

## The Increase in Skin Hydration after Application of Emollients with Different Amounts of Lipids

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Emollients can increase the water content in the stratum corneum by delivery of their water to the skin, and by occlusion. These two mechanisms were studied using three preparations with different concentrations of lipids. The products were applied to the skin and then removed by cleaning the surface after 5 and 40 min. The increase in skin water loss following removal of product residue was considered as a release of excess water in the skin.

Exposure of the skin to pure petrolatum for 5 min gave no increase in the water loss from the skin surface following removal of the product residue. A lipid rich cream (66% lipids) gave a significant increase, but the highest increase was found after removal of an ordinary cream (27% lipids). Release of water from the skin indicates that water in the creams had previously been absorbed into the skin.

The occluding properties of the products were determined after 40 min of exposure. Petrolatum reduced the water loss by approximately 50% and the other products by 16%. The occlusion caused an increase of water in the skin, which resulted in a release of water following removal of the products. The release was related to the reduction of water loss. Thus petrolatum gave a higher release of water than the other emollients. *Key words: Occlusion; Skin moisture; Evaporimeter; Skin surface water loss.*

(Accepted January 27, 1992.)

Acta Derm Venereol (Stockh) 1992; 72: 327-330.

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The healthy stratum corneum can stay soft and flexible under various environmental conditions. This allows free body movement without cracking. This is due to the plasticizing effect of the water in the skin, as shown in the classic experiments by Blank in 1952 (1). The stratum corneum constantly receives water from within the body and from the environment. In general the net flux is from the body to the environment. Maintaining an appropriate water content in the skin is an important clinical and cosmetic concern.

Emollients are believed to increase skin hydration according to two different principles: (I) by occlusion of the skin surface, and (II) by introduction of substances which can maintain the moisture in the stratum corneum. Besides ordinary humectants, the intercellular lipids are believed to play an important role in the maintenance of the water content in the stratum corneum (2, 3). The decreased water-holding capacity of the horny layer is closely associated with an impaired barrier function in pathologic scaly skin (4-6).

The water in the applied products is believed not to contribute to the increase in hydration, since water easily evaporates

from the surface. Emulsions lose most of their water content within 15 min of application (7-9). To our knowledge no data exist concerning the absorption of water into the skin following application of topical products. Neither do we know the relationship between occlusion and the increase of water in the skin. The techniques available for measurements of skin hydration (e.g. electrical, spectroscopic, fluorescence) only give qualitative information on the water content at poorly defined locations within the skin (10, 11). Furthermore, cream components on the surface may give misleading results on the skin hydration (12). The aim of the present study was to illustrate two mechanisms by which emollients could increase skin hydration, namely by delivery of their water into the skin and by occlusion. The measurements were made with an evaporimeter using an approach that circumvented the influences of cream components on the measurements.

### MATERIALS AND METHODS

#### Products

Pure petrolatum and two oil-in-water creams were tested. One of the creams was lipid rich, containing 66% lipids and 30% water, whereas the other was an ordinary cream with 27% lipids and 71% water.

#### Study procedure

Seven healthy individuals with no clinical signs of dermatological diseases or dry skin participated in the study. Their mean age was 38 years (35-46 years). The influence of the creams on the evaporation of water from the skin was measured with an evaporimeter EPI (Servomed, Sweden). The products were randomly allocated to six areas on the volar forearm. The measurements were made according to details previously described (13). All of the data were collected with a pen-recorder.

Before any measurement, the skin was cleaned with a soft tissue impregnated with dehydrated diethyl ether. Thereafter the basal level of TEWL was measured. After this determination, the products were applied at a rate of 3 mg/cm<sup>2</sup> and spread during 15 s. The evaporation of water from the skin surface was recorded with the evaporimeter during 5 or 40 min, whereupon product residue was gently removed by wiping the skin with a soft tissue impregnated with diethyl ether. Immediately after cleaning the skin, the water loss was recorded until the basal level was reached (usually within 15-20 min).

Control experiments were performed in order to see if the released water originated from cream residue on the skin, or from the skin. In these experiments the cream was applied to the skin and then immediately removed as above. No increase in the evaporation of water from the skin was noted, verifying that the increase after exposure of the skin for 5 or 40 min originated from the build-up of water in the stratum corneum.

#### Statistics

Student's *t*-test for paired comparisons was used to evaluate the statistical difference between the basal TEWL and the water loss obtained after application or removal of the products. *p* < 0.05 was considered significant.

Table I. The effect of three emollients on the evaporation of water from the skin surface. Basal skin value and the evaporation 1 min after application of the products.

Results ( $\text{g m}^{-2} \text{ hr}^{-1}$ ) are mean  $\pm$  S.D. ( $n = 7$ ). The figures in parentheses denote changes in percent compared to the basal level.

Emollient	Basal TEWL	1 min level
Ordinary cream	$5.5 \pm 1.3$	$72.7 \pm 4.1^*$ (1220%)
Lipid-rich cream	$5.8 \pm 1.3$	$54.3 \pm 1.2^*$ (836%)
Petrolatum	$5.4 \pm 1.4$	$2.3 \pm 0.4^*$ (-57%)

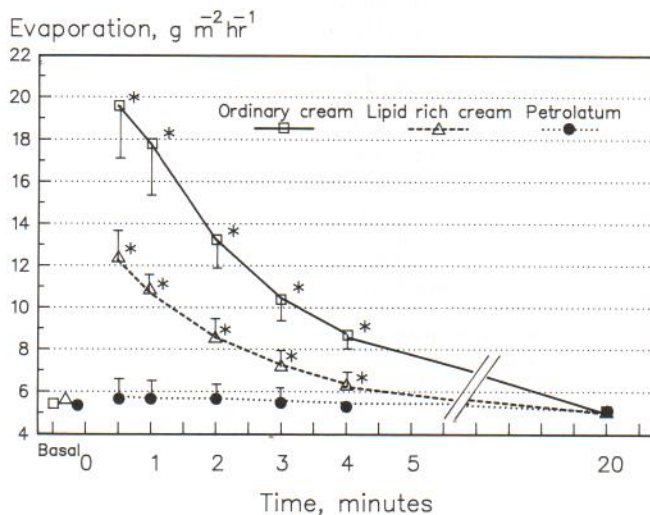
\* Significantly different from the basal level,  $p < 0.05$ .

## RESULTS

The water loss from the cream-treated surfaces were significantly increased during the first minutes after application (Table I). The increase in water loss was due to evaporation of water from the creams and was related to their water concentration. Petrolatum, without any content of water, reduced the evaporation of water from the skin surface (Table I).

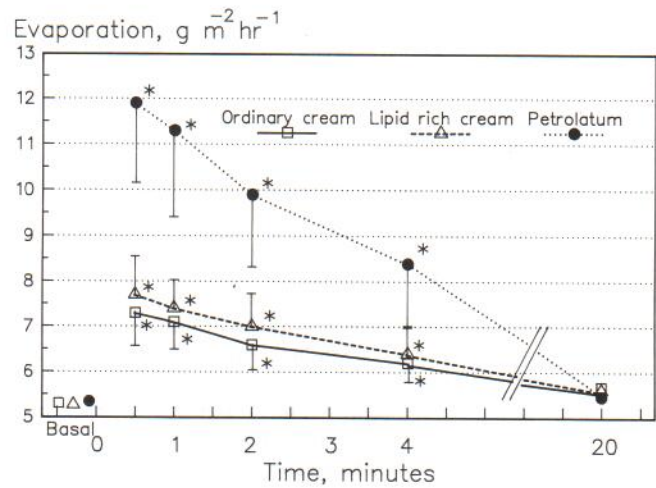
The water loss declined 1–2 min after application but was still above the basal level when the excess product was removed after 5 min of exposure. Removal of the emollients at that time did not restore the basal level immediately but caused evaporation of water from the skin (Fig. 1). Petrolatum gave only a marginal (non-significant) increase in the water loss, whereas the lipid rich cream and the ordinary cream gave a significant increase in the water loss. This water did not originate from cream residue on the skin, as checked by the control experiments (see Materials and Methods). The increase in water loss was only temporary. The basal level was reached after 10–20 minutes.

Removal of the emollients after 40 min of exposure also



\* Significantly different from the basal value.

Fig. 1. Evaporation of water from skin surface after removal of product residue. The skin was exposed to the products for 5 min. Results are mean  $\pm$  S.E.M.



\* Significantly different from the basal value.

Fig. 2. Evaporation of water from skin surface after removal of product residue. The skin was exposed to the products for 40 min. Results are mean  $\pm$  S.E.M.

gave an immediate and temporary increase in water loss (Fig. 2). However, in contrast to the removal at 5 min, the water loss was inversely related to the water content in the emollients, i.e. petrolatum gave a higher water loss than the creams. The lipid-rich cream gave a higher water loss than the ordinary cream. The water loss at that time was probably due to the occlusive effects from the products, since 40 min after application the TEWL was lower than the basal level (Table II).

## DISCUSSION

A new approach was used to measure the immediate increase in the stratum corneum hydration following application of emollients. The technique enabled us to differentiate between the hydrating effects from products with different amounts of lipids. The obtained results support earlier findings that single applications of emollients increase skin hydration (7, 9, 11, 12). However, it is believed that this is the first study to demonstrate an uptake of water in the skin from applied

Table II. The effect of three emollients on the evaporation of water from the skin surface. Basal skin value and the value 40 min after application.

Results ( $\text{g m}^{-2} \text{ hr}^{-1}$ ) are mean  $\pm$  S. D. ( $n = 7$ ). The figures in parentheses denote changes in percent compared to the basal value.

Emollient	Basal TEWL	* Prior to cleaning
Ordinary cream	$5.0 \pm 0.7$	$4.2 \pm 0.6^*$ (-16%)
Lipid-rich cream	$4.9 \pm 0.4$	$4.1 \pm 0.6^*$ (-16%)
Petrolatum	$5.1 \pm 0.8$	$2.8 \pm 0.7^*$ (-45%)

\* Significantly different from the basal level,  $p < 0.05$ .

products. One of the advantages of the technique is that electrolytes and other components in the products cannot influence the measurements, which is sometimes the case using electrical methods (11, 12). A possible pitfall is that a temporary influence on the barrier function or an increased sweat gland activity may also cause the increased water evaporation. However, in the control experiments it was shown that the cleaning procedure with diethyl ether did not influence the barrier properties of the skin, and screening experiments using the same methodology on excised human skin supported the findings (data not presented). This verifies that what is being measured is the evaporation of water from the stratum corneum rather than a change in barrier function or transpired water.

Hydration achieved from the products resulted in an increased TEWL upon cleaning of the skin, 5 and 40 min after application of the products. This was due to the release of excess water in the skin. Exactly where the water is located is not known, but water in the stratum corneum is supposed to be bound up to 30–40% (14–16) and free at higher contents, based on the dry stratum corneum weight (15, 16). Changes in hydration is suggested to influence the water content mainly at the keratin fibrils in the corneocytes (17). Increased hydration may also cause a lateral swelling of the alkyl chain in the lipid bilayer, whereas the distance between the intercellular bilayers is not affected (18). When the excess water in the corneum had evaporated, skin surface water loss equalled the basal TEWL.

Skin hydration increases immediately after application of emollients. The results indicate that the higher the concentration of water is in the products, the more water is absorbed into the skin. This was revealed by the high TEWL after the short exposure time (5 min) to the ordinary cream, compared to the lower increase after exposure to the lipid-rich cream, and the non-significant increase after exposure to petrolatum. Thus, besides evaporating from the surface, the water in the applied products is absorbed into the skin. However, the absorbed amount is low compared to the amount evaporated. The evaporation rate is probably due to the diffusion constant and the thermodynamic activity of the water in the emulsion, the same parameters which are important to the penetration of drugs into the skin. Hence, the rate of evaporation is probably indicative of the amount of water that will be absorbed into the skin.

It is possible that the temporary increase of water in the stratum corneum after application of water-containing creams is of clinical importance. Firstly, it is a well-known fact that there is a positive relationship between the degree of skin hydration and the percutaneous absorption of both hydrophilic and lipophilic drugs. This may shorten the time until reaching pharmacological amounts of active drug in the viable parts of the body (19). Secondly, the evaporation of volatile agents from the applied products induces cooling of the skin. Cooling reduces the itching in pruritic skin disorders.

The evaporation of water from the treated surfaces was below the basal level 40 min after application of the products. This was due to occlusion which caused a build-up of water in the skin, as revealed by the increase in water loss after clean-

ing the surface (9). Greater hydration was observed with the products containing higher concentration of lipids. This might be due to the larger amount of non-volatile material deposited on the skin surface after evaporation of volatile compounds. However, it is not only the amount of non-volatile components but also their capacity to form an isotropic oily phase that seems to be important for the occlusivity (8, 20). Pure petrolatum showed the highest degree of occlusion and caused the highest amount of released water after 40 min of exposure.

In conclusion, measurement of the increase in skin hydration following application of emollients showed that water in the applied products was absorbed into the stratum corneum. The method also proved useful for measurement of the increase in hydration due to occlusion.

#### ACKNOWLEDGEMENTS

I am grateful to Ms Lizbet Skare for her excellent technical assistance and to Dr Magnus Lindberg for valuable criticism of the manuscript.

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