COMPARISON OF SKIN TEMPERATURE AND MOISTURE BUILDUP BETWEEN TWO PROSTHETIC LINERS

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INTRODUCTION
Heat and perspiration are common problems in the prosthetic socket environment. In an effort to better manage the thermal environment of the prosthetic socket, prosthetic liner materials have been modified with additives to increase thermal conductivity and heat capacity. The proprietary material additives use a phase-change material (PCM) to store and release heat. Patient anecdotal comments indicated that the modified liner provided a more comfortable temperature environment for the residual limb and several patients commented they noticed less moisture buildup inside the liner. To assess these anecdotal claims, testing was conducted to compare amputees’ skin temperature and moisture buildup when wearing a standard off-the-shelf prosthetic liner compared to a modified liner during an exercise session on a treadmill.

METHOD
Subjects: Six transtibial amputees participated in this study.

Apparatus: Skin temperature was measured using a K type thermocouple from Omega plugged into a signal amplifier and a hand-held digital multimeter. The amount of moisture on the skin was measured using skin surface electrode capacitance (SEC).

Procedures: Skin temperatures were taken under the following conditions: 1) Atmospheric with no prosthetic liner or socket donned; 2) Initial donning of the liner; 3) Steady-state temperature with the liner donned; 4) Prosthetic socket donned; 5) Standing; 6) After 5 minutes walking at a slow pace; 7) After 5 minutes walking at a fast pace; 8) After 5 additional minutes (total 10 minutes) walking at a fast pace; 9) After 5 minutes walking at a slow pace; 10) Sitting down immediately post activity; and 11) After 15 minutes at rest in a seated position.

SEC was taken prior to donning and immediately after doffing the liner. Measurements were collected at the distal end, posterior calf, back of the knee, medial, and lateral. The order in which the liners were tested was randomized and there was a 30-minute rest period between testing the two liners to allow for the residual limb to re-acclimate with atmospheric air.

Data Analysis: Data was plotted on graphs that were color-coded to indicate differences between each patient and between each liner material.

RESULTS
Evaluating the complete temperature data for all six patients indicated the following general trends:

1) Donning either liner initially reduced the skin temperature. 2) Activity increased the skin temperature. 3) Both types of liners exhibited similar temperature curves; however, the modified liners demonstrated lower skin temperatures especially during activity. 4) Temperature associated with the modified liner was relatively stable post activity.

For 5 of the 6 patients, use of a standard liner correlated to a larger increase in skin temperature for each activity condition. The data for the sixth patient exhibited a considerable decrease in temperature associated with the modified liner, indicating that the modified liner was assisting in buffering the increase in temperature.

The data for the 15-minute rest period post activity displays minimum change for the modified liner, signifying the PCM’s material’s ability to maintain a steady temperature environment. Several of the standard liners exhibited an increase in temperature during this rest period.

Comparison of the SEC data favored the modified liner or indicated no difference between the liners in 23 out of 30 comparisons. Only 7 out of 30 comparisons resulted with a greater buildup of moisture on the skin after testing the modified liner.

DISCUSSION
Overall, the results from the testing indicated that: 1) The modified liner buffered the temperature increase during activity, exhibiting a lower temperature increase during activity compared to the standard liner. 2) The modified liner stabilized the temperature post activity. 3) There was less moisture buildup for the modified liner compared to the standard liner. One influencing factor may be the lower skin temperatures experienced while testing the modified liner.

CONCLUSION
The results support continuing the evaluation of a modified liner as a potential means of regulating prosthetic socket temperature.

CLINICAL APPLICATIONS
Regulating the temperature in the socket and reducing the amount of perspiration can lead to improved comfort, health and quality of life for amputees.

REFERENCES

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