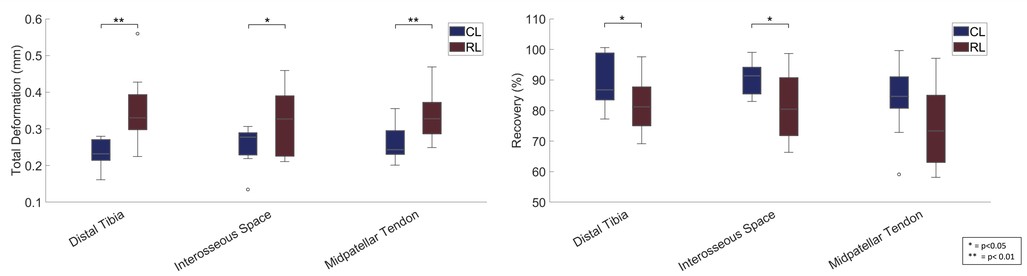
- Wilcoxon signed-rank tests compared mean values of each measure between matched residual and contralateral limbs ($p<0.05$).

Results – Barrier Function

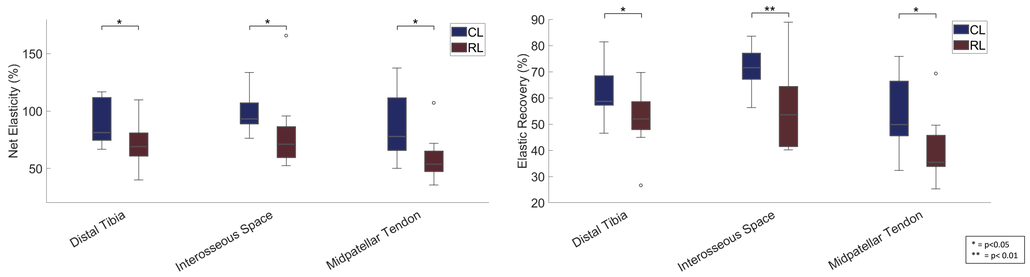


- TEWL of the RL was higher than the CL at all sites (Left); SEC of the RL was higher than the CL at all sites (Right)

Results – Biomechanics

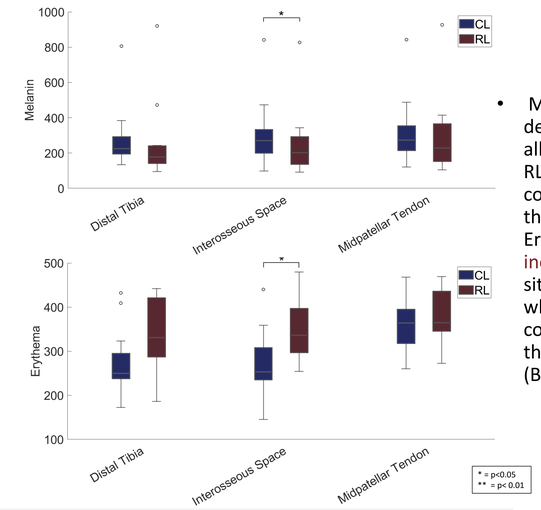


- R0 of the RL increased from the CL at all sites (Left); R2 of the RL decreased from the CL at all sites (Right)



- R5 of the RL decreased from the CL at all sites (Left); R7 of the RL decreased from the CL at all sites (Right)

Results – Pigment



- Melanin decreased at all sites of the RL when compared to the CL (Top); Erythema increased at all sites of the RL when compared to the CL (Bottom).

Discussion

- The RL measured poorer skin health outcomes when compared to the CL evidenced by diminished biomechanics, impaired barrier function, and increased redness.
- Differences in skin properties suggests that socket wear impacts skin properties in established prothesis users.
- Prosthesis loading sites (DT, MPT) where socket forces tend to be increased showed significant changes in barrier function between limbs, while significant biomechanic changes were measured at all sites.

Conclusions

- Consistent significant differences seen in measures of barrier function and skin biomechanics support the ability of these measures to differentiate between the RL and CL.
- Future work plans on relating these measures to clinical skin health outcomes to better sustain quality of life, and operational capability of affected service members.

References: 1. Highsmith. inMotion. 2011. 2. Andersen. Skin Res. And Tech. 2008. 3. Prakash. J Clin. And Aesthetic Derm. 2017.

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