Acta Derm Venereol 2003; 83: 338–341

Taylor & Francis healthsciences

INVESTIGATIVE REPORT

Influence of Climatic Conditions on the Irritant Patch Test with Sodium Lauryl Sulphate

HARALD LÖFFLER and RUDOLF HAPPLE

Department of Dermatology, Philipp University of Marburg, Germany

Irritant patch testing with detergents is increasingly being used as a measure of skin barrier function, but there is evidence that climatic changes can influence the test outcome. In this study we investigated the relation between cutaneous reactivity to a detergent and climatic conditions. Between January 2000 and December 2001 epicutaneous patch testing with 0.5% sodium lauryl sulphate was performed on the forearm of 487 volunteers and evaluated by measuring transepidermal water loss (TEWL). Atopic individuals were excluded. Climatic conditions recorded by the German Meteorological Service were then compared with the test outcome. Climatic measurements 7 days before evaluation of the patch test were used to calculate an arbitrary mean value for each climatic parameter. A strong correlation was observed between temperature, steam pressure, absolute and relative humidity and the increase in TEWL, and most pronounced during winter and spring. The data provide experimental confirmation of epidemiological studies in which the incidence of irritant skin changes was found to be increased during the winter season with cold and dry air. For the first time, two formulae for adjusting TEWL values according to climatic conditions are presented. It is possible with these formulae to compare between a measured TEWL value and a calculated value. ***Key words: skin irritation: transepidermal water loss; seasonal variation; epidermal barrier; temperature; humidity; irritant contact dermatitis.***

(Accepted May 5, 2003.)

Acta Derm Venereol 2003; 83: 338–341.

Harald Löffler, Department of Dermatology, University of Marburg, Deutschhausstr. 9, D-35033 Marburg, Germany. E-mail: Harald.Loeffler@mailer.uni-marburg.de

The influence of climatic conditions on skin changes is an interesting and probably underestimated problem. Recently it has been shown that during cold and dry weather the incidence of irritant skin changes increases (1). If this were due to an increase in skin susceptibility, irritant patch testing would be influenced by climatic changes. There is some evidence that irritant patch testing is influenced by the season – patch testing with sodium lauryl sulphate (SLS) gives higher reactivity during winter than summer (2, 3). Similarly, in an animal model a low environmental humidity can lead to stronger skin reactions to SLS (4). The aim of this study was to investigate and quantify the influence of various climatic parameters on the result of an epicutaneous patch test with SLS.

MATERIAL AND METHODS

Study population

Four-hundred-and-eighty-seven volunteers recruited from the outpatient clinic of our department participated in the study (281 women and 206 men; aged 18 to 60 years). Atopic patients with an atopy score >10 (according to Diepgen et al. (5)) and dermatitis were excluded. Informed consent was obtained, and the study was approved by the ethics committee at the hospital.

Sodium lauryl sulphate testing

Occlusive patch testing with aqueous SLS (0.5%) was performed for 48 h using a Large Finn Chamber® (inner diameter 12 mm, Epitest Ltd., Helsinki, Finland) on the volar side of the left forearm in accordance with the guidelines on SLS testing (6). We measured transepidermal water loss (TEWL) with an evaporimeter (Tewameter TM 210, Courage & Khazaka, Cologne, Germany) prior to application and again 24 h after removal of the patch test. Delta values were calculated as post-TEWL minus pre-TEWL values. Room temperature was maintained at 20–22°C; relative humidity was between 30% and 45%; and volunteers had rested in these conditions for at least 20 min prior to measurement. TEWL measurement was performed according to the guidelines of the Standardization Group of the European Society of Contact Dermatitis (7).

Climatic parameters

The climatic data were obtained from the German Meteorological Service (Deutscher Wetterdienst), Medical Meteorology, Freiburg, Germany, using the nearest weather station at Giessen, which is 16 km from the Department of Dermatology in Marburg. Noon values were recorded. Because the skin is most likely influenced by the climatic conditions of previous days, we also calculated an adjusted mean of the week for each climatic parameter before test evaluation in the following way:

(day of test evaluation ×7)+(day before test evaluation ×6)+(2 days before test evaluation ×5)+(3 days before test evaluation ×4)+....l(7+6+5+4+3+2+1)

The following climatic data were included: temperature, steam pressure, absolute humidity, relative humidity, atmospheric pressure and wind force. For interdependence of absolute and relative humidity and temperature, see Uter et al. (1). As

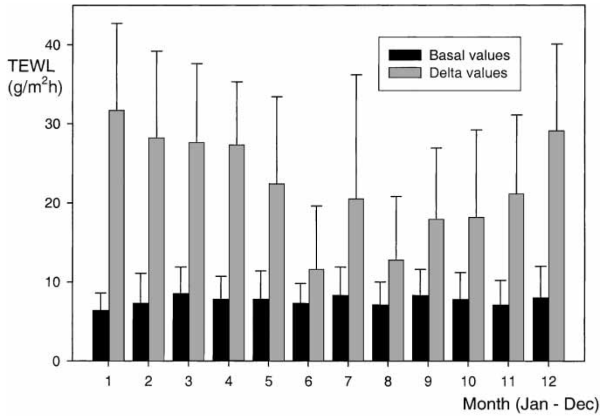

Fig. 1. Median transepidermal water loss (TEWL) and 75% value (basal and delta values after sodium lauryl sulphate patch test) over 2 years

temperature has a very strong influence on absolute and relative humidity (1), we used steam pressure as another parameter for humidity, which is far less influenced by temperature (8).

Statistical methods

The data were analysed using SPSS for Windows. Data distribution was calculated using the Kolmogorov-Smirnov test. Correlation analysis between TEWL values and climatic parameters was performed using Pearson's correlation coefficient. The relative risk for higher TEWL values was calculated for all climatic parameters correlating with the outcome of the SLS test. For this purpose, each climatic parameter was divided into four ranges of values, each range containing approximately the same number of volunteers. The relative risk (odds ratio) of obtaining a delta TEWL value above the 75% value (chosen as an arbitrary cut-off value for discriminating normal values from higher ones according to previous studies (9)) was calculated for each range by comparing with the range of the lowest risk, to which we gave an odds ratio of 1. A formula for predicting delta TEWL value dependent on absolute humidity was calculated as follows: By means of linear regression analysis (algorithm see (10)), a linear regression equation was calculated according to the formula: $y=a+b*x$ (y = expected delta TEWL value, x = absolute humidity, a = hypothetic delta TEWL at an absolute humidity of 0, y = slope of the curve). The target delta TEWL for formula 1 was the expected mean delta TEWL (= 50% value) and for formula 2 the expected mean delta TEWL + SD value (50% value + 1/2 SD area = 83.3% value).

RESULTS

The Kolmogorov-Smirnov test did not show a normal distribution of the values obtained, neither of the TEWL values nor of the climatic parameters. During the study period the median basal TEWL value of all 487 volunteers was 7.1 g/m^2 h; the median delta TEWL value after SLS testing was 18.7 g/m^2 h.

On examining the distribution of basal and delta TEWL values of different months we observed that basal TEWL values were unchanged over the year, while there was a sharp decrease in delta TEWL values from winter to summer (Fig. 1 and Table I).

We found no correlation between any climatic parameter and the basal TEWL values. However, a highly significant correlation was observed between the climatic parameters temperature, steam pressure, absolute and relative humidity and the delta TEWL values. Wind force and atmospheric pressure showed no correlation with the delta TEWL values.

Calculating the relative risk of delta TEWL values being above the 75% value, we found that low temperature led to an odds ratio of up to 2.76, and a higher relative humidity up to 2.35. The highest relative risk was found at low absolute humidity with an odds ratio up to 4.34 and at low steam pressure with an odds ratio up to 4.14 (Table II).

We calculated two formulas with the linear regression analysis. The first describes the estimated delta TEWL value (mean delta TEWL) dependent on the absolute humidity: *Formula 1.* Calculated mean TEWL value = 36.6 – 1.89 × absolute humidity

Table I. *Median, 25%* and 75%# value of basal TEWL and delta TEWL after SLS patch test over 2 years (in g/m^2 h), n = 487*

Month	Jan $n=30$		Feb $n=38$		Mar $n=47$		Apr $n=22$		May $n=49$		Jun $n=50$	
Basal TEWL	5.9	*4.9 #7.8	6.7	*4.3 #8.6	8.0	*6.5 #10.2	7.6	*5.9 #9.8	7.1	*5.3 #9.3	7.0	*5.8 #8.4
Delta TEWL	33.3	*20.0 #41.5	27.1	*18.1 #39.6	25.4	*12.2 #41.9	25.7	*12.3 #36.5	19.2	*4.3 #36.6	12.4	*3.1 #22.4
Month	**July $n=28$**		**Aug $n=59$**		**Sept $n=48$**		**Oct $n=40$**		**Nov $n=50$**		**Dec $n=26$**	
Basal TEWL	7.9	*5.1 #9.9	7.1	*5.1 #8.5	7.6	*6.0 #10.5	7.9	*5.1 #9.9	7.1	*5.1 #8.5	7.6	*6.0 #10.5
Delta TEWL	16.1	*8.9 #26.7	11.2	*2.3 #20.4	15.1	*9.5 #26.8	16.1	*8.9 #26.7	11.2	*2.3 #20.4	15.1	*9.5 #26.8

Table II. *Relative risk (odds ratio) for an increased delta TEWL (above the 75% value) compared to the reference group (RG) depending on different climatic conditions*

	Prevalence of climatic conditions over one year (%)	Odds ratio	Confidence interval (95%)
Temperature (°C)			
>19.2 (RG)	25.5	1.00	
19.3–13.9	24.4	0.71	0.35–1.46
13.8–8.3	25.7	2.76	1.52–5.00
<8.2	24.6	2.64	1.15–4.82
Relative humidity (%)			
<58.3 (RG)	23.3	1.00	
58.4–72.2	27.1	1.51	0.81–2.87
72.3–79.1	23.6	2.35	1.25–4.40
>79.2	26.1	1.96	1.01–3.66
Absolute humidity (mg/l)			
>10.20 (RG)	25.3	1.00	
10.20–8.57	24.4	1.60	0.80–3.21
8.56–6.06	25.2	2.77	1.44–5.32
<6.06	25.1	4.34	2.29–8.22
Steam pressure (hPa)			
>13.81 (RG)	24.2	1.00	
11.31–13.80	25.5	1.45	0.73–2.91
7.99–11.30	25.3	2.64	1.37–5.08
<7.98	25.1	4.14	2.18–7.84

The second formula describes the delta TEWL value where 83.3% (mean + SD) of all tested individuals had a lower result: *Formula 2*. Calculated upper threshold TEWL value $= 51.5 - 1.89 \times$ absolute humidity

A measured TEWL value above this calculated upper threshold TEWL value may indicate increased skin susceptibility regardless of climatic conditions.

DISCUSSION

Irritant patch testing is a widely accepted tool for evaluating skin barrier function (11, 12). In recent years, the anionic detergent SLS has become a standard irritant (13–15). Because we wanted to study the influence of climatic parameters on test outcome, all known influencing factors were either the same for all volunteers (SLS concentration and purity (16, 17), application time (16, 18, 19), application area (20, 21), age of volunteers (22, 23)), or they were eliminated (exclusion of atopic volunteers and individuals with acute dermatitis (23–25)).

We saw hardly any influence of season and basal TEWL, thus confirming earlier findings by Agner & Serup (2). In a recent study, Kikuchi et al. (26) observed a slightly higher basal TEWL in winter (26). However, following SLS testing we observed a marked difference in skin reactions when the mean TEWL values of different months were compared (Fig. 1): the skin reacts much more in winter than in summer, which has also been observed by other groups (2, 3, 27). Our correlation analysis showed that temperature, absolute and relative humidity and steam pressure, but not atmospheric pressure or wind force, correlated with the SLS-induced barrier disruption. Hence the relative humidity is of minor relevance when estimating climatic influence on skin susceptibility, which confirms the investigation of Uter et al. (1). Because absolute and relative humidity is strongly dependent on temperature (1), we studied steam pressure, which is far less influenced by temperature (8). This parameter also showed a marked risk for increased TEWL values (odds ratio increased to 4.14) after SLS testing (Table II). We conclude that the major reason for the seasonal increase in skin susceptibility is low environmental humidity, resulting in decreased steam pressure and absolute humidity.

The difference between the median delta TEWL test results in January and those obtained in August is threefold. It may therefore be useful to compare the measured delta TEWL values with climatic adjusted delta TEWL values. We therefore developed two formulas in which the absolute humidity (at noon) can be inserted and two estimated delta TEWL values can be calculated: the first formula describes the estimated 50% value (50% of our tested individuals had lower delta TEWL values). Any measured delta TEWL can now be compared with this calculated value to estimate whether it is higher or lower than normal. The second formula describes the 83.3% value, where 83.3% (mean + SD) of our tested individuals had lower delta TEWL values. Any measured delta TEWL above the calculated value of the second formula (calculated upper threshold TEWL value) indicates enhanced skin susceptibility independently of climatic conditions.

The SLS test may be a useful concomitant tool in allergy patch testing because weather-dependent skin susceptibility is useful information. Various studies have shown that during winter the number of positive reactions to allergens is rising (31–33), particularly allergens which act simultaneously as mild irritants (34–36). When patch testing for contact allergens is combined with SLS testing, seasonal effects can be revealed and the allergic patch test may perhaps be more accurate. Currently, a study investigating this hypothesis is being performed by the German Contact Dermatitis Research Group (Deutsche Kontaktallergie-Gruppe).

ACKNOWLEDGEMENTS

We thank Professor Dr. Gerd Jendritzky and Dr. Klaus Bucher for providing the meteorological data and for helpful discussions concerning all meteorological problems. Special thanks to Sabine Weimer for technical assistance, to Sebastian Schmitt for data management and to Peter Zoefel for statistical help.

REFERENCES

1. Uter W, Gefeller O, Schwanitz HJ. An epidemiological study of the influence of season (cold and dry air) on the occurrence of irritant skin changes of the hands. Br J Dermatol 1998; 138: 266 – 272.
2. Agner T, Serup J. Seasonal variation of skin resistance to irritants. Br J Dermatol 1989; 121: 323 – 328.
3. Tupker RA, Coenraads PJ, Fidler V, De Jong MC, van der Meer JB, De Monchy JG. Irritant susceptibility and weal and flare reactions to bioactive agents in atopic dermatitis. II. Influence of season. Br J Dermatol 1995; 133: 365 – 370.
4. Denda M. Epidermal proliferative response induced by sodium dodecyl sulphate varies with environmental humidity. Br J Dermatol 2001; 145: 252 – 257.
5. Diepgen TL, Fartasch M, Hornstein OP. Evaluation and relevance of atopic basic and minor features in patients with atopic dermatitis and in the general population. Acta Derm Venereol 1989; Suppl. 144: 50 – 54.
6. Tupker RA, Willis C, Berardesca E, Lee SH, Fartasch M, Agner T, Serup J. Guidelines on sodium lauryl sulfate (SLS) exposure testing. Contact Dermatitis 1997; 37: 53 – 69.
7. Pinnagoda J, Tupker RA, Agner T, Serup J. Guidelines for transepidermal water loss (TEWL) measurement: a report from the Standardization Group of the European Society of Contact Dermatitis. Contact Dermatitis 1990; 22: 164 – 178.
8. Deutscher-Wetterdienst: Aspirations-Psychrometer-Tafeln (ed. 6.). Braunschweig: Vieweg Verlag, 1979.
9. Löffler H, Pirker C, Aramaki J, Frosch PJ, Happle R, Effendy I. Evaluation of skin susceptibility to irritancy by routine patch testing with sodium lauryl sulfate. Eur J Dermatol 2001; 11: 416 – 419.
10. Zöfel P. Statistik in der Praxis, vol. 3. Auflage. Stuttgart, Jena: G. Fischer Verlag, 1992.
11. Basketter DA, Miettinen J, Lahti A. Acute irritant reactivity to sodium lauryl sulfate in atopics and non-atopics. Contact Dermatitis 1998; 38: 253 – 257.
12. Agner T. Noninvasive measuring methods for the investigation of irritant patch test reactions: a study of patients with hand eczema, atopic dermatitis and controls. Acta Derm Venereol Suppl 1992; 173: 1 – 26.
13. Lee CH, Maibach HI. The sodium lauryl sulfate model: an overview. Contact Dermatitis 1995; 33: 1 – 7.
14. Effendy I, Maibach HI. Surfactants and experimental irritant contact dermatitis. Contact Dermatitis 1995; 33: 217 – 225.
15. Löffler H, Effendy I, Happle R. Epikutane Testung mit Natriumlaurylsulfat: Nutzen und Grenzen in Forschung und Praxis. Hautarzt 1999; 50: 769 – 778.
16. Aramaki J, Löffler C, Kawana S, Effendy I, Happle R, Löffler H. Irritant patch testing with sodium lauryl sulfate: interrelation between concentration and exposure time. Br J Dermatol 2001; 145: 704 – 708.
17. Agner T, Serup J, Handlos V, Batsberg W. Different skin irritation abilities of different qualities of sodium lauryl sulphate. Contact Dermatitis 1989; 21: 184 – 188.
18. Aramaki J, Effendy I, Happle R, Kawana S, Löffler C, Löffler H. Which bioengineering assay is appropriate for irritant patch testing with sodium lauryl sulfate? Contact Dermatitis 2001; 45: 286 – 290.
19. Wilhelm KP, Cua AB, Wolff HH, Maibach HI. Surfactant-induced stratum corneum hydration in vivo: prediction of the irritation potential of anionic surfactants. J Invest Dermatol 1993; 101: 310 – 315.
20. Cua AB, Wilhelm KP, Maibach HI. Cutaneous sodium lauryl sulphate irritation potential: age and regional variability. Br J Dermatol 1990; 123: 607 – 613.
21. Elsner P, Wilhelm D, Maibach HI. Sodium lauryl sulfate-induced irritant contact dermatitis in vulvar and forearm skin of premenopausal and postmenopausal women. J Am Acad Dermatol 1990; 23: 648 – 652.
22. Lévêque JL, Corcuff P, de Rigal J, Agache P. In vivo studies of the evolution of physical properties of the human skin with age. Int J Dermatol 1984; 23: 322 – 329.
23. Löffler H, Effendy I, Happle R. The sodium lauryl sulfate test. A noninvasive functional evaluation of skin hypersensitivity. Hautarzt 1996; 47: 832 – 838.
24. Tupker RA, Coenraads PJ, Fidler V, De Jong MC, van der Meer JB, De Monchy JG. Irritant susceptibility and weal and flare reactions to bioactive agents in atopic dermatitis. I. Influence of disease severity. Br J Dermatol 1995; 133: 358 – 364.
25. Agner T. Skin susceptibility in uninvolved skin of hand eczema patients and healthy controls. Br J Dermatol 1991; 125: 140 – 146.
26. Kikuchi K, Kobayashi H, Le Fur I, Tschachler E, Tagami H. The winter season affects more severely the facial skin than the forearm skin: comparative biophysical studies conducted in the same Japanese female in later summer and winter. Exog Dermatol 2002; 1: 32 – 38.
27. Basketter DA, Griffiths HA, Wang XM, Wilhelm KP, McFadden J. Individual, ethnic and seasonal variability in irritant susceptibility of skin: the implications for a predictive human patch test. Contact Dermatitis 1996; 35: 208 – 213.
28. Geier J, Uter W, Pirker C, Frosch PJ. Patch testing with the irritant sodium lauryl sulfate (SLS) is useful in interpreting weak reactions to contact allergens as allergic or irritant. Contact Dermatitis 2003; 48: 99 – 107.
29. Mathias CG, Wilson DM, Maibach HI. Transepidermal water loss as a function of skin surface temperature. J Invest Dermatol 1981; 77: 219 – 220.
30. John SM, Uter W, Schwanitz HJ. Relevance of multiparametric skin bioengineering in a prospectively followed cohort of junior hairdressers. Contact Dermatitis 2000; 43: 161 – 168.
31. Bruze M. Seasonal influence on routine patch test results. Contact Dermatitis 1986; 14: 184.
32. Edman B. Seasonal influence on patch test results. Contact Dermatitis 1989; 20: 226.
33. Ingber A, Sasson A, David M. The seasonal influence on patch test reactions is significant in Israel. Contact Dermatitis 1998; 39: 318 – 319.
34. Kränke B, Aberer W. Seasonal influence on patch test results in central Europe. Contact Dermatitis 1996; 34: 215 – 216.
35. Hjorth N. Jahreszeitliche Schwankungen der Kontaktekzeme. Hautarzt 1975; 26: 75 – 76.
36. Uter W, Geier J, Land M, Pfahlberg A, Gefeller O, Schnuch A. Another look at seasonal variation in patch test results. A multifactorial analysis of surveillance data of the IVDK. Information Network of Departments of Dermatology. Contact Dermatitis 2001; 44: 146 – 152.