THESIS ABSTRACT

MEASUREMENT AND CONTROL SYSTEM FOR INSIDE SOCKET TEMPERATURE OF TRANSTIBIAL PROSTHESIS: DESIGN, MANUFACTURE AND EVALUATION

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ABSTRACT

BACKGROUND
Heat and perspiration discomfort with prostheses are common complaints in the majority of amputee people regardless of prosthesis type, amputation cause, and amputated limb or side. In the majority of amputee people all thermal transfer mechanisms, including convection, radiation, evaporation, and conduction are disturbed due to the prosthetic socket barrier, decreased body surface area, and vascular disease. Heat accumulation inside prosthetic socket causes tissue injury and in addition to discomfort, perspiration, and unpleasant odor, reduces prosthesis suspension and prosthesis use. However, there are some people with amputation who suffer from cold skin of the residual limb inside the prosthesis, i.e. those with great vascular insufficiency and those who live in cold climate countries.

OBJECTIVE(S)
At present, prostheses lack required mechanisms to deal with heat and cold stresses and their threatening sequelae. This project aims to introduce a thermoregulatory technique/system as a potential solution for those problems in prostheses wearers. Further investigations of the temperature measurement and control (TM&C) system were done during bench-top and clinical evaluations.

METHODOLOGY
The prototype of a thermoregulatory system was designed and manufactured to measure and control the temperature inside prosthetic socket. The system was comprised from six internal and six external temperature sensors to a silicone liner. The control system was programmed to select required heating or cooling functions of a thermal pump to provide thermal equilibrium based on the amount of temperature difference from a defined set temperature, or the amount of temperature differences between inside and outside temperature averages.

CITATION

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KEYWORDS
Prosthetics, Rehabilitation, Amputee, Lower limb amputee, Silicon liner, Prosthetic socket, Heat, perspiration, discomfort, thermoregulatory.
A thin layer of Aluminum was used to conduct temperature between thermal pump and different sites around the silicone liner. The functionality of this prototype to measure and control the temperature was evaluated on both a phantom model during a bench-top laboratory evaluation. Thereafter, the functionality of the prototype was evaluated during its clinical application in a setting with reversal, single subject design using a real prosthetic socket of a transtibial amputation. The TM&C system was installed on fabricated prosthetic socket of a man with unilateral transtibial amputation. Skin temperature of the residual limb, without prosthesis at baseline, and with prosthesis during rest and walking was evaluated. The thermal sense and thermal comfort of the participant were also evaluated.

FINDINGS
The results showed the feasibility of the proposed ideas for designing and manufacturing the thermoregulatory system for inside prosthetic socket. In present prototype, by increasing distance from centre of thermal pump, the amount of the induced temperature change due to activation of thermal pump was decreased. In spite of great temperature change at various sites around the silicone liner during heating and cooling activities, the thermal energy and power of the TM&C system were low. The clinical results showed different skin temperature around the residual limb with a temperature decrease tendency from proximal to distal. The TM&C system decreased skin temperature rise after prosthesis wearing. The same situation was occurred during walking; but the thermal power of the TM&C system was insufficient to overcome heat build-up in some regions of the residual limb. The participant reported no significant change of thermal sense and thermal comfort.

CONCLUSIONS
The introduced technique can be used to resolve heat and perspiration discomfort inside prosthetic sockets. The selection of material and pattern of thermal transfer layer needs further investigation. Hence, there was just one thermal pump in the structure of the TM&C system, the heating and cooling energies and powers were low. Therefore, choosing the proper quantity and best attachment site of thermal pump to the prosthetic socket needs further investigation. The best design of the TM&C system should consider these issues to decrease its power consumption and total weight.

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AUTHOR SHORT SCIENTIFIC BIOGRAPHY
Kamiar Ghoseiri received his PhD in Orthotics and Prosthetics from University of Social Welfare and Rehabilitation Sciences in 2015. Moreover, he was a visiting research scholar in the Hong Kong Polytechnic University in 2014 while introduced the prototype of a smart assistive device to thermoregulate inside socket temperature. His main research interests are innovation in Orthoses and Prostheses, evaluation of gait and its pathologic conditions, improving the rehabilitation process, conducting methodological studies, and designing assistive devices and adapting them to users. Many of his research articles have been published in international peer-reviewed journals.