

Assessment of Skin Moisture

Measurement of Electrical Conductance, Capacitance and Transepidermal Water Loss

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Blichmann CW, Serup J. Assessment of skin moisture. Measurement of electrical conductance, capacitance and transepidermal water loss. *Acta Derm Venereol (Stockh)* 1988; 68: 284-290.

Experiments on skin moisture, i.e. the hydration state of the outer epidermis, were undertaken using three different types of equipment, i.e. the Skicon-100[®] and Corneometer CM 420[®] hydrometers and the Servo Med EPI[®] evaporimeter. The studies included 10 healthy volunteers. Water was applied to test sites on the forearm and the palm of the hand, and effects monitored by the three methods. Parallel increases in conductance, capacitance and transepidermal water loss were registered for a duration of about 5 min. The Skicon-100[®] was more sensitive for measurement of increased hydration, while the Corneometer CM 420[®] might be more sensitive for measurement of decreased hydration. Inter- and intra-individual variations were minor with all instruments. According to reproducibility studies, the Corneometer CM 420[®] was more accurate than the Skicon-100[®]. Technical experiments indicated that the Corneometer CM 420[®] depicts changes of hydration down to a depth of 0.1 mm, while the Skicon-100[®] measures very superficially. In conclusion, both hydrometers were deemed relevant and valid for assessment of skin moisture. The methods are complementary, and their combined use is recommended. *Key words: Skin moisture; Skin hydration.* (Received May 11, 1987.)

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The rationale of moisturizers, i.e. substances which increase the hydration of the outer epidermis, is still obscure and poorly documented. However, during recent years, new non-invasive methods for assessment of skin hydration kinetics have become available.

The present study was intended to compare two types of commercially available equipment for measurement of stratum corneum hydration, i.e. the Skicon-100[®], developed by H. Tagami, MD (1, 2), and the Corneometer CM 420[®], developed by Schwarzhaupt (3) (see Fig. 1). Results were compared with values of transepidermal water loss as measured by the Servo Med EPI[®] evaporimeter (Fig. 1) developed by G. E. Nilsson (4). Electrical methods for studying skin moisturization were recently reviewed by J. L. Leveque & J. De Rigel (5).

MATERIALS AND METHODS

Materials

Ten healthy volunteers (7 women, 3 men) aged 30-47 years were studied. Four are medical doctors, and six are secretaries. They were requested to refrain from using any moisturizer for 12 h before recordings and had not washed their hands for the last hour. Only subjects without evidence of psychological stress were examined.

Methods

Two sites 2 cm in diameter were studied, viz. on the palm of the hand, just proximate to the index finger, and on the flexor side of the forearm, about 8 cm above the wrist. Distilled water, 0.75 ml, was spread over the test area and blotted away with a pad of gauze after 10 s.

Recordings were performed before application of water in order to obtain a prehydration level. Measurements were performed every minute for a 10 min period following application using the three instru-



Fig. 1A-C. Apparatus compared in the present study.

(A) Skicon-100[®] for examination of electrical conductance, electrode diameter 6.2 mm.



(B) Corneometer CM 420[®] for examination of electrical capacitance, electrode diameter 16.5 mm.



(C) Evaporimeter EP1[®] for measurement of transepidermal water loss, chamber diameter 12.00 mm, diameter of protective shield 12.6 mm.

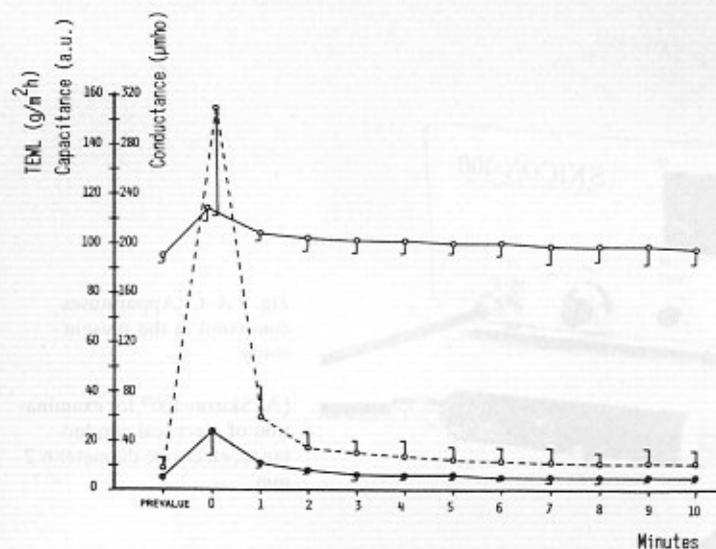


Fig. 2. Forearm. Measurement of electrical conductance (○---), electrical capacitance (○—) and TEWL (●—) in 10 subjects. Successive measurements during a 10-min period after application of water. Mean and SD.

ments described in detail below. At the beginning and at the end of each experiment, reference values were obtained from the palm of the hand, just proximate to the fifth finger, and from the flexor side of the forearm, 12 cm above the wrist.

The Skicon-100[®] hydrometer registers the electrical conductance of the skin surface (1, 2, 6, 7). The equipment consists of a main recording body and a probe with two concentrically arranged brass electrodes with diameters of 1 and 4 mm respectively. The probe is applied to the skin with a standard pressure of 30 g. Recording time is 3 s. A high-frequency current of 3.5 MHz flows between the two electrodes via the skin, and the conductance is registered and displayed digitally, expressed as reciprocal impedance in terms of 1/micro ohm or μmho .

The Corneometer CM 420[®] registers the electrical capacitance of the skin surface (3). The probe consists of a circular brass grid 16 mm in diameter, covered with a plastic foil 0.02 mm thick. The skin surface below this electrode represents the other electrode. The probe is applied to the skin with a pressure of 3.5 N, recording time 3 s. The capacitance is expressed digitally in arbitrary units (a.u.).

The Servo Med EPI[®] measures the water evaporation from the skin surface (4). The probe consists of a cylindrical chamber 12 mm in diameter mounted with sensors for registration of the relative humid-

Table I. Reproducibility of the Skicon-100[®] hydrometer, the Corneometer CM 420[®] and the Servo Med EPI[®] evaporimeter in three individuals

	Pro-band	Forearm			Palm of the hand		
		Mean	SD	Coeff. of variation	Mean	SD	Coeff. of variation
Skicon-100 [®]	1	46.0	5.46	11.9%	49.6	15.04	30.3%
	2	64.9	12.84	19.8%	51.3	14.97	29.2%
	3	29.5	5.56	18.9%	144.0	25.65	18.5%
Corneometer CM 420 [®]	1	104.0	1.76	1.7%	86.7	2.36	2.7%
	2	123.2	1.14	0.9%	82.4	2.22	2.7%
	3	102.2	2.30	2.3%	94.3	1.49	1.6%
Servo Med EPI [®]	1	4.1	0.32	7.7%	30.9	4.36	14.1%
	2	9.7	0.82	8.5%	28.4	1.65	5.8%
	3	5.2	0.79	15.2%	40.6	3.20	7.9%

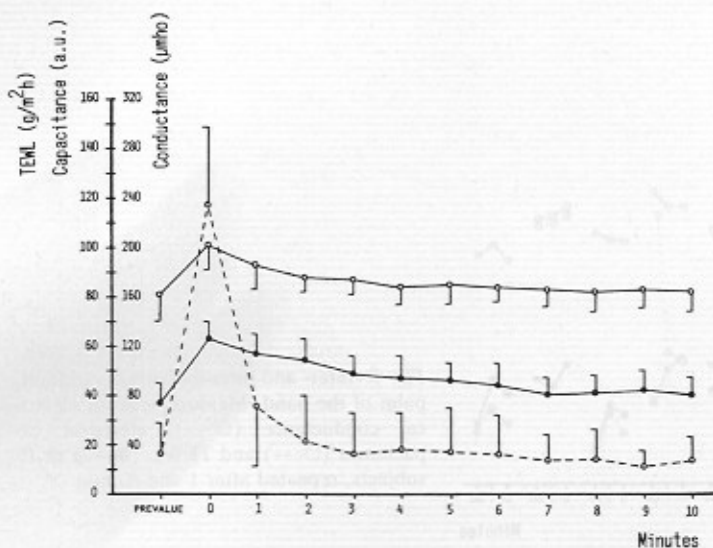


Fig. 3. Palm of hand. Measurements of electrical conductance ($\circ\text{---}$), electrical capacitance ($\circ\text{---}$) and TEWL ($\bullet\text{---}$) in 10 subjects. Successive measurements during a 10-min period after application of water. Mean and SD.

ity and the temperature. The transepidermal water loss (TEWL) is calculated automatically and displayed digitally in terms of $\text{g}/\text{m}^2 \text{ h}$. Readings were done 30 s after applying the probe to the skin (8).

The study was performed during the month of May. The room temperature was kept constant at 22–24°C. The relative humidity varied between 28% and 39%. An attempt was made to avoid convection of air in the laboratory.

The reproducibility of the three methods was determined in 3 persons by ten repeated measurements at the same site of the palm of the hand and the flexor side of the forearm, expressed as coefficient of variation.

The intra-individual variation of the three parameters was determined in the same 10 individuals in both regions by repeated measurements after 1 and 60 min.

In order to illustrate the detection depth of the two hydrometers, experiments on technical models were performed. Silicone rubber was covered with a cuprous foil and measurements were undertaken after successive layers of different materials with different electrical properties had been placed on this foil. Materials used for testing were: Tesa® cellulose tape (thickness 0.05 mm, conductance adhesive side

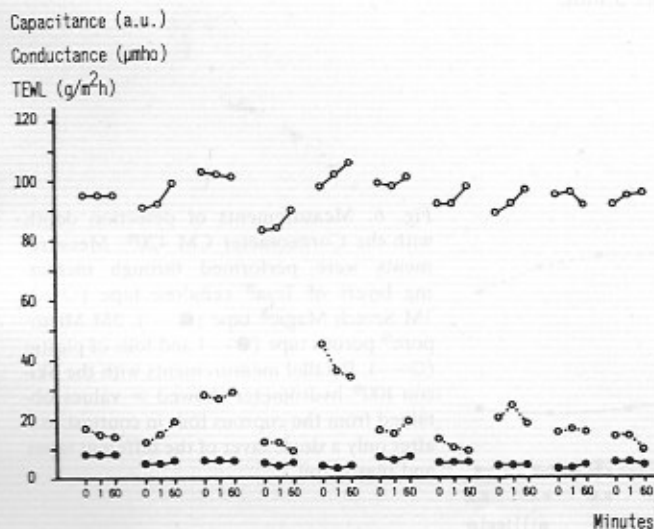


Fig. 4. Inter- and intra-individual variation, forearm. Measurements of electrical conductance ($\circ\cdots$), electrical capacitance ($\circ\text{---}$) and TEWL ($\bullet\text{---}$) in 10 subjects, repeated after 1 and 60 min.

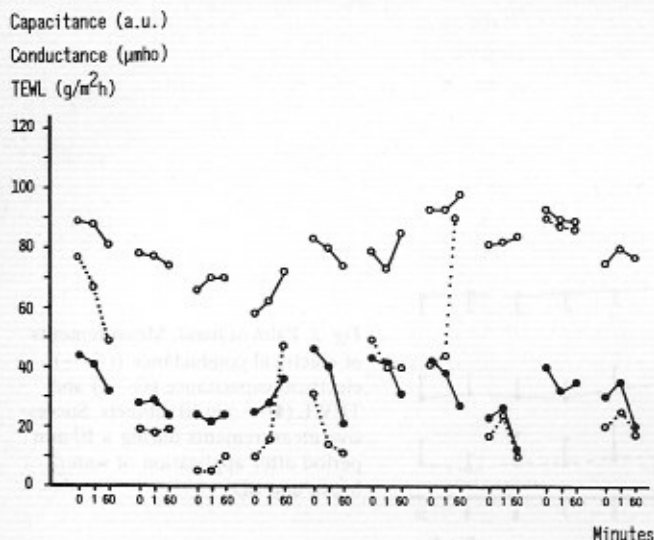


Fig. 5. Inter- and intra-individual variation, palm of the hand. Measurements of electrical conductance (○···), electrical capacitance (○—) and TEWL (●—) in 10 subjects, repeated after 1 and 60 min.

2 μmho conductance non-adhesive side 0 μmho , 3M Scotch Magic 810[®] tape (thickness 0.06 mm, conductance adhesive side 1 μmho conductance non-adhesive side 0 μmho 3M Micropore[®] porous tape (thickness 0.10 mm, conductance adhesive side 0 μmho conductance non-adhesive side 0 μmho and foils of plastic 0.01 and 0.05 mm in thickness with conductance 0 μmho on both sides. Moreover, experiments were undertaken with paper sprayed with graphite powder and paper treated with electrode paste (Minogograf[®] electrode cream Siemens-Elema AB and EKG sol[®] Medi-Trace).

For statistical analysis, Student's *t*-test was used. Probabilities less than 0.05 were considered significant.

RESULTS

Reproducibility studies in 3 individuals with the three instruments are shown in Table I. Fig. 2 shows results obtained from the forearm during a period of 10 min after application of water. The three methods all showed significantly increased values immediately after application of water, followed by a rapid decrease. The conductance became normal after 4 min, the capacitance after 7 min, and TEWL after 3 min.

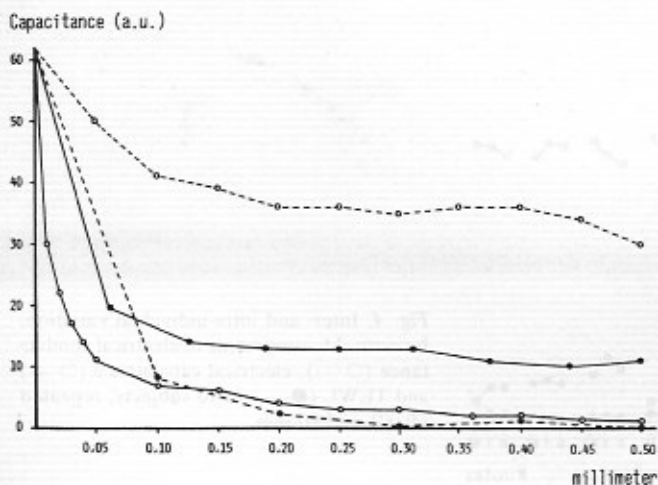


Fig. 6. Measurements of detection depth with the Corneometer CM 420[®]. Measurements were performed through increasing layers of Tesa[®] cellulose tape (○---), 3M Scotch Magic[®] tape (●—), 3M Micropore[®] porous tape (●---) and foils of plastic (○—). Parallel measurements with the Skicon-100[®] hydrometer showed ∞ values obtained from the cuprous foil, in contrast to 0 after only a single layer of the different tapes and plastic foil.

Fig. 3 shows the results obtained from the palm of the hand during a period of 10 min after application of water. Results in this location were analogous to those obtained from the forearm. The conductance became normal after 1 min, the capacitance after 2 min, and TEWL after 6 min.

Figs. 4 and 5 show the results of repeated measurements with all three instruments in the same 10 individuals after 1 min and 60 min on the flexor side of the forearm and on the palm of the hand, respectively.

Fig. 6 contains the results of technical experiments with the two hydrometers to illustrate the detection depth.

Experiments with graphite-sprayed paper showed increased values when the graphite layer was continuous (Skicon-100[®] ∞, Corneometer CM 420[®] 53 a.u.) whereas values were unchanged when the layer was discontinuous. Values obtained from paper not sprayed were 0 µmho and 6 a.u., respectively. Thus, neither instrument reacted to polar particles unless these particles represented a conductive system. Measurement on paper treated with electrode pastes, which had been allowed to dry, also showed low values as obtained on untreated paper. However, after exposure to humidity, values of 59 µmho and 58 a.u. were registered. Thus, polar particles do not, themselves, influence registrations unless they are in an environment having a certain humidity.

DISCUSSION

The three methods used in this study showed parallel and significant changes in skin hydration kinetics after application of water. Effects lasted about 5 min. Thus, all methods applied appeared relevant for assessment of skin moisture. Figs. 2 and 3 indicate that the Skicon-100[®] is more sensitive for measurement of increased hydration, while the Corneometer CM 410[®], due to its high basal level, may be better suited to measure decreased hydration. Figs. 4 and 5 indicate that inter- and intra-individual variations are minor, particularly on the forearm, in comparison with the palm of the hand. Studies on reproducibility clearly indicated (Table I) that the Corneometer CM 410[®] is more accurate than the Skicon-100[®] hydrometer.

Regional differences between forearm and the palm of the hand might be due to the difference in the thickness of the stratum corneum and the volume of water, which can be bound under a certain area of the skin when soaked with water. Differences between these two regions might also be related to the number of sweat glands and their activity.

Technical studies indicated that the level of detection in depth is different for the two hydrometers. The Skicon-100[®] measures very superficially, as was also reported by the inventor (1, 6). The Corneometer CM 410[®] may depict changes in hydration down to a depth of about 0.1 mm (Fig. 6). This depth in most body regions accounts for the full-thickness of the stratum corneum, which represents the transitional zone between the humid internal body and the dry external environment (9). Thus, the Skicon-100[®] is probably more sensitive to fluctuations in water diffusion between the skin surface and the ambient atmosphere.

For a more detailed and conclusive evaluation of skin moisture, we think that application of further methods based on different principles is necessary. The Skicon-100[®], the Corneometer CM 410[®] and the Servo Med EPI[®] are all valid instruments.

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