Continence Project

An Experimental Study of Friction Between Wet and Dry Skin and Nonwoven Fabrics

Funded by SCA Hygiene Products AB, Sweden

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Description of Research

It is estimated that over 50 million people worldwide have urinary incontinence, many of whom manage it with the use of absorbent hygiene products, such as pads. Long-term use of such products can lead to mechanical skin damage – abrasion by friction between the coverstock and the skin – which can be exacerbated by the addition of a fluid (urine). The aim of the work described in my thesis was to characterise and improve the understanding of the interface between a broad range of coverstock (nonwoven) materials and human skin, and was divided into four main blocks.

Measurements on a skin surrogate were used to model frictional interaction with a large range of nonwoven fabrics and to select a smaller subset for further testing. This subset was tested against human volar forearm skin *in vivo* to describe how friction forces vary, in dry conditions, with nominal interfacial pressure, compliance of the substrate, and nonwoven properties. The effect of skin hydration on friction was then explored in more detail. Examining fibre footprints of nonwovens on a surrogate skin surface, aided the interpretation of these data by providing insight into how friction is mediated by the interface.

It was found that Amontons' Laws held for all dry friction measurements, despite the viscoelastic nature of human skin. The coefficients of friction varied between participants and between nonwovens, although the fabrics were ranked in mostly the same order for coefficient of friction with each participant and the differences were not age-related. There was also an apparent relationship between the amount of excess water in the skin and coefficient of friction, which depended on the participant-nonwoven combination but was always a positive correlation. Total fibre contact length always increased with increasing pressure, usually due to an increase in the number of contacts and sometimes because of an increase in the lengths of existing fibre contacts.

Methodologies

Dry friction measurements involved slowly pulling strips of five different nonwoven fabrics across the volar forearms of 19 female volunteers (aged 20-95 years), under five different loads. This was done using a tensometer, which simultaneously measured the friction forces. Video cameras were used to record the deformation of the skin and the fabric from different angles, with the aim to later compare it with the forces measured.

Key Results

Remarkably, there was a linear and proportional relationship between applied load and friction force for all participants of all ages, irrespective of the compliance of the skin and underlying tissues.

Coefficient of static friction (μ_s) values were not affected by age or ethnicity, although there were clear differences between participants and between nonwoven fabrics. The order of nonwovens (ranked by μ_s) was broadly the same for all participants, and one fabric always had the lowest μ_s.

These similarities meant that data for one person's skin was typically representative of similar data for many people, suggesting that the coverstock materials could relatively easily be improved for everyone, at least when the skin and pad are dry ("normal").

Links to Published Papers

http://discovery.ucl.ac.uk/1458878/1/Sabrina_S_Falloon_-_PhD_thesis_-_electronic_REDACTED.pdf