Epidermal Hydration and Skin Mechanics

The Relationship between Electrical Capacitance and the Mechanical Properties of Human Skin In Vivo

GREGOR B. E. JEMEC and J. SERUP

Department of Dermatology (Bioengineering and Skin Laboratory), Righospitalet, University of Copenhagen, Copenhagen, Denmark

The possible relationship between skin capacitance and the mechanical properties of the skin was studied using non-invasive techniques. Skin hydration was changed by soaking skin with tap water. Hydration of the skin increased the capacitance significantly ($p < 0.01$) and hysteresis (creeping phenomenon) ($p < 0.01$). The elasticity of the skin was reduced by hydration ($p < 0.01$). Capacitance was found to be a poor predictor of the mechanical properties of untreated skin; while increases in hysteresis (creeping phenomenon) and decreases in elasticity were significantly ($p < 0.0001$) related to changes in the capacitance of hydrated skin. Key words: Rheology; Bioengineering; Emollients.

(Accepted December 4, 1989.)


G. B. E. Jemec, Emilievej 10, DK-2920 Charlottenlund, Denmark.

Moisturizers improve the subjective perception of the mechanical properties of human skin. After using a moisturizer the skin is often felt to be more supple and elastic. Previous studies have shown that application of a moisturizer increases the capacitance and hydration of the skin (1, 2, 3). Water can be regarded as the ultimate moisturizer, although its effects are short-lived. Hydration increases skin capacitance as well. The electrical capacitance of the epidermis is strongly correlated to the water content, although it may also be influenced by other polar substances contained in moisturizers. Capacitance is therefore not a specific measure of hydration.

Superficial hydration with plain tap water has been shown to affect the mechanical properties of human skin in vivo (4). Especially the hysteresis, representing the creeping phenomenon, is increased.

This study was undertaken in order to establish whether capacitance measurements are related to the mechanical properties of the skin.

MATERIALS AND METHODS

Studies were carried out in 17 healthy volunteers, 4 men and 13 women. Their median age was 46 (range 22–62 years). There was neither history of nor current skin disease among the volunteers.

The flexor side of the underarms was used exclusively in

![Graph A and B](image1)

**Fig. 1.** Linear relationship between changes in capacitance and changes in hysteresis (A) ($p < 0.0001$) and elasticity (B) ($p < 0.0001$). □ Values before hydration, hysteresis (hyst, ○ in (A)) measured in mm; elasticity (elast, ○ in (B)) measured in %, capacitance (corneo), measured in arbitrary units.

_Acta Derm Venereol (Stockh)_ 70
Table I. Changes induced in the skin by hydration with tap water

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-hydration</th>
<th>Hydration 10 min</th>
<th>Hydration 20 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacitance (arbitrary units)</td>
<td>92.40</td>
<td>111.90*</td>
<td>113.10*</td>
</tr>
<tr>
<td></td>
<td>92.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hysteresis (mm)</td>
<td>0.14</td>
<td>0.28*</td>
<td>0.31*</td>
</tr>
<tr>
<td></td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distensibility (mm)</td>
<td>1.52</td>
<td>1.55</td>
<td>1.53*</td>
</tr>
<tr>
<td></td>
<td>1.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elasticity (%)</td>
<td>69.60</td>
<td>61.60*</td>
<td>62.20*</td>
</tr>
<tr>
<td></td>
<td>70.40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Two pre-hydration values are given, one for each arm. The appropriate post-hydration values are lined up with pre-hydration values for comparison. *p < 0.01.

the study. A comparable area 5 cm distal to the elbow was studied. All measurements were repeated three times with the Corneometer® and twice with the Dermatix®, and the means were used in subsequent calculations. In 9 persons, skin hydration was changed by applying paper towels soaked in tap water. The towels were applied for 10 or 20 min, under occlusion with cling foil (PVC) to reduce evaporation. The surface was wiped dry before any measurements were made.

The Corneometer CM 420® (5) measures the electrical capacitance of the skin surface. The capacitance is expressed in arbitrary units. The Dermatix® (4) measures elevation of the skin in a sealed chamber during suction. The machine operates in repeated cycles, each cycle lasting 4 s and applying 0.3 Bar of suction. After six cycles, the following parameters are presented: hysteresis, reflecting the creeping phenomenon of the skin; distensibility, reflecting the maximum distention achieved; and elasticity, reflecting the ability of the skin to return to its original position after being stretched.

The Spearman test was used to compare changes in skin capacitance with changes in mechanical parameters, and the paired Wilcoxon test was used to compare pre-hydration and post-hydration values.

RESULTS

In untreated skin the capacitance was not significantly related to skin hysteresis ($r^2 = 0.091$), skin distensibility ($r^2 = 0.068$) or skin elasticity ($r^2 = 0.003$).

Hydration caused significant changes, as is evident from the values in Table I. Changes in hysteresis ($p < 0.0001$) and elasticity ($p < 0.0001$) were significantly correlated to changes in capacitance. See Fig. 1A, 1B. There was no correlation between skin distensibility and capacitance in the hydrated skin ($r^2 = 0.001$).

REFERENCES

2. Blichmann G, Serup J, Winther A. Effects of single application of a moisturizer. Evaporation of emulsion...

Potassium Iodide Inhibits Neutrophil Chemotaxis
KOICHI HONMA, KENJI SAGA, HIDEO ONODERA and MAKOTO TAKAHASHI
Department of Dermatology, Sapporo Medical College, Sapporo, Japan

We studied the effect of potassium iodide on the chemotaxis of neutrophil in 15 healthy subjects with a modified Boyden chamber method. Orally administered potassium iodide (15 mg/kg/day for 3 days) significantly inhibited the neutrophil chemotaxis in peripheral blood. It is postulated that the therapeutic effect of potassium iodide on erythema nodosum, nodular vasculitis, and Sweet’s syndrome might be mediated through the inhibition of neutrophil chemotaxis by this agent. Key words: Modified Boyden chamber method; Leukocyte chemotaxis; Healthy subjects.

(Accepted December 4, 1989.)
Acta Derm Venereol (Stockh) 1990; 70: 247–249.
K. Saga, Department of Dermatology, Sapporo Medical College, Minami 1 Nishi 16, Chyuou-ku, 060 Sapporo, Japan.

Potassium iodide (KI) has been successfully used for the treatment of subacute migratory panniculitis, erythema nodosum, nodular vasculitis, Sweet’s syndrome and Behçet’s disease (1,2,3). Although the clinical courses and dermatological signs differ in these diseases, their cutaneous lesions histologically show infiltration of neutrophils in the early stage of the diseases (4). Therefore we speculated that KI might be effective through the modulation of the function of neutrophils, chemotaxis in particular. The purpose of this investigation was to test if systemically administered KI would inhibit neutrophil chemotaxis of peripheral blood in healthy subjects. Our study has shown that KI significantly suppressed the chemotaxis of neutrophils.

MATERIALS AND METHODS
Subjects
This study was carried out according to the principles of the Declaration of Helsinki. Healthy male volunteers were recruited for the study and informed consent was obtained from each subject. The ages of 15 subjects were between 22 and 32 years, while one subject was 58 years old.

Preparation of chemotactic factor
The chemotactic factor was prepared according to the description by Waba et al. (5). Normal human serum pooled from 5 healthy donors was incubated with 1.5 mg/ml Escherichia coli lipopolysaccharide for 90 min at 37°C. The endotoxin-activated serum was then heated at 56°C for 30 min. It was then centrifuged at 3000 g for 30 min at 40°C. Aliquots of the serum were stored at -20°C.

Preparation of neutrophil suspension
Ten ml of heparinized (100 units/ml) venous blood was mixed with 10 ml of 2% dextran 250 in phosphate-buffered saline (PBS) in a 15×150 mm glass test tube. The tubes were allowed to stand for 30–40 min at 37°C. The supernatant was transferred to a siliconized, conical 50-ml centrifuge tube. After centrifugation at 900 rpm for 8 min, the supernatant was discarded with a Pasteur pipette, leaving 3–5 ml of the dextran-plasma mixture. The cells were gently mixed with 35 ml of 0.87% ammonium chloride to hemolyze the erythrocytes. The leukocytes were then washed twice with PBS, resuspended in RPMI 1640 medium, and brought to a concentration of 2.5×10⁶ cells/ml for use.

Chemotactic assay
Chemotaxis was measured by a modified Boyden chamber method (6). A two-section chamber separated by a membrane was used for the study. The chemotactic factor was diluted 1:4 in RPMI 1640 medium before being added to the lower section (0.2 ml/well) of a Blind-Well chamber. Polycarbonate membrane filters (Uni-Pore, 3 μm pore size)

Acta Derm Venereol (Stockh) 70