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INVESTIGATIVE REPORT

Hydration and Plasticity Following Long-term Use of a Moisturizer: A Single-blind Study

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Skin hydration is thought to have an influence on skin plasticity, and moisturizers have therefore gained widespread use. However, the effects of long-term moisturizer use on the mechanical properties and the long-term correlation between plasticity and hydration of human skin *in vivo* remain unknown. Nineteen healthy volunteers applied a moisturizer to the volar surface of their forearms for 3 weeks, once daily on one arm and twice daily on the other. The skin capacitance, distensibility, hysteresis and elasticity were measured in both treated areas and in an untreated regional control area. Measurements were carried out at baseline, at one-week intervals during the trial and one week after the termination. Data were assessed in a single-blind fashion. No change was found in any of the mechanical parameters in the moisturizer-treated skin compared to the control. The capacitance of skin was found to increase independently of dose. One week after termination of the treatment, the skin capacitance remained increased. No dose-response effect was seen, however. Long-term use of moisturizers increases skin capacitance significantly, but does not change the mechanical properties. *In vivo* skin hydration is a poor predictor of skin mechanics. *Key words: mechanical properties of skin; emollient cream; capacitance*.

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Moisturizers are commonly used as adjuvant dermatological therapy in connection with, for example, topical corticosteroids. In addition, they are widely used as cosmeceuticals to improve skin function and appearance. However, the exact mechanisms by which they exert their effects remain only partially known, and additional studies on specific aspects of moisturizer–skin effects are therefore needed.

Moisturizers actively influence the physical properties of human skin (1). Plasticity has been shown to change in short-term studies, where applications of moisturizers, water or simple moisturizing ingredients were all found to soften the skin (2–4). Most moisturisers, water or simple moisturizing ingredients also increase the capacitance of the skin, which further suggests a causal correlation between hydration and plasticity *in vivo* (5). However, correlation does not imply causality. A previous study of the capacitance and the mechanical properties of untreated human skin *in vivo* suggested that while the two are correlated, capacitance is a poor predictor of the mechanical properties (6).

This study was therefore undertaken to establish the effects of long-term moisturizer use on skin plasticity and hydration, and to explore the relationship between hydration and mechanical properties *in vivo* further.

SUBJECTS AND METHODS

Subjects

Nineteen volunteers, 10 males (age range: 24–75) and 9 females (age range: 30–72), were recruited in this study. The median age of the volunteers was 42 years. None of the volunteers had any diagnosed generalized skin disease at the time of the study.

Moisturizer treatment of skin

The volunteers were instructed to apply a moisturizer cream (Danatekt®, Norpharma A/S, Vedbæk, Denmark; composition: octyl cocoate, cetearyl octanoate, cera microcryst., glycerin, propyglyceryl-4 isostearate, cetyl dimethicone copolyol, hexyl laureate, sodium chloride, paraben) on the volar surface of their forearms, once a day on one arm and twice a day on the other for 21 days (mean 23; range 15 to 28 days). The entire volar skin between the fold-lines at the wrist and elbow joints was treated. Assignment of the arms to receive either dose was randomly decided at entry to the study, by flipping a coin. The cream was weighted and registered before the treatment started, and at the end of the treatment. The protocol was approved by the Regional Ethics Committee, and volunteers were included after informed consent.

The cream used was shown to cause changes in the mechanical properties of skin *in vivo* in the short term after application using identical methodology to previous studies (2).

Measurements of mechanical properties of skin

The mechanical properties of skin were measured with Dermaflex (Cortex Technology, Hadsund, Denmark), the skin capacitance was measured using Corneometer CM812 (Kazake Courage, Cologne, Germany). The measurement was taken from the treatment areas and one of the medial upper arms

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that served as a control. Triple measurements of each parameter were taken before the treatment started, treatment at one-week intervals, at the end of the treatment, and one week after termination of the treatment. The means of the triple measurements were used in subsequent calculations.

Dermaflex contains a 10-mm suction cup that is attached to the skin with an adhesive ring, and an air pump that provides a vacuum in repeated, preset cycles. The instrument measures the change of the skin surface level in the vacuumed cup, and presents 3 parameters: distensibility, hysteresis and elasticity. Distensibility (mm) reflects the elevation of the skin surface following the first cycle of the suction. Hysteresis (mm; i.e., the "creep" phenomenon) denotes the maximum elevation in the repeated suction cycles. Elasticity (%) is the degree of total retraction of skin after the first cycle of suction.

The corneometer consists of a main housing and a measuring probe that functions as a condenser. The probe consists of an inter-digital grid of electrodes covered by low dielectric vitrified material that prevents direct contact between the electrode and the skin. By putting the probe on the skin, an electric field of variable frequency (40 to 75 kHz) is established. Following the application of the alternating current (F), the total impedance (Z) of skin varies with its capacitance (C) and resistance (R) according to the following equation: $Z = (R^2 + 1/2\ \pi\ FC^2)^{1/2}$. The instrument calculates the capacitance and presents as arbitrary units (a.u.) of skin hydration ranging from 0 to 150.

Data analysis

The total cream weight used for each arm of each individual was calculated. The value of each parameter was corrected according to the measurements taken from the control area. The change in the parameters was calculated by subtracting the pretreatment value from the values at the end of the treatment or the one-week post-treatment. One sample t-test was used to evaluate whether the change in each parameter on each arm was significantly different from zero. The Wilcoxon matched pairs test was used to determine whether the change in the parameters was significantly different between the two arms.

RESULTS

An average of 0.18 ± 0.11 mg moisturiser/cm^2/day was used for treatment once daily, and 4.63 ± 2.22 mg moisturiser/cm^2/day for treatment twice daily.

By the end of the 4-week moisturizer treatment period, the skin capacitance was significantly greater than that measured before the treatment started. This improvement was found for both arms treated ($p < 0.001$ for both), and no significant difference in the degree of improvement was found between the two treatments despite the different doses used (Table I). Similar results were found one week after the end of treatment. There was no significant change of skin distensibility, elasticity and hysteresis in either arm.

DISCUSSION

Several studies using different methods have documented changes in the mechanical properties of skin shortly after application of moisturizers (2, 7, 8). In this study, the long-term use of a moisturizer did increase the capacitance of skin, suggesting improved hydration, but had no effect on skin distensibility, elasticity and hysteresis. Previous cross-sectional studies have suggested that skin hydration, expressed as capacitance, is a poor predictor of skin plasticity (6). This is supported by the present observations and strongly suggests that no direct relationship can be found between the mechanical properties of human skin *in vivo* and hydration. In addition to technical considerations of sensitivity and specificity of the mechanical measurement technique, several possible explanations may be proposed.

In short-term studies, it has been suggested that skin lipidization rather than hydration is an important factor

Table I. *Measured changes after moisturizer application*

	Baseline	At end of treatment	One week after treatment
Area (×1[a]) cm^2	318 ± 65	–	–
Area (×2[b]) cm^2	315 ± 63	–	–
Control area			
Capacitance a.u. (control)	66 ± 7	70 ± 9	66 ± 5
Distensibility mm (control)	3.02 ± 0.53	3.09 ± 0.60	3.15 ± 0.51
Hysteresis mm (control)	0.213 ± 0.051	0.250 ± 0.056	0.214 ± 0.037
Elasticity % (control)	80 ± 10	83 ± 11	81 ± 9
Actively treated area			
Capacitance a.u. (×1)	63 ± 8	77 ± 8	68 ± 7
Capacitance a.u. (×2)	62 ± 11	79 ± 7	69 ± 6
Distensibility mm (×1)	2.53 ± 0.23	2.49 ± 0.26	2.54 ± 0.31
Distensibility mm (×2)	2.55 ± 0.27	2.61 ± 0.23	2.60 ± 0.38
Hysteresis mm (×1)	0.197 ± 0.032	0.234 ± 0.036	0.210 ± 0.051
Hysteresis mm (×2)	0.206 ± 0.042	0.244 ± 0.039	0.221 ± 0.056
Elasticity % (×1)	76 ± 6	77 ± 7	78 ± 8
Elasticity % (×2)	75 ± 9	76 ± 8	80 ± 7

[a]Area treated once daily.
[b]Area treated twice daily.
a.u.: Arbitrary units.

in the alteration of skin mechanics (9, 10). This is in agreement with the proposed role of lipids in the intercellular membranes, where it is speculated that lipids and/or water influence the physical properties of membrane lipids (11). Formulations with a higher lipid content may therefore have a more pronounced effect on skin mechanics. Other substances contained in the moisturizers may influence the capacitance measurements. Although capacitance has been shown to be proportional to hydration *in vitro*, other electrically charged molecules can influence the readings (5, 12). Capacitance changes can therefore reflect accumulation of these other molecules in the stratum corneum, rather than increased hydration. Finally, the parameter of hydration may be of less importance to skin plasticity *in vivo* than *in vitro*, since a natural state of maximum hydration may be normal due to the hydration of the underlying living tissue.

On a practical clinical level, data are provided on the unsupervised use of moisturizers. A large variation is noted suggesting that many volunteers have applied the cream unevenly to the skin. Furthermore, the variation appeared to be disproportionate, suggesting non-compliance or uneven spread of the cream. Uneven spread is more common with creams than when ointments are used (13). Although, according to Fick's law, this potentially affects the absorption of applied substances, it is not thought to have influenced the results of this long-term study significantly, since the period of study was long, i.e. increased the likelihood of the entire study area being treated at some point. This may, however, explain the absence of a significant dose-response effect for plasticity. Skin mechanics are of importance to the maintenance of good dermatological health. It is a common experience among dermatological patients that skin loses its normal elasticity and resilience, becomes bruised and cracked. Clinical experience shows that the use of moisturizers or emollients can ameliorate conditions characterized by reduced skin plasticity. Improvements of skin hydration do not appear to imply increased plasticity and it is therefore speculated that simple hydration is not the main effect of moisturizers *in vivo*.

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