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In Vivo Hydration and Water-retention Capacity of Stratum Corneum in Clinically Uninvolved Skin in Atopic and Psoriatic Patients

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Hydration and the water-retention capacity of stratum corneum have been investigated in uninvolved psoriatic and atopic skin and compared with that of healthy controls. Thirty-three subjects of either sex and matched for age entered the study. The subjects were free from all signs of skin disease and skin dryness. Hydration was evaluated by means of transepidermal water loss and skin capacitance measurements. Water-retention capacity was investigated using the plastic occlusion stress test. Atopic skin differed significantly from uninvolved psoriatic and control skin which had a reduced water content and an increased transepidermal water loss. Furthermore, the skin surface water loss profile representing the stratum corneum water-retention capacity was significantly lower in normal atopic skin. The data suggest that clinically normal skin may be functionally abnormal, resulting in a defective barrier that could lead to higher risk of irritant or contact dermatitis. ***Key words: Skin surface water loss; Occlusion.***

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Hydration and stratum corneum water content are important factors influencing skin plasticization and barrier function. Several studies have correlated diseased skin with barrier function impairment (1, 2, 3) and reduced water content (4, 5). In most, lesional skin was compared with uninvolved skin on the assumption that clinically normal skin should be considered normal; scant attention has been paid to the relationship between non-lesional skin and normal skin of healthy subjects.

The present study investigated skin pathophysiology in clinically normal skin to elucidate these interrelationships. Volunteers with no signs of skin disease or skin dryness entered this study. Stratum corneum hydration and stratum corneum water-retaining capacity were evaluated in symptom-free skin of psoriatic and atopic subjects and compared with healthy controls using transepidermal water loss assessment (TEWL) and electrical capacitance measurements. Hydration achieved by occlusion results in an increased TEWL when the occluding film is removed (6). Skin surface water loss represents the evaporation of water from the skin surface after occlusion. When the excess water present in the corneum after occlusion has evaporated, skin surface water loss equals TEWL. This technique can be utilized to quantitate the skin water-retaining capabilities and gives an indirect measurement of the in vivo water content. Water-retaining capacity (WRC) has been studied using the plastic occlusion stress test. This technique has been demonstrated to be useful in investigating WRC in subliminally irritated skin (7).

MATERIALS AND METHODS

Subjects

Thirty-three volunteers of either sex gave informed consent to the study and were investigated (11 psoriatic and 11 atopic patients, compared with 11 healthy controls). Subjects were matched for age (age range 25–40 yrs, median 31 in atopics, 33 in psoriatics and control group). All subjects were in good general health and showed no signs of skin disease. Atopic patients included in the study were selected according to Hanifin & Rajka (8). Psoriatic and atopic patients were not undergoing any treatment, either systemic or topical; they were asked to discontinue any topical pharmacological or cosmetological treatment (if any) one month prior to the procedures. Only atopic subjects with clinically normal skin on the arm and forearm entered the study; subjects with 'dry' eczematous skin were excluded. Measurements were performed on the distal third of volar forearm on skin sites that had not shown any sign of pathological involvement during the last 6 months.

Water-retention capacity using the plastic occlusion stress test

On day 1, plastic occlusion was applied to the forearm by means of a plastic chamber (Hill Top®, Cincinnati, USA) of 25 mm diameter backed by paper tape (Micropore® tape, 3M, St. Paul, Minn.). On day 2 (after 24 h) the occlusion

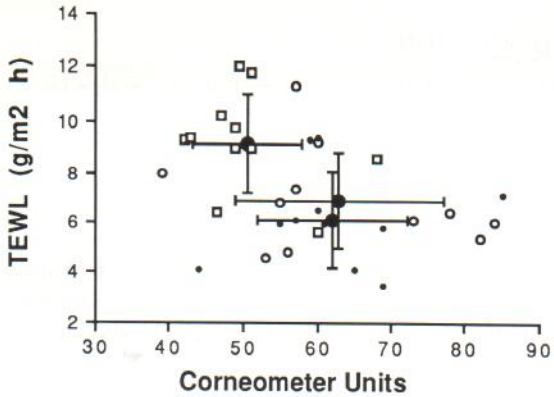

Fig. 1. Transepidermal water loss (TEWL) and stratum corneum water content plotted simultaneously. Clinically normal atopic skin differs from non-lesional psoriatic and control skin, being characterized by higher TEWL and lower water content. ○, psoriatics; ●, control; □, atopic; ■, mean. Mean values for each group (± *x* and *y* standard deviation).

chamber was removed and the visible excess of water wiped away with tissue paper left on the skin surface for 2 s. Immediately afterwards, the probe of an evaporimeter (ServoMed Ep-1, Sweden) was applied to the previously occluded site and skin surface water loss measured continuously every minute for 25 min. The probe was equipped with a gold-plated protection cover with grid (no. 2107) provided by the manufacturer. To avoid heating, the probe was held on the investigation site with a clamp.

Skin hydration

Measurement of the actual water content was performed by means of a capacitance device (Corneometer, CM 420, Courage and Khazaka, West Germany) on the contralateral forearm. Three different measurements were made on a 16 cm^2 surface and values averaged. Basal TEWL levels were recorded at the same time on this site. The choice of left or right forearm for plastic occlusion stress test and hydration measurements was randomized between the two arms.

Skin temperature was measured on the two forearms with an electronic thermometer (Omega Corp. Stamford, Conn., USA). Skin surface water loss and TEWL values were converted to logarithms and values were normalized for a temperature of 30°C according to Mathias et al. (9). Skin surface water loss decay constants were calculated according to Wagner (10). The one-compartment open model with first-order absorption was used. This model has been the most widely used model in pharmacokinetics. TEWL and skin surface water loss values are given in g/m^2h, stratum corneum water content is in Corneometer Units.

Room temperature was between 19° and 21°C, relative humidity 40–50%. Subjects rested 30 min prior to the procedures.

Statistics

Statistical analysis of the data was performed using one-way analysis of variance and Fisher's PLSD test. A level of $p < 0.05$ was considered statistically significant. Calculations were done using the software package for statistical analysis Statview II.

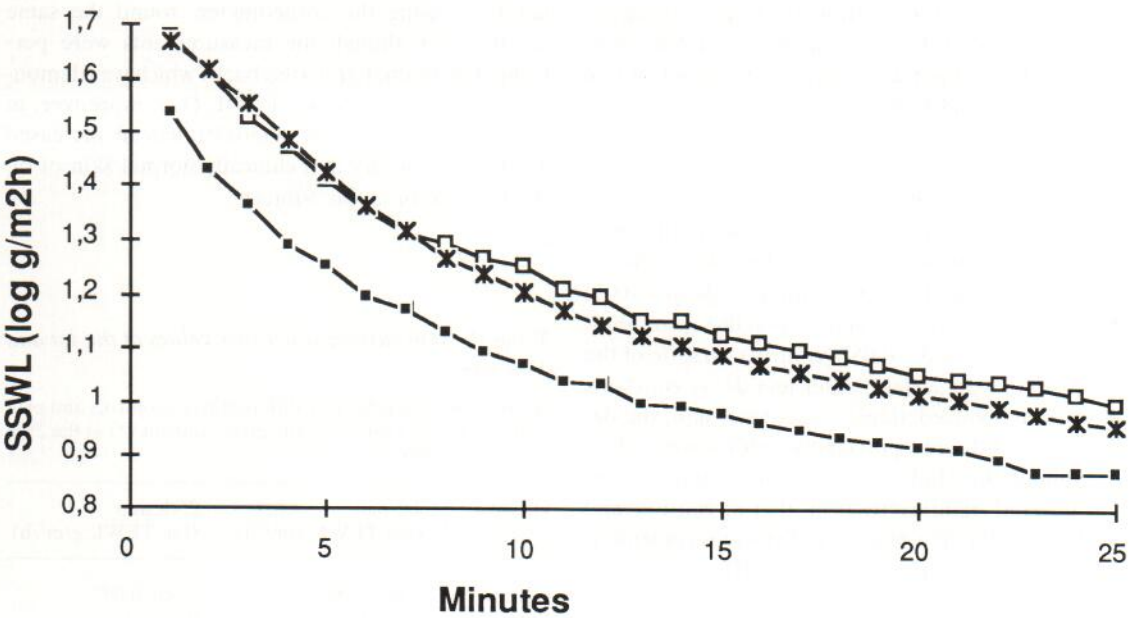

Fig. 2. Skin surface water loss curves after plastic occlusion stress test. □ = control, * = psoriatic, ■ = atopic. Psoriatic skin differs slightly from control skin.

Table I. *Stratum corneum water content and transepidermal water loss (TEWL) in the assessment of skin hydration in visually normal skin*

There is a significant difference among the groups for both water content and TEWL ($p < 0.01$). Non-lesional atopic skin significantly differs from control and psoriatic skin ($p < 0.05$).

Group	Water content (Corneometer Units ± SD)	TEWL ($g/m^2/h$)	P-value
Control	62.1±10.2	6.1±1.9	
Psoriatic	63±14	6.9±1.9	
Atopic	50.5±7.4*	9.1±1.9*	*<0.05

RESULTS

The results are summarized in Figs. 1 and 2 and Tables I and II.

Hydration

TEWL was significantly increased in clinically normal atopic skin (9.1) compared with non-lesional psoriatic (6.9) and control (6.1) skin (analysis of variance $p < 0.01$) (Table I); the 95% confidence limits were between 4.8 and 7.4 in controls, 7.9 and 10.8 in atopics and 5.5 and 8.2 in psoriatics; furthermore, in the atopic group, stratum corneum water content was significantly reduced (50.5 vs. 63 in psoriatic skin and 62.1 in controls) (analysis of variance, $p < 0.01$) (Table I, Fig. 1). The 95% confidence limits for water content were between 55.2 and 69.0 in controls, 45.5 and 55.5 in atopics, and 53.9 and 72.5 in psoriatics.

Water-retention capacity

Water-retention capacity of the stratum corneum as detected by skin surface water loss decay curves differed significantly between the groups ($p < 0.05$) (Fig. 2). The decay constants were 0.063 (psoriatic), −0.055 (atopic) and −0.057 (control). In spite of the similarity of skin surface water loss decay constants between uninvolved atopic and control skin, the decay curves differed appreciably, with lower values throughout the study in the atopic group. Atopic skin differed significantly from that of controls and psoriatics at the first minute and vîs-à-vîs controls at the 25th minute ($^* p < 0.05$) (Table II).

DISCUSSION

Tagami et al. (1) used the sorption–desorption test to evaluate the water-retaining capacity in vivo in several scaly skin conditions, and found close correlation between clinical scaling in psoriasis and chronic eczema and reduced water-retention capacity of the corneum (thicker scaling, lower water-retention capacity). Inconspicuous eczematous lesions showed defective water-retention capacity. By performing simultaneous measurements of TEWL with an evaporimeter and cutaneous conductance to record skin hydration, the same group (11) assessed the stratum corneum of psoriatic patients with varying grades of disease severity. Data obtained indicated both the existence of an inverse relationship between these two parameters and the presence of a reduced water-retention capacity associated with increased TEWL in psoriatic lesions.

Serup & Blichmann (4) confirmed these results in psoriasis by using the same technique and emphasized that this inverse pattern is a common feature in scaly dermatoses. These investigations compared involved with uninvolved pathological skin, or involved with normal control skin; few attempts have been made to investigate clinically normal skin of atopic and psoriatic patients compared with normal subjects. Al-Jaberi & Marks (12) reported normal water content in normal skin of atopic patients; Werner (13), using the corneometer, found the same results, even though the measurements were performed in another area (the back) which was demonstrated to have a normal TEWL (14); moreover, in this study, the authors demonstrated an increased TEWL in both dry and clinically normal skin of on the forearm of atopic subjects.

Table II. *Skin surface water loss values at the 1st and 25th min*

Atopic skin is significantly different from controls and psoriatics at the first min (†) and versus controls (*) at the 25th min ($^* p < 0.05$).

Group	1st min (log TEWL $g/m^2/h$)	25th min (log TEWL $g/m^2/h$)
Control	1.68±0.06†	1.00±0.09*
Psoriatic	1.66±0.06†	0.0±0.1
Atopic	1.53±0.2†	0.87±0.1*

Hydration

Our study revealed an increased TEWL in clinically normal atopic skin associated with a reduced water content. Uninvolved atopic skin differed significantly from both normal and clinically normal psoriatic skin. Uninvolved psoriatic skin did not differ from healthy skin of the control group. Simultaneous plotting of TEWL vs. water content of the stratum corneum (Fig. 1) showed that the inverse relationship (1,4,11,15) between TEWL and water content described by other groups in pathological skin is also present in uninvolved atopic skin. The increased TEWL and the reduced stratum corneum water content confirm that the disorder of water barrier function in atopic subjects also occurs in clinically normal skin. Why is this finding not evident in uninvolved psoriatic skin? We do not know! Changes in epidermal lipids resulting in a defective barrier function in atopic dermatitis may play a role (16). TEWL in psoriasis is slightly but non-significantly increased. In this condition, a key disturbance is keratinocyte hyperproliferation; therefore, apparently normal skin could have a normal water flux through the epidermis (as detected by these techniques).

Water-retention capacity

Skin surface water loss curves show different patterns of decay in the three groups (Fig. 2). Atopic skin had lower values throughout the study. Interestingly, the decay constants are equal in atopic and normal subjects (-0.055 and -0.057, respectively). This means that the rate of evaporation of water accumulated under occlusion from the stratum corneum is the same, even though the total amount trapped in 24 h was significantly less in atopics (Table II). Skin surface water loss in psoriatic skin closely equals that in normal skin, confirming a normal WRC in uninvolved psoriatic skin. Werner et al. (17) found the same pattern of decay when investigating in an in vitro model the desorption curves from atopic subjects with 'dry' non-eczematous skin vs. normal volunteers. Since the first part of the decay curve reflects the evaporation of free water (17) we may assume that the stratum corneum content of both free and bound water is reduced in normal skin of atopic subjects. Interestingly, only the decay of bound water differs slightly in psoriatic subjects compared with that in controls, reflecting the disturbed keratinization.

Thaler et al. (18) found no differences between the keratin proteins in the skin of atopics, psoriatics and normal controls. No major histological differences have been reported between atopic and control skin (19). The mean corneocyte area is grealy reduced in atopic subjects and abnormally small corneocytes have an altered intercellular cohesion (12) which results in a defective barrier function with increased TEWL and decreased water-retention capacity. Marks et al. (20) believe this variation in barrier function is due to the presence of small corneocytes and may be related to the increased intercellular volume per unit area with increased water diffusion.

The data presented here suggest that clinically normal skin may be functionally abnormal, resulting in a defective barrier that could lead to a higher risk for irritant dermatitis. The abnormalities are evident in atopic subjects, but not in uninvolved psoriatic skin. At present, there is no explanation for this different behaviour, but differences in pathogenetic mechanisms of the two entities are presumably involved; on the other hand, from a clinical viewpoint, atopic subjects are more prone to develop dry skin and irritant dermatitis than other groups, perhaps partly explaining the functional abnormalities reported here. Restoration of normal stratum corneum water content levels in atopics should prevent these clinical problems and thus improve the management of these patients. We are intrigued by this additional example of the background of the so-called 'invisible dermatoses'. The data on 'normal' skin presented here may well facilitate the further investigation of the role of the so-called moisturizers and lubricants in the treatment of atopic patients.

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