

Horny skin layer enhances the skin barrier function and water bonding with increasing age

Human skin consist of three layers – epidermis, dermis and subcutaneous tissue. The main age–related changes in the skin are well investigated for the dermis and include the delay of bio fluids’ microcirculation, reduced synthesis of extracellular matrix components, reduction of collagen I and its replacement by elastin, etc. The cells of the epidermis change their proliferation activity with ageing. The stratum corneum (SC), the thin ($\gg 20 \mu\text{m}$) uppermost horny layer of the skin, provides an efficient barrier function against the penetration of substances into the skin and is responsible for the regulation of water homeostasis in the skin. It is known that ageing is also accompanied with changes of water, lipid and protein concentrations in the SC composition and with increasing its thickness. A majority of these results was obtained invasively by analyzing skin biopsies. The skin barrier function provided by the SC is often determined non-invasively by measuring the transepidermal water loss through the skin. The age-dependent variations of this parameter are controversially discussed in the scientific literature.

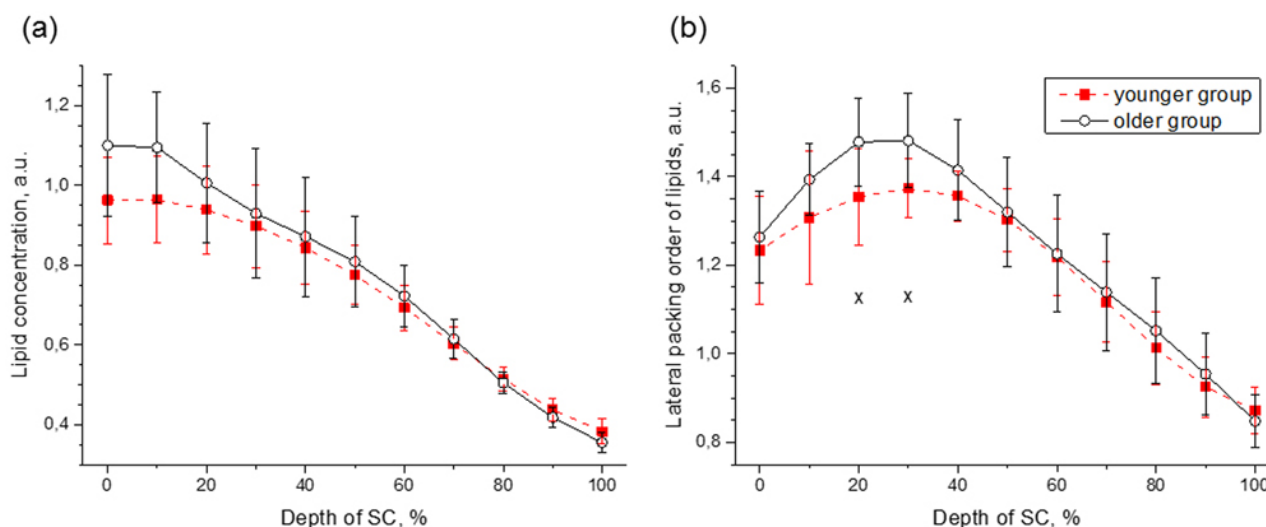


Fig. 1. Depth profiles of the lipid concentration in the SC (a) and lateral packing order of lipids in the SC (b) for the younger (red squares) and older group (black empty circles). “x” represents modest statistical differences

In the present study, the authors used a non-invasive method based on confocal Raman microscopy, which provides the possibility to analyze the chemical composition of the SC at high resolution. The inner forearm was placed on the microscope’s glass window and an infrared laser (785 nm, 20 mW on the skin surface) irradiated each skin point for 5 seconds in order to record Raman spectra of the entire SC (0–30 μm , 2 μm increments). Volunteers of two age groups –

younger (mean 29 y.o.) and older (mean 50 y.o.) were recruited in this study. Analysis of the Raman spectra provides information about the skin barrier function–related parameters, such as lateral packing order of lipids and hydrogen bonding states of water molecules in the SC.

Figure 1 shows that in spite of similar lipid concentrations in the human SC (Fig. 1a), younger SC is characterized by a statistically lower lateral packing order of lipids than older SC at the depths 20–30% of the SC thickness (SC depth) (Fig. 1b). The lateral packing order of lipids shows how dense the lipids are packed, and is therefore directly related to the skin barrier function. Thus, the results show that older SC has more densely packed lipids, i.e. higher skin barrier function than younger SC in the intermediate SC layers, which shows better resistance against the penetration of substances and prevention of water evaporation.

Interestingly, despite of similar water concentration profiles in the human SC (Fig. 2a), the hydrogen bonding state of water molecules in the SC is significantly higher for the older group than for the younger group at 10–30% SC depth (Fig. 2b).

These results show that water molecules of the older human SC are in states of stronger hydrogen bonding with surrounding molecules, such as adjacent water, lipids and natural moisturizing factor (NMF), than of younger SC. Thus, the water holding properties in these depths (10–30% SC depth) are higher in older SC than in younger SC, which is confirmed by statistically higher concentration of NMF in 20–40% SC depth in older human SC (Fig. 2c).

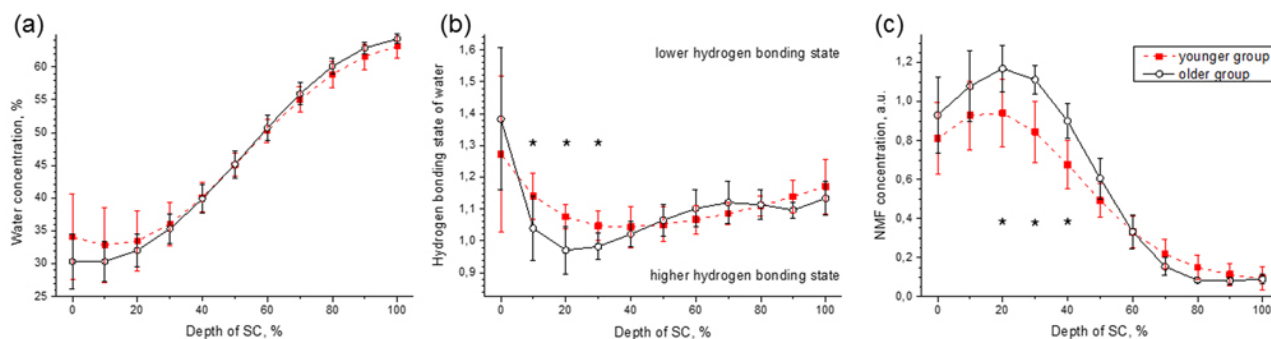


Fig. 1. Depth profiles of the water concentration (a), the hydrogen bonding state of water molecules in the SC (b) and NMF concentration (c) in the SC for the younger (red squares) and older group (black empty circles). “*” represents statistically significant differences.

Thus, older SC is characterized by increased thickness ($\gg 10\%$), skin barrier function and hydrogen bonding state of water molecules, than younger SC, which could be a compensatory mechanism for maintaining the water concentration in older skin. This method based on confocal Raman microscopy is the only *in vivo* method suitable for depth dependent analysis of the lipid organization and hydrogen bonding states in the SC.

Future investigations of an age group exceeding 60 y.o. is needed to confirm these results.

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Publication

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