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THE INFLUENCE OF SKIN TEMPERATURE, ENVIRONMENTAL TEMPERATURE AND RELATIVE HUMIDITY ON TRANSEPIDERMAL WATER LOSS

J. Hattingh

From the Department of General Physiology, The Dental Hospital, University of the Witwatersrand, Johannesburg, South Africa

Abstract. The influence of relative humidity (air), environmental temperature, and skin temperature on transepidermal water loss (T.W.L.) has been re-investigated. It was found that T.W.L. correlates well with a combination of skin temperature and relative humidity and, of the two, relative humidity seems to be the more important. The amount of fluid available for T.W.L., therefore, seems to be actively regulated in accordance with environmental conditions.

The influence of skin temperature (S.T.), environmental temperature (E.T.), and air relative humidity (R.H.) on the value of transepidermal water loss (T.W.L.) has not been clearly elucidated up to date. In 1967, Spruit & Herweyer (11) showed that the loss increases with increased E.T. and Thiele & Sinden (12) supported this view. Bettley & Grice (2), Grice (5) and Bettley (1) all showed that T.W.L. decreases with decreasing R.H. Goodman & Wolf (3) found a non-linear relation between T.W.L. and R.H., the former decreasing when the latter increased and Hey & Kats (9) could find no evidence that E.T. influences T.W.L. in babies.

The experimental technique utilized by the above-mentioned workers usually employs a measuring time of 15–30 minutes. It has been shown previously (6) that measuring time has a pronounced effect on T.W.L.; the longer the measuring time, the lower the recorded value of T.W.L. This efect results in a "dehydration" of the skin (probably due to the removal of water bound to the stratum corneum) and it is then very difficult to correlate this with environmental changes, due to the small value. In the experiments reported here, a measuring time of 3 minutes was used and the results indicate that T.W.L. is dependent upon a combination of environmental factors rather than on one factor alone.

MATERIAL AND METHODS

T.W.L. was measured with a modified unventilated capsule as described previously (7, 8). This capsule covers an area of 8 cm² and has a fan built into one side so as to assure complete absorption of fluid liberated from the skin. The fluid is absorbed by dried magnesium perchlorate (Anhydrone) which is placed in containers which can be screwed airtight in the measuring capsule. These containers are weighed before and after a T.W.L. determination (in airtight transport capsules). All results are expressed in mg/5 cm²/3 min. Human volunteers were used and determinations were made on various areas of the body. The areas used had very little hair covering the surface. In all experiments, the subjects were rested for an hour or more before taking measurements (all areas atropinised).

Environmental temperature (E.T.) and relative humidity of the air (R.H.) were measured with standardized mercury thermometers, wet and dry bulb. Skin temperature (S.T.) was measured with thermistor units or with a Thermotron Hm-202P (Zeniter-Heiwa Electronic Industrial Co.).

RESULTS

It was found convenient to obtain some arbitrary constants to aid in the evaluation of the results. In the first place, E.T. and R.H. were multiplied with one another and the product divided by 100. The numerical value so obtained is called the environmental factor (E.F.). Secondly, S.T. was multiplied with R.H. and the product divided by 100. The resultant factor was then termed the water loss factor (W.F.). It was hoped that these factors would give an indication as to which environmental factors are important in determining

Table I. *The effect of environmental conditions and skin temperature on T.W.L.*

T.W.L. (mg/5 cm²/3 min)	E.T. (°C)	S.T. (°C)	R.H. (%)	W.F.	E.F.
Thigh					
1.2	20.0	31.0	50	15.5	10.0
0.9	17.5	29.5	63	18.5	11.0
1.0	19.5	31.0	53	15.3	10.3
1.0	18.0	29.0	51	14.8	9.3
1.1	18.0	29.5	52	15.3	9.4
1.0	22.0	31.0	53	16.4	11.7
1.1	21.8	30.1	51	15.4	11.1
0.8	27.5	33.0	20	6.6	5.5
0.7	27.5	32.5	20	6.5	5.5
0.9	25.0	32.0	52	16.6	13.0
0.8	24.5	32.0	36	11.2	8.8
0.8	23.0	31.5	36	11.3	8.3
1.0	28.5	33.5	36	12.1	10.3
1.6	22.0	30.5	79	24.0	17.3
1.6	22.5	30.5	70	21.3	15.8
1.5	23.5	31.0	63	19.5	14.8
1.0	26.5	32.0	47	15.0	12.5
1.1	28.5	33.0	44	14.5	12.5
Mean water loss: 1.06±0.25 mg/5 cm²/3 min					
Abdomen					
1.7	25.0	32.5	74	24.0	18.5
1.3	22.0	31.5	62	19.5	14.3
1.1	19.5	31.5	60	18.8	11.7
0.9	17.0	31.0	51	14.8	8.6
0.8	19.5	31.0	53	16.4	10.3
0.8	18.0	29.0	51	14.8	9.2
1.1	18.0	29.5	52	15.3	9.4
0.8	25.5	33.5	38	12.7	9.7
1.0	25.5	33.0	38	12.7	9.7
0.7	28.0	33.5	31	10.4	8.7
1.0	27.5	33.5	25	8.4	6.9
1.4	28.0	32.5	43	14.0	12.0
1.1	25.0	32.5	65	21.1	16.2
1.1	24.0	32.0	70	22.5	16.8
0.9	23.0	31.5	53	16.7	12.2
Mean water loss: 1.10±0.15 mg/5 cm²/3 min					
Chest					
1.1	23.5	31.0	53	16.4	12.4
0.6	25.5	32.0	40	12.8	10.2
0.6	26.5	32.5	37	12.0	9.8
0.4	28.0	33.0	34	11.2	9.5
0.4	29.5	33.5	19	6.4	5.6
0.9	29.0	33.5	32	10.7	9.3
Mean water loss: 0.67±0.30 mg/5 cm²/3 min					

T.W.L., considering that no clear or single relationship seem to exist between any one factor and water loss.

Determinations of T.W.L. were done on various areas of the human body and the mean result of each is indicated in Table I, together with the corresponding environmental conditions. Different localities were used in each case.

By analysing the results stastistically the following values are found for the correlation coefficients (statistically significant):

T.W.L. and E.T. $r=0.156$
T.W.L. and S.T. $r=0.262$
T.W.L. and E.F. $r=0.480$
T.W.L. and R.H. $r=0.561$
T.W.L. and W.F. $r=0.737$

DISCUSSION

From the presented results, it can be seen that T.W.L. does vary with environmental conditions and in fact it appears that it is dependent on a combination of environmental factors. The relevant combination sems to be the relative humidity of the air and skin temperature. Of the two, relative humidity seems to be the more important. If T.W.L. were a simple diffusion process of extracellular water (10), one would expect to find a good positive correlation between the loss and S.T. and E.T. respectively, and a negative correlation with the air relative humidity. This is not the case and T.W.L. is not, therefore simply a pure physical diffusion process through an epidermal membrane. The possibility must be borne in mind that the water loss is actively regulated by some or other physiological mechanism and the blood vascular system might be a good candidate (7). The above statement is not meant to imply that the process of water movement through the epidermal membrane is not controlled by physical laws (4) but rather that the amount of fluid made available for T.W.L. is actively regulated in accordance with environmental conditions.

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J. Hattingh, M.D.
Department of Zoology
Rand Afrikaans University
Johannesburg
South Africa