Application of Biophysics and Bioengineering to the Assessment of Skin Barrier Function

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Objectives:
As a result of filaggrin mutation, lower levels of natural moisturising factor (NMF) are generated in atopic dermatitis (AD) and this may contribute to an impaired barrier function[1].

The stratum corneum (SC) on the face is thinner, and the surface area of the corneocytes smaller, resulting in a shorter path-length for water transport and a noticeably higher permeability. Therefore, it is proposed that forearm and forehead skin from healthy volunteers may be used to model the distinction between a competent SC and one predisposed to AD.

The goal of this project is to apply different bioengineering methods to screen SC barrier function and to identify markers for its impairment.

Materials and methods:
NMF components were extracted from the forearm and forehead of 6 healthy volunteers using reverse iontophoresis, passive diffusion and tape-stripping.

• Transepidermal water loss (TEWL) measurements together with the results from weighing and scanning the tapes were used to derive the thickness of the SC [2].
• The SC was also examined by attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR) before and after each tape-stripe to probe lipid quantity and organisation.

• The extracted samples were analysed by LC-MS to identify and quantify the amounts of 22 components of NMF.

Results:

1) Thickness of SC

The greyscale method indicates a thinner SC on forehead comparing to forearm. The weighing method, on the other hand, show no apparent difference.

Table 1: Estimated apparent thickness (mean ± SD) of SC on both forehead and forearm.

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<thead>
<tr>
<th>Weighing method (μm)</th>
<th>Greyscale method (x10^6 integrated pixels)</th>
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<tbody>
<tr>
<td>Forehead</td>
<td>Forearm</td>
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<tr>
<td>9.1±1.4</td>
<td>4.3±1.3</td>
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<tr>
<td>57.6±4.6</td>
<td>112.1±12.4</td>
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2) IR absorbance of lipids (CH_2 stretching absorbances)

• Lipids near to the skin surface were relatively disordered most probably due to the contribution from sebaceous constituents.
• More but less ordered lipids on the forehead are suggested by higher frequency and normalised area of lipid peaks throughout the SC.

3) NMF quantification

Zwitterions
The cumulative amounts of NMF on the forearm were higher than forehead.

Negatively charged compounds
The cumulative amount of glutamine detected in forehead was higher than in forearm.

Positively charged compounds

Conclusions:
The results confirm that forehead SC may be considered a less competent barrier than that on the forearm, as characterised by the presence of

• Thinner SC
• Less ordered lipids
• Smaller amount of NMF