

Correlation Between the Greasiness and the Plasticizing Effect of Moisturizers

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Moisturizers are used as cosmetics and as adjuvant therapy in dermatology. The strength or relative efficacy of moisturizers is poorly described and thus advising patients is difficult. It has been suggested that lipidization of the skin by moisturizers and the changes in skin mechanics following the application of a moisturizer may be useful measures of outcome. The aim of this study is to describe the relative efficacy of 5 different moisturizers, a barrier cream and a gel in terms of changes in skin mechanics and electrical capacitance before and after application. Assessment of the greasiness or absorption of the cream was made by standardized blotting of unabsorbed residue. Lipid-rich creams (Vaseline[®], Locobase[®] and Decubal[®] creme) caused increased skin distensibility, while no differences were found in hysteresis changes. In contrast, the relative efficacy in increasing skin capacitance was significantly greater in the moisturizers with a lower lipid content (Clinique[®], Nivea[®]) and gel. The results suggest that lipidization is of major importance to the plasticity of the skin. When moisturizers are used to improve skin plasticity it is suggested that lipid-rich formulations be used. Cosmetically more acceptable creams and gel were however better at increasing skin capacitance which has been interpreted as a measure of skin hydration. The difference may reflect a design adaptation of these creams to a specific outcome measure and our results raise the question of appropriate outcome measures in future moisturizer studies. *Key words: moisturizer; emollient; skin mechanics; measurement; research method.*

(Accepted August 19, 1998.)

Acta Derm Venereol (Stockh) 1999; 79: 115–117.

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Moisturizers and emollients are used extensively in cosmetic treatment of normal skin, for treating mild xerosis and as adjuvant therapy for many other dermatological diseases (1). In spite of the large number of products available, comparatively few efforts have been made to compare the preparations and identify differences that may help optimize their use in clinical dermatology (2).

The short-term effects of moisturizers are of immediate clinical and practical relevance. A product with an immediate effect is more likely to be perceived as beneficial by the user and its continued use encouraged. The time normally allowed for the absorption of applied moisturizers is thought to be short, i.e. the interval between putting on a moisturizer and putting on clothes is measured in seconds rather than minutes. Clothing consists of absorbent fibres, and it is therefore not unreasonable to expect that a significant proportion of non-absorbed moisturizer will be absorbed by the cloth rather than by the skin. In daily use, any moisturizing effect is therefore dependent on the short-term effect of moisturizers.

MATERIALS AND METHODS

A total of 20 healthy volunteers, age range 20–40 years, took part in the study. Skin mechanics were studied using a Dermaflex[®] machine (Cortex Technology, Hadsund, Denmark). The Dermaflex[®] is a device with a 10 mm diameter suction cup, in which the cup is fastened to the skin with an adhesive tape to prevent slipping within the probe (3). The change of the position of the skin surface within the suction cup is the measure. Two parameters were studied: distensibility, reflecting the elevation of the skin surface in the probe following the first application of suction; and hysteresis, reflecting the change in maximum elevation following repeated suction (i.e. the “creep” phenomenon). Mechanical measurements were supplemented by studies of skin capacitance in order to correlate the findings with previous studies. Capacitance was measured using the Corneometer[®] 812M (Khazaka & Courage, Cologne, Germany) (4). The mean of duplicate measurements was used in all calculations.

Six different creams commonly available on the Danish market, a gel and an untreated control area were studied: (a) gel (carboxymethylcellulosodium, glycerol, water, benzalconiumchloride, sodiumedatate). (b) Clinique Moisture-on-call[®], Clinique laboratories, New York, NY, USA (Moisture-on-call[®], no data available). (c) Nivea Visage[®], Beiersdorf OY, St. Karins, Finland (Liposome complex 10%). (d) Decubal creme[®], Alpharma-Dumex A/S, Copenhagen, Denmark (isopropyl myristas glycerolum, sorbitani steras adeps lanae purif., dimeticomin cetolatum, polysorbatum 60, acid. Sorbicum, aq. purif.). (e) Locobase[®], Yamanouchi Europe B.V., Leiderdorp, Netherlands (alc.cetostearyl, cetomacrogol 1000, paraf. liq., vas. alb., acid citr. anhydr., natr. citr. anhydr., methylparahydroxybenz., aq. purif.). (f) Vaseline[®], Johnson & Johnson, New Jersey, USA (Vas. alb.). (g) Kerodex[®], ArSiMa, Copenhagen, Denmark (Paraffin products, sodiumphosph., emulgators, E172, methylparab.). They were chosen to represent a spectrum of lipid concentrations and cosmetic acceptability, ranging from high lipid content and generally low cosmetic acceptability to low lipid content and high cosmetic acceptability.

The short-term effects of a single application of cream were studied in a similar manner to previous studies of possible emollient constituents (2, 5). Eight areas each 5 × 5 cm were marked on the back of the test subjects, and baseline mechanical and capacitance values measured. Using a fine syringe 0.05 ml of cream was applied to each area at random, using a rubber finger tip to apply the cream evenly.

We allowed 20 min for the water of the tested moisturizers to evaporate, before repeating measurements of skin mechanics and capacitance. The repeated measures were made within the marked test areas, but in different places from the baseline measurements in order to avoid artefacts from repeated stretching of the skin (3).

The absorption of the cream was hypothesized to be inversely proportional to the amount removed from the skin surface by simple blotting. The water content of moisturizers has previously been shown to evaporate within the first 15 min of application (6). The weight of the applied non-volatile contents of the moisturizers was calculated from pilot studies. The method has a coefficient of variation of 23%, which is similar to other non-invasive methods such as trans-epidermal water loss (TEWL). The results are also significantly correlated with skin surface lipids as measured by the Sebumeter ($p < 0.0001$) (7, 8). Residual moisturizer, i.e. non-absorbed excess cream, was then blotted from the skin surface, and the weight increase of the blotting paper was taken to express excess moisturizer lipids.

The effects of individual creams were studied using paired non-

Table I. Changes in distensibility and hysteresis and capacitance after application of a moisturizer.

The median baseline distensibility (95% confidence levels) was 2.70 (2.63–2.76) mm. The median baseline hysteresis (95% confidence levels) was 0.25 (0.25–0.26) mm. The median baseline capacitance (95% confidence levels) was 78.0 (77.2–81.2) a.u. * = significantly ($p < 0.05$) different from untreated control. For significance of relative efficacy please refer to the Results section

Product	Distensibility: overall change (mm)	Distensibility: relative efficacy (mm/mg absorbed)	Hysteresis: overall change (mm)	Hysteresis: relative efficacy (mm/mg absorbed)	Capacitance: overall change (a.u.)	Capacitance: relative efficacy (a.u./mg absorbed)
Gel	-0.10 (-0.18–0.007)	-0.21 (-0.38–0.0001)	0.03 (0.02–0.06)	0.80 (0.55–1.45)	20 (12–23)	1 (0.5–1)
Clinique [®]	0.14 (0.03–0.18)	0.31 (0.05–0.41)	0.03 (0.01–0.05)	0.94 (0.40–1.66)	11 (-4–15)	1 (-0.3–1)
Nivea [®]	-0.05 (-0.10–0.11)	-0.30 (-0.63–0.68)	0.02 (0.001–0.04)	1.09 (0.43–3.51)	7 (-1–14)	1 (0–4)
Decubal [®]	0.25 (0.09–0.40)	0.94 (0.35–1.27)	0.08 (0.05–0.10)	2.75 (1.57–3.87)	15 (6–17)	2 (1–2)
Locobase [®]	0.46 (0.37–0.54)	1.91 (-0.35–5.92)	0.06 (0.02–0.06)	1.44 -182.10–525.87	-14 (-23–-5)	-2 -8–-0.4
Vaseline [®]	0.64 (0.49–0.76)	1.03 (0.96–1.77)	0.05 (0.03–0.08)	1.08 (0.76–2.02)	-25 (-37–-21)	-2 (-2–-1)
Kerodex [®]	0.07 (-0.06–0.17)	0.18 (-0.09–0.34)	0.03 (-0.007–0.04)	0.64 (-0.04–1.16)	-5 (-17–1)	-0.3 (-1–1)
Untreated control area	-0.12 (-0.15–-0.002)	Not relevant	0.01 (-0.02–0.04)	Not relevant	4 (1–10)	Not relevant

parametric tests, while cream-to-cream differences were studied using Friedman's non-parametric repeated measures test (Dunn's post-test correction for multiple comparisons) and $p < 0.05$ was considered significant.

RESULTS

The results are shown in Table I. Comparing distensibility with hysteresis and capacitance after application of a cream with untreated control areas there were significant differences between the moisturizers tested ($p < 0.002$).

The relative efficacy, i.e. corrected for absorption, of the creams tested showed a similar pattern. The distensibility expressed as mm/mg absorbed cream showed significant variation between the creams tested ($p < 0.0001$). Vaseline[®] caused significantly greater increases than Nivea[®] and gel (both $p < 0.001$), and greater than Clinique[®] ($p < 0.05$). Locobase[®] increased distensibility significantly more than Nivea[®] and gel ($p < 0.001$) and Kerodex[®] ($p < 0.01$), while Decubal[®] induced significantly larger increases than gel ($p < 0.01$). In contrast, the hysteresis was not affected in a significantly different way by the different creams when the changes were corrected for absorption ($p = 0.3$).

The relative efficacy of the creams to induce changes in skin capacitance was also significantly different ($p < 0.0001$). Gel increased skin capacitance compared with Vaseline[®], Locobase[®] (both $p < 0.001$) and Kerodex[®] ($p < 0.05$). Decubal[®] increased skin capacitance significantly in comparison with Vaseline[®], Locobase[®] (both $p < 0.001$) and Kerodex[®] ($p < 0.05$). The moisturizers from Clinique[®] and Nivea[®] increased skin capacitance significantly over that of Locobase[®] and Vaseline[®] (both $p < 0.01$).

DISCUSSION

We studied the primary variable of moisturizer or emollient effect, i.e. skin plasticity, directly for some of the commonly used

moisturizers. The word moisturizer is used as a generic term for all the products in the remainder of this text. Assessment of the plasticity changes prior to correction for the absorbed amount of moisturizer, confirmed our previous observations, i.e. that moisturizers with a high lipid content appear to be superior modifiers of skin mechanics in the short term. Comparing the efficacy of moisturizers, i.e. after correcting for the estimated short-term absorption of lipids or lipidization, the differences and the conclusions were unchanged. Our observations therefore suggest that the efficacy of lipid-rich moisturizers to affect the mechanical properties of human skin *in vivo* is superior to that of less greasy moisturizers. They also support the notion that the plasticizing qualities of moisturizers are predominantly due to the lipid rather than the water phase.

Using a suction cup technique, slippage of the skin surface within the suction cup is a potential source of error. The removal of excess moisturizer by blotting prior to measurement, as well as the use of an adhesive ring to fasten the suction probe to the skin surface is thought to have reduced the risk of this. In addition our observation of increased plasticity of the skin surface following application of lipids, is in agreement with previous studies of glycerol using a different method not subject to potential errors due to changes in surface friction (9).

The results are in good accordance with common clinical impressions relating to the treatment of hyperkeratotic disorders. Where moisturizers are used for their plasticizing effects it therefore appears to be appropriate to recommend a lipid-rich formulation, particularly when mechanical problems due to reduced skin plasticity may aggravate or precipitate dermatological diseases, e.g. hand eczema.

Electrical capacitance was studied as the only hydration parameter. This method has previously showed significant changes following a single application of a moisturizer (10). Comparing the changes in skin capacitance corrected for absorbed moisturizer significant differences were seen, which were not in immediate agreement with the changes in mechanical properties of the skin. In contrast with differences in skin

mechanics, changes in skin capacitance were mostly due to significant reductions in skin capacitance following the application of lipid-rich moisturizers such as Vaseline®. These changes may be related to the composition of the lipids, with some lipids acting as isolators giving false negative results, while others may give false positive results as suggested by Lodén et al. (1, 11). These differences confirm the previous observation, that skin capacitance is a poor predictor of skin mechanics (12). In contrast, the different pattern of hydration and plasticity parameters suggest that the water phase of moisturizers is not primarily or predominantly responsible for the changes in skin plasticity, and that lipidization is responsible for the improved plasticity following the application of a moisturizer (13, 14).

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