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The Hydrating Effect of a Cream and White Petrolatum Measured by Optothermal Infrared Spectrometry *In vivo*

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Optothermal infrared spectrometry (OTIS) is a novel way of measuring the water content of stratum corneum non-invasively. This principle has been used in the present study to evaluate the hydrating effect of a one-week treatment of human skin twice a day with either white petrolatum or a cream (o/w emulsion). Forty-two females volunteered for the study, which comprised one control pretreatment week, one treatment week, and one post-treatment week. White petrolatum was greasy and did not produce any hydrating effect at any point in time when the hydration was measured 10 h after application, whereas the cream produced a clear hydration that became statistically significant from day one of treatment and was maintained for at least 2 days after the treatment was stopped. The hydrating effect amounted to an about 80% increase in those volunteers who had initial values below the mean OTIS value of 23.5%. It is concluded that saturation of the stratum corneum with appropriate lipids and emulsifiers as in the cream leads to hydration of the stratum corneum to about 35% water as measured by the OTIS technique. ***Key words: Stratum corneum; Water; Skin hydration.***

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The water content of the stratum corneum plays an important part in providing the skin surface with pliability and smoothness (1). Available evidence suggests that water-soluble materials, such as free amino acids, organic acids, urea, and inorganic ions, are important for the water-holding properties of the stratum corneum (2).

It has been suggested that lipids in the lamellar structures in the intercellular spaces of the stratum corneum also play a part in water-holding (3, 4). These lipids have been thought to originate from the lamellar body and consist mainly of cholesterol, glycolipids, phospholipids, and free fatty acids. Removers of lipids, such as organic solvents, induce dry skin with markedly reduced water content as a result (5, 6).

A variety of measures are usually taken to ensure sufficient hydration of the skin and thereby good pliability and barrier function. The present study tested the hypothesis that hydration of the stratum corneum may be improved by a mineral oil preparation, white petrolatum, and by a lanolin containing oil in water emulsion cream when comparisons are being made with untreated skin.

MATERIALS AND METHODS

Test subjects

Forty-two healthy females aged 25–55 years, with normal skin, volunteered for the study. They were asked not to use any cosmetic preparation on their arms for a 3-week period (November 27–December 18, 1989). Washing with soap and water before application was permitted.

Testing

All subjects were tested on the same dates. They arrived at the laboratory 15 min before testing and were asked to relax by reading. Laboratory temperature and relative humidity were 21–23°C and 42–52%, respectively. The OTIS was calibrated with air as zero and water as 100%. The testing by the OTIS was performed on the central part of the distal half of the flexor aspect of the forearm. The probe was placed on the skin for 1 min and the signal was recorded on an X–Y pen recorder. The OTIS value at 10 s was read 'blind' by a technician (10 s was chosen to reduce the effect of occlusion).

The features of the OTIS technique have been described in detail by Frödin et al. (7, 8). The present modified apparatus used 30 Hz chopper frequency instead of 20 Hz which concentrates the measuring depth presumably to the stratum corneum only (15–25 μm depth from the skin surface). The measuring window of the probe was 1×1 mm and measurement with this probe was only slightly affected by variations in the pressure against the skin.

Products to be tested

White petrolatum and a cream containing lanolin (non-sensitizing), isopropylmyristate, cetanol, glycerol and sil-

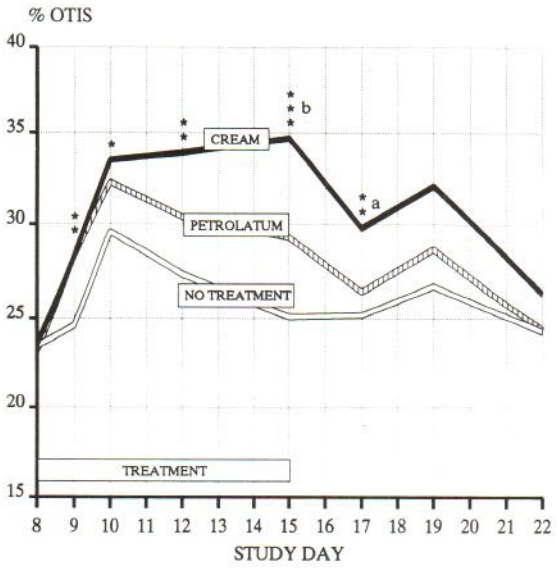

Fig. 1. Effect of twice daily applications of the cream or white petrolatum during study days 8–14 vs. no treatment on the epidermal hydration of normal skin. Measurements were performed 10 h after evening application. The data are pooled from groups I, II and III, with 25–27 observations for each treatment. The data were analysed by ANOVA. $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$ (cream vs. no treatment); *a*: $p<0.05$, *b*: $p<0.01$ (cream vs. petrolatum).

icone as an oil-in-water emulsion with 38% oil phase (Decubal/Abitima cream, Dumex A/S Copenhagen).

Treatment

The volunteers received printed instructions not to use skin preparations on their arms from day 1 to day 7 inclusive, and from day 15 through day 22 of the study. On study day 8 the preparations were applied at bed time, and testing was performed the following morning (effect of one application). The preparations were then applied and repeated the same evening at bed time. Next morning the testing was repeated (effect of three applications) followed by a further application. The applications were made twice the following days up to day 14 with morning applications, always subsequent to testing. Consequently, testing was always carried out about 10 h after the application.

The preparations were delivered in 2 ml syringes containing 0.2 ml. This amount was placed on the centre of the distal half of the flexor aspect of the forearm and distributed equally over that half. This gives a calculated initial thickness of 10 μm.

The volunteers were randomly distributed to one of three groups, each comprising 14 volunteers. Group I was treated with the cream on one arm only (right or left). Group II was treated with white petrolatum on one arm only (right or left). Group III was treated with the cream on one arm and with white petrolatum on the other (right or left). Within each group an equal number were treated on each side.

Data analysis

Data from day one were not used as the volunteers may have applied various skin preparations preceding that day. The mean OTIS values from day 4 and day 8 (presented in Figs. 1–2 as day 8) were used as a calibration for the initial level of skin humidity for each volunteer and each treatment. Testings were further carried out on days 9, 10, 12, and 15 during treatment, and days 17, 19, and 22 without treatment.

The changes in the water content in the skin (OTIS) in relation to the initial level were analysed by means of an analysis of variance (ANOVA) with the main effects *SUBJECT*, *TREATMENT* and *ARM* (right/left) within each time point (PROC GLM, SAS Institute, 15).

With respect to the changes in OTIS, the differences between treatments (the cream vs. control, petrolatum vs. control or the cream vs. petrolatum) were estimated in the model with the main effects described above by means of the ESTIMATE directive in PROC GLM.

The average of the mean initial values as defined above was 23.5%. Changes in OTIS among subjects with mean initial OTIS values (from the two arms) less than 23.5% (and $\geq 23.5\%$, respectively) were compared in the same way as the changes in OTIS among all subjects.

The possible influence of the initial water content on the change in the water content obtained by the treatments was analysed by means of an analysis of variance with the main effects *SUBJECT* and *TREATMENT* and initial water content as co-variate.

RESULTS

Basal period

No differences between the skin humidity of the arms randomly allocated to the three treatments were observed, either between the groups or between the study days 4 and 8. The means of the two values at day 4 and day 8 may therefore be good estimates of the initial hydrations.

Treatment period

There was no statistically significant difference between the effects measured on the right and left arms.

Statistically significant differences in the changes in water content between the treatments were found on day 9 ($p = 0.03$), day 12 ($p = 0.007$) and day 15 ($p < 0.001$). The treatment effect was caused mainly by a difference between the cream and no treatment, but the difference between the cream and petrolatum was also statistically significant on day 15 ($p = 0.002$) (Fig. 1).

Recovery period

The analysis of variance showed a significant treatment effect on day 17 ($p = 0.007$), 2 days after the

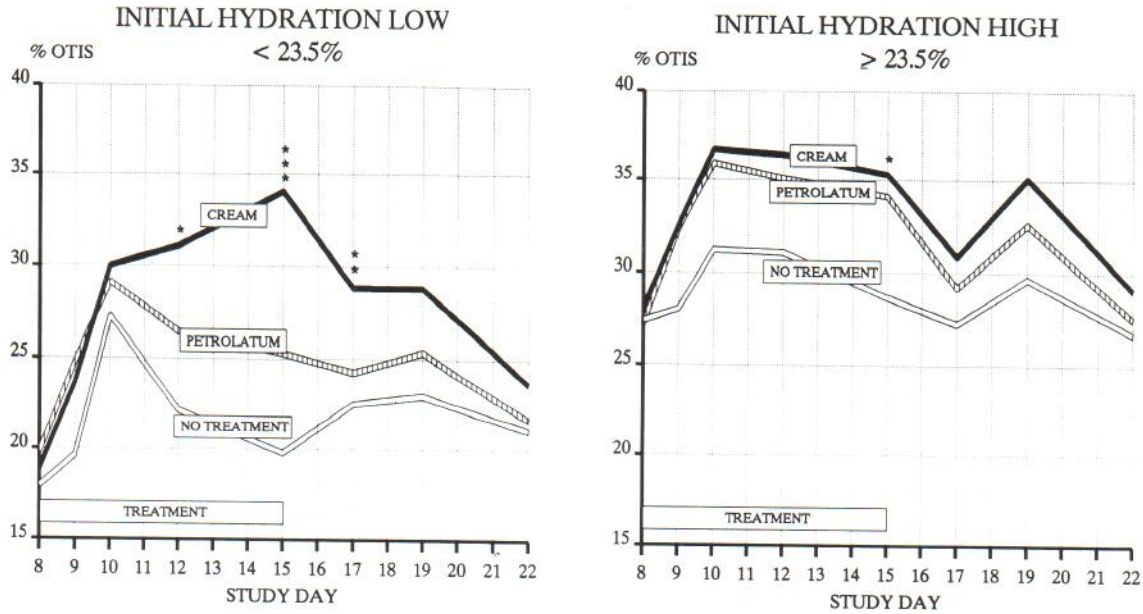

Fig. 2. Data presented in Fig. 1 analysed according to the mean initial hydration being below or above the mean level of 23.5%. The data were analysed by ANOVA. $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$ (cream vs. no treatment).

applications were completed. The treatment effect in Fig. 1 was due to a statistically significant greater change in the water content by the cream vis-à-vis the petrolatum ($p = 0.02$) and vs. no treatment ($p = 0.003$).

All three groups had almost returned to their initial levels 7 days after the last application.

Influence of initial % OTIS on change of hydration by treatments

The initial level of water content of the stratum corneum had a statistically significant effect on the hydrating effect at each time point (p in the range <0.001–0.02). This means that the changes in the % OTIS obtained by the treatments are about 1 (range 0.6–1.4) less for each 1% higher initial OTIS, suggesting a saturation effect within this population. Subdividing the subjects into relatively dry (<23.5%) and more hydrated subjects leads to a clear illustration of the more marked effect in the former group (Fig. 2).

DISCUSSION

The study found a cream to be highly effective for hydrating the stratum corneum to a saturation level of about 35%, particularly of dry skin, whereas white petrolatum was ineffective. The literature does not provide evidence that white petrolatum might produce any lasting hydration of stratum corneum.

The results with this lanolin-based cream are consistent with similar studies using a lotion based essentially on the same ingredients (4, 7–10).

The time course of the OTIS values for the untreated arms showed a variation of the mean values between 23 and 29% which was reflected in the values from the treated arms as well. A similar variation was found by Frödin et al. (7). The cause of this fairly consistent variation is at present unknown and was not a topic of study.

The level of skin hydration may be important for the functional state of the skin. Water seems to be bound to the stratum corneum as tightly bound water (about 5%), readily releasable water (about 30%) and free water (11). Free water appears only in the highly hydrated state of stratum corneum (12). Patients with xerosis senilis and psoriasis seem to have only 20–25% readily releasable water (11) which may be worth correcting up to 30% by an emollient cream.

Stratum corneum extracted for lipids by acetone/ether for 1–20 min showed an immediate as well as long-lasting impairment of hydration by water ap-

plied directly to the skin (13). Daily topical applications of a ceramide lipid fraction induced a more rapid recovery of the hydration than found in controls (14).

The water content of an emollient lotion does not seem to participate in the hydration of the stratum corneum, as it evaporates quickly (4). The absorbed lipids and emulsifiers from the present cream appear to be significantly more effective than white petrolatum in establishing a lasting hydration of the skin. Although white petrolatum may possess some useful properties on the surface of the skin, it may not improve the hydration by occlusion or other mechanisms.

The OTIS technique used in the present study appears to be a novel and valuable technique with which to measure hydration of the stratum corneum under various conditions, measuring not only on the surface cell layers but also deeper into the stratum corneum with only a small input from the lowest, more hydrated layers (8).

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