

# Reproducibility and Variability of Transepidermal Water Loss Measurement

## *Studies on the Servo Med Evaporimeter*

CHRISTA W. BLICHMANN and JØRGEN SERUP

*Department of Dermatology, Gentofte Hospital, Copenhagen, Denmark*

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Recording technique and accuracy of the Servo Med EPI evaporimeter were studied. The technical accuracy of this equipment was found high with a coefficient of variation of 3.3%. Measurements of transepidermal water loss (TEWL) were performed on the palm of the hand and on the flexor side of the forearm in 10 healthy volunteers. Continuous registrations were undertaken for a three-minute period and repeated immediately thereafter. Values reached a linear state 30 sec after application of the probe. The variation of TEWL in relation to time was determined in the same individuals. Measurements were repeated after 1 hour and 24 hours. In conclusion, though the TEWL as measured by the Servo Med evaporimeter shows a considerable interindividual variation, the intraindividual variation and the variation by time are relatively minor. We recommend that more detailed studies are based on paired observations, with recordings read 30 sec after application of the probe onto the skin. *Key words: Accuracy; Water barrier; Skin.* (Received June 17, 1986.)

C. W. Blichmann, Gentofte Hospital, Department of Dermatology 1502, DK-2900 Hellerup, Denmark.

During the seventies Nilsson and co-workers developed a convenient method for measurement of evaporative water loss (1). This open chamber method has widely replaced more complicated methods previously used (2).

Transepidermal water loss (TEWL) measurement has many important applications in experimental and clinical dermatology (3, 4, 5, 6, 7). However, studies on the accuracy of the method and inter- and intraindividual variations are few (1).

## MATERIAL AND METHODS

Ten healthy volunteers (7 females, 3 males) aged 25-40 years were studied. Measurements were performed on two sites, i.e. the palm of the hand (just proximate to the II finger) and the flexor side of the forearm (about 8 cm proximate to the wrist). Volunteers were not allowed to use emollients 12 hours before recording, and they had not washed their hands for the last hour. Only subjects without evidence of psychological stress were examined.

The Servo Med Evaporimeter of Servo Med AB, Vällingby, Sweden, was used. The accuracy of TEWL measurement given by the manufacturer is  $\pm 15\%$  or  $2 \text{ g/m}^2 \text{ h}$ , whatever greatest. It is recommended that readings are performed 10-20 sec after application of the probe. The probe should only be applied with a slight pressure. The chamber of the probe is cylindrical with a diameter of 12 mm. Two pairs of sensors measuring temperature and relative humidity respectively are placed centrally in the probe chamber. From these registrations the TEWL is automatically calculated and displayed digitally in units of  $\text{g/m}^2 \text{ h}$ .

Measurements were performed every five seconds during a period of three minutes. Measurements were repeated immediately. From these observations we determined the optimum recording time to be 30 seconds after application of the probe, and this reading time was used hereafter. Measurements were then performed in the same individuals at 0, 1 and 24 hours.

To determine the technical accuracy of the evaporimeter a piece of cotton material measuring

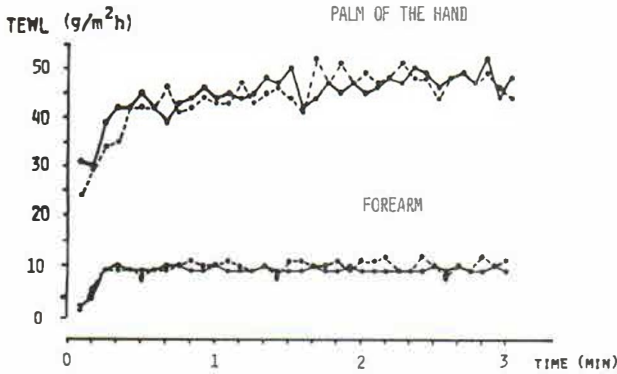


Fig. 1. TEWL measurements on the palm of the hand and on the flexor side of the forearm in a representative subject. Successive measurements during a three-min period (●—●), repeated immediately on the same location (●---●).

10×10 cm was soaked with water for 10 minutes and laid upon a metal plate. TEWL from this cotton pad was measured at exactly the same place every minute for a period of 10 minutes.

To determine the in vivo accuracy, measurements of TEWL were made on the palm of the hand and the flexor side of the forearm every one minute for a period of 10 minutes. One healthy individual was studied.

The study was performed during the winter season. The room temperature was kept constant at 22–23°C. The relative humidity varied between 18% and 28%. It was attempted to avoid convection of air in the laboratory.

Statistical methods used were Wilcoxon rank sum test and nonparametric analysis of variance (Kruskal-Wallis-test).

## RESULTS

Measurements of TEWL on the palm of the hand and on the flexor side of the forearm in one representative case are shown in Fig. 1.

In every case the values from the palm were higher than the values from the forearm ( $p < 0.01$ ). After 30 sec the TEWL on the palm as well as on the forearm reached a linear

Table 1. Inter-individual variation in TEWL ( $\text{g}/\text{m}^2 \text{h}$ ) and reproducibility in the group of individuals from two successive measurements on the palm of the hand and on the flexor side of the forearm respectively ( $n=10$ )

Time	10 sec	20 sec	30 sec	1 min	2 min	3 min
<i>Palm of the hand</i>						
Mean	30.0	33.7	37.4	40.5	43.7	45.1
	31.5	36.8	39.4	41.1	43.9	42.9
SD	13.36	12.48	13.53	14.02	15.29	16.00
	14.83	15.41	14.37	14.58	15.12	13.41
Coefficient of variation	44.5%	37.0%	36.2%	34.6%	35.0%	35.5%
	47.1%	41.9%	36.5%	35.5%	34.4%	31.3%
<i>Forearm</i>						
Mean	4.1	5.2	5.7	6.0	6.0	6.2
	5.1	5.4	5.6	5.8	6.4	6.5
SD	1.52	2.30	2.00	2.63	2.71	2.62
	1.85	2.41	2.72	3.33	3.31	3.47
Coefficient of variation	37.1%	44.2%	35.1%	43.8%	45.2%	42.3%
	36.3%	44.6%	48.6%	57.4%	51.7%	53.4%

state, although still slightly increasing on the palm. On the forearm the majority of individuals reached this state within 20 sec. Based on these observations the ideal time of recording was defined as 30 sec after application of the probe onto the skin.

In Table I data on the inter-individual variation in TEWL and the reproducibility in the group of individuals are presented. Statistical analysis of variance at different times of recording showed no significant difference.

Results of repeated measurements in the same individuals after 1 hour and 24 hours are shown in Fig. 2.

Data on the variation in TEWL by time (measurements repeated after 1 hour and 24 hours) are presented in Table II.

In Table III data on the intra-individual reproducibility in TEWL according to successive measurements in the same individuals are presented.

Determination of technical accuracy of the evaporimeter showed mean  $52.4 \text{ g/m}^2 \text{ h}$ , SD  $1.71 \text{ g/m}^2 \text{ h}$  and a coefficient of variation of 3.3%.

Determination of in vivo accuracy as measured on the palm of the hand and on the flexor side of the forearm showed mean  $37.0 \text{ g/m}^2 \text{ h}$ , SD  $3.50 \text{ g/m}^2 \text{ h}$ , coefficient of

Table II. Variation in TEWL ( $\text{g/m}^2 \text{ h}$ ) by time in the group of individuals ( $n=10$ ) from measurements on the palm of the hand and on the flexor side of the forearm

Time (hours)	0	1	24
<i>Palm of the hand</i>			
Mean	38.7	38.2	37.3
SD	12.47	13.69	12.97
<i>Forearm</i>			
Mean	7.7	7.6	7.8
SD	2.87	2.07	2.62

Table III. Intra-individual reproducibility in TEWL ( $\text{g/m}^2 \text{ h}$ ) according to two successive measurements on the palm of the hand and on the flexor side of the forearm ( $n=10$ )

Time	10 sec	20 sec	30 sec	1 min	2 min	3 min
<i>Palm of the hand</i>						
Mean difference	2.7	4.9	3.4	2.6	3.2	3.2
SD of the mean difference	1.70	4.12	1.78	1.71	2.3	3.16
TEWL initial value	30.0	33.7	37.4	40.4	43.7	45.1
Mean diff. $\times 100$ / initial TEWL	9.0%	14.5%	9.1%	6.4%	7.3%	7.1%
<i>Forearm</i>						
Mean difference	1.4	1.0	1.1	0.8	1.0	0.7
SD of the mean difference	0.97	0.67	0.57	0.79	0.67	0.68
TEWL initial value	4.1	5.2	5.7	6.0	6.0	6.2
Mean diff. $\times 100$ / initial TEWL	34.1%	19.2%	19.2%	13.3%	16.7%	11.3%

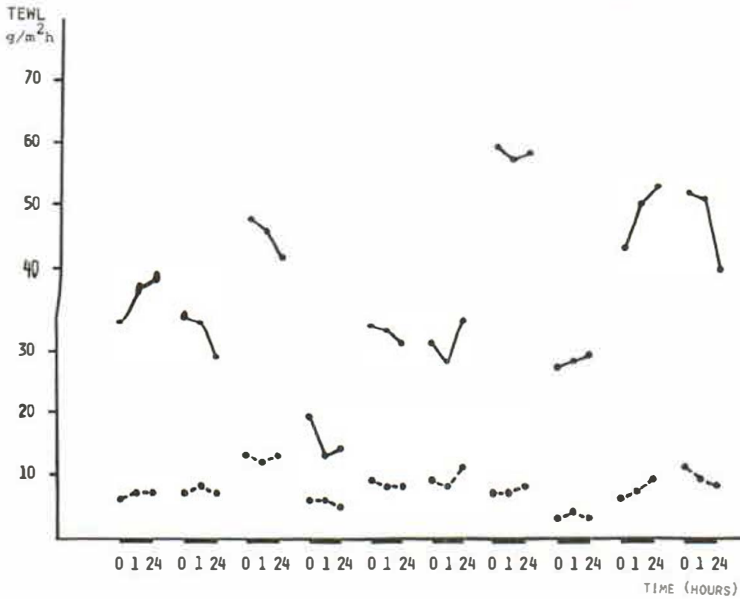


Fig. 2. TEWL measurements on the palm of the hand (●—●) and on the flexor side of the forearm (●—●) in 10 subjects, repeated after 1 and 24 hours.

variation 9.4% and mean  $8.1 \text{ g/m}^2 \text{ h}$ , SD  $0.74 \text{ g/m}^2 \text{ h}$ , coefficient of variation 9.1% respectively. Thus, technical accuracy was about three times as high as in vivo accuracy.

Through all the measurements there was no tendency to difference between men and women.

## DISCUSSION

This study shows that there is a great variation in TEWL among different individuals according to measurements on the palm of the hand as well as on the flexor side of the forearm (Table I) with coefficient of variation ranging from 31–57%.

In contrast, repeated measurements in the same individual showed considerably smaller variation (Table III) and an acceptable reproducibility. As a consequence of an acceptable intra-individual reproducibility, the variation by time of a group of individuals was relatively minor (Table II, Fig. 2) and at the level of the intra-individual variation.

Fig. 1 indicates that after approximately 30 sec, a state of equilibrium is reached in the probe chamber with a constant water flux through the chamber reflecting the evaporation from the skin surface. The further linear increase in TEWL may be artificial, resulting from the application of the probe chamber onto the skin, and we therefore prefer that measurements are recorded 30 sec after application of the probe. The reproducibility of measurements performed between 30 sec and 3 min appears at the same level (Fig. 1 and Table III).

In conclusion, TEWL as measured by the Servo Med EPI evaporimeter shows a considerable inter-individual variation, however, the intraindividual variation and the variation by time are relatively minor. The technical accuracy of the evaporimeter is high. As a consequence we recommend that more detailed studies are based on paired observations, with recordings read 30 sec after application of the probe onto the skin.

## REFERENCES

1. Nilsson GE. On the measurement of evaporative water loss. Methods and clinical applications. Linköping University Dissertation, Linköping, 1977.

2. Wilson, DR, Maibach H. A review of transepidermal water loss. In: Maibach H, Boisits EK, eds. Neonatal Skin: Structure and function. New York-Basel: Marcel Dekker, 1982: 83-100.
3. Kiistala R, Kiistala U, Parkkinen MU, Mustakallio KK. Local sweat stimulation with the skin prick technique. Acta Derm Venereol (Stockh) 1984; 64: 384-388.
4. Frödin T, Skogh M. Measurement of transepidermal water loss using an evaporimeter to follow the restitution of the barrier layer of human epidermis after stripping the stratum corneum. Acta Derm Venereol (Stockh) 1984; 64: 537-540.
5. Werner Y, Lindberg M. Transepidermal water loss in dry and clinically normal skin in patients with atopic dermatitis. Acta Derm Venereol (Stockh) 1985; 65: 102-105.
6. Valk PGM van der, Kruis de Vries MH, Nater JP, Bleumink E, De Jong MCJM. Eczematous (irritant and allergic) reactions of the skin and barrier function as determined by water vapour loss. Clin Exp Dermatol 1985; 10: 185-193.
7. Serup J, Rasmussen I. Dry hands in scleroderma. Acta Derm Venereol (Stockh) 1985; 65: 419-423.