Skin Model Development for the Study of Complex Skin/Textile Interactions in Dry and Humid Conditions

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Abstract

Skin damage, such as pressure ulcers and blisters, often results from a complex interplay of factors including pressure, friction-induced shear, moisture accumulation, temperature, and the duration of strain on various skin layers. Paraplegics are particularly susceptible, with approximately 30% affected by pressure ulcers. These ulcers manifest when blood vessels in the dermis experience compression, coupled with moisture build-up in the epidermis and shear forces at the dermis-epidermis interface. Unfortunately, these wounds exhibit slow healing, often becoming chronic. Consequently, considerable efforts have been directed towards preventive measures like pressure-distributing mattresses and low-friction bedsheets. However, establishing the efficacy of such products proves challenging due to the necessity for large clinical trials to demonstrate statistically significant benefits.

Hence, there is an urgent need for basic and still realistic skin models useful for textile companies during the product development process before clinical campaign. Notably, these models must represent the skin's elastic anisotropy and be able to sweat to analyze mechanical stresses under dry and wet conditions, during friction and compression against textile materials.

The present project aims to develop such a model in the form of a slider able to measure friction and compression through a deformable optical sensor: a polymeric optical fiber (POF) inserted into a knitted fabric, whose performance has been studied in previous works. The knitted fabric serves both as support for the sensor while bringing perspiration by capillarity. Finally, the skin simulation will be provided by the polydimethylsiloxane (PDMS) material already used in skin models for its stiffness and compression behavior similar to skin.

The final structure was validated through finite element analysis as well as compression tests. It was then tested under both dry and wet friction conditions, showing results close to the friction coefficient of skin in both environments. The model was compared with another innovative model capable of adjusting its stiffness by inflation, as well as with other artificial skins. These encouraging results demonstrate that this friction simulator could be used as a realistic skin model.

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