

## 'RUSTERS'. THE CORROSIVE ACTION OF PALMAR SWEAT: I. SODIUM CHLORIDE IN SWEAT

O. Jensen

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

**Abstract.** Sweat from 8 'rusters' and 8 control persons was examined for its sodium concentration. Sweating was induced by iontophoresis of pilocarpine on the distal forearm. In no case did the concentrations exceed the normal upper limit for this procedure, and no difference was found between the two groups. In this way the study failed to confirm earlier reports of elevated sodium chloride concentrations in sweat from 'rusters'. Proposals of a relationship between 'rusters' and patients with pancreatic cystic fibrosis were not substantiated. Hyperhidrosis of the palms and volar surfaces of the fingers was present in all 'rusters'. This seemed to be the main cause of the corrosive tendency, and patients referred for palmar hyperhidrosis were found to produce corrosion similar to the 'rusters'. Topical application of aluminium chloride hexahydrate in a 25% solution in absolute ethyl alcohol proved effective against both hyperhidrosis and the corrosive tendency.

**Key words:** Corrosion of metal by palmar sweat; Sodium chloride concentration; Treatment of hyperhidrosis

Contamination of metal objects by palmar sweat, resulting in corrosion, has been known for many years (11), and metal workers with this tendency are called 'rusters'. It is considered a problem in the metal industry (6), as the corrosion may cause malfunction of the components, especially in industries manufacturing tools, ballbearings and electronic components. The condition does not seem to be rare and constitutes a risk to the 'ruster' of being discharged from his job (2).

Investigations of the condition have dealt particularly with the concentration of sodium chloride in sweat (3, 4, 6). The reporting of abnormally high concentrations in sweat from 'rusters' (3, 4), and the proposed relationship between 'rusters' and patient with pancreatic cystic fibrosis (3, 8), seemed surprising. The purpose of the present study was to further investigate these problems and to make an attempt at treating the condition.

### MATERIALS

Nineteen persons were examined. Eight were 'rusters' (4 apprentices and 4 skilled workers in the metal industry) with a known tendency to produce corrosion. Three patients referred to the clinic for palmar hyperhidrosis were also examined, plus 8 persons who had never noticed any corrosive tendency; the latter served as a control group. The 'rusters' and control persons were all males and had identical occupations in the metal industry. The mean age for the 'rusters' was 28.5 years and for the controls, 30.3 years. Two of the patients with hyperhidrosis were females (aged 14 and 46 years) and one was a male (aged 26 years).

### METHODS

#### *Corrosion tests*

A preliminary test was performed on all 19 persons. The palms and volar surfaces of the fingers were pressed against carefully rinsed steel plates (mild steel, containing 0.09% carbon). The plates were exposed at 21-23°C and 60% relative humidity, and the corrosion was evaluated 2 weeks later.

#### *Measurement of the sodium concentration in sweat*

Sweating was induced on the distal part of the volar surface of the right forearm of 'rusters' and control persons by iontophoresis of pilocarpine nitrate 0.2%. This method, originally described by Gibson & Cooke (10), was used in a slightly modified way (9). Sweat was collected from the carefully cleansed skin surface on electrolyte-free filter paper and analysed for its sodium content by flame photometry.

### RESULTS

All 'rusters' and patients with palmar hyperhidrosis reported a long history of troublesome palmar sweating. Four 'rusters' and the 3 patients had additional complaints of excessive sweating from the feet and axillary regions. In both groups, mental stress and nervousness would provoke or worsen the sweating. The 'rusters' stated that increased



Fig. 1. Corrosion test on sheet of mild, unpolished steel. Left: print made by a 'ruster'; right: print made by one of

the patients with palmar hyperhidrosis, a 46-year-old woman who had never noticed any corrosive tendency.

sweating would aggravate corrosion. No history of pancreatic cystic fibrosis was found in them or in their families. The patients had never noticed any corrosive tendency.

On examination, hyperhidrosis of the palms and volar surfaces of the fingers was present to a varying extent in all 'rusters' and patients. Severe hyperhidrosis with drops of sweat on fingers and palms, occasionally dripping to the floor, was seen in 5 'rusters' and the 3 patients, while the rest of the 'rusters' had a more moderate hyperhidrosis with small droplets of sweat on fingers and palms.

None of the control persons complained of hyperhidrosis, and their hands were dry except for 2 subjects with slightly moist fingertips.

#### Corrosion tests

Corrosion was produced by all 'rusters' and patients (Fig. 1) in varying degrees. None of the controls produced corrosion.

#### Determination of sodium concentration in sweat

The mean value for the 'rusters' were 49.1 mEq/l (range 26-67 mEq/l) and for the control persons, 49.6 mEq/l (range 31-68 mEq/l). The difference was

not significant ( $p > 0.10$ ). In no case did the results exceed 80 mEq/l, the normal upper limit for this procedure (9).

The weight of collected sweat was higher for the 'rusters' (mean 0.093 g) than for the controls (mean 0.066 g). The significance of the difference is questionable ( $0.10 > p > 0.05$ ).

#### TREATMENT OF HYPERHIDROSIS

Five of the 'rusters' and the 3 patients with palmar hyperhidrosis were treated with aluminium chloride hexahydrate in a 25% solution in absolute ethyl alcohol (16). The formulation was applied to the palms and volar surfaces of the fingers from a roll-on bottle in the evenings just before sleep. Occlusion of the hands, recommended in the original description of this treatment (16), was not used. The hands were washed next morning. During the first week treatment was given every night, and thereafter every second night. After 3 weeks all 8 persons had noticed excellent improvement. On examination the palms and fingers were dry in 6 persons, while 2 were moist on the fingertips. On continued observation for 2 months the effect could be maintained by application every second to third

night, and the 'rusters' stated that the corrosive tendency either had disappeared or diminished to a negligible extent. No side effects were seen.

## DISCUSSION

Rusting of metal by palmar sweat is an example of atmospheric corrosion. The chemical processes are described by Evans (7). In the sweat drop, being rich in sodium chloride and having an oxygen-containing surface, an electrolytic reaction will take place, resulting in the formation of brown rust ( $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ). The function of sodium chloride is to carry the electric current.

In the published works on 'rusters', interest has been focused on the sodium chloride content of sweat, as this seems to be the most important factor in the chemical reaction taking place on the metal surface. An increase in sodium chloride concentration would tend to exacerbate the corrosion.

It is generally accepted that the concentration of sodium chloride in sweat is less than in plasma (14). Great individual variations are seen in sweat from normal persons, though concentrations above 80 mmol/l seldom occur (14). Variations may be caused by differences in sweat rates, as increasing concentrations are observed with increasing sweat rates (12). The method of stimulating sweating may influence the concentration, as pharmacologically stimulated sweat tends to have a higher concentration than thermal sweat (15). The region from which sweat is collected may also be of importance, but results are conflicting. In palmar sweat, values of 215–1640 mg NaCl per 100 ml have been reported (13), while another study on palmar sweat resulted in concentrations of 4–100 mEq/l of chloride (5), similar to concentrations from other regions of the body. Whether the analysis is made on sodium or chloride, the results are by and large similar (12).

Previous reports on abnormally high concentrations of chloride in palmar sweat from 'rusters' (3, 4) were based upon different methods. Using a semiquantitative technique, Buckley & Lewis (3) found values up to 150 mEq/l of chloride, but even higher concentrations—up to 1000 mmol/l of sodium chloride—were reported by Burton et al. (4), without mention of the technique.

For many years the technique employed in the present study has been used in the diagnosis of pancreatic cystic fibrosis, and reliable normal values exist. Although individual variations are seen

among adults, values exceeding 80 mEq/l of sodium are rarely found (9).

In the present study all concentrations were within normal limits, and no difference was found between 'rusters' and control persons. We are therefore unable to confirm the above-mentioned reports on elevated salt concentrations. The most striking observation was the finding of hyperhidrosis of the palms in all 'rusters'. The importance of hyperhidrosis was further substantiated, as it was observed that the 3 patients with palmar hyperhidrosis caused corrosion similar to that of the 'rusters', with regard to both quantity and chemical content (Fig. 1). It is interesting to note that these patients had never observed any tendency to corrode metal, probably because they did not handle metal specimens in their daily work. They must nevertheless be considered potential 'rusters' and if they work in the metal industry, their future employment may, in consequence, be at risk.

Treatment of hyperhidrosis with aluminium chloride hexahydrate in alcohol (2, 16) proved effective in both 'rusters' and patients, and occlusion of the hands proved unnecessary. Following continued therapy the 'rusters' noted disappearance of the corrosive tendency.

The fact that greater amounts of sweat were obtained after iontophoresis of pilocarpine from the 'rusters' than from the control persons is difficult to explain, but it is conceivable that persons suffering from hyperhidrosis may be more susceptible to cholinergic stimulation (1).

A relationship between 'rusters' and patients with cystic fibrosis of the pancreas, based upon reports of elevated sodium chloride concentrations in sweat from 'rusters', has been proposed (3, 8). We feel that this does not seem likely. Apart from normal sodium concentrations, all 'rusters' were in good health, with no history in themselves or in their families of this disease, which usually causes distinct symptoms in childhood.

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#### REFERENCES

1. Allen, J. A., Armstrong, J. E. & Roddie, I. C.: Sweat responses of a hyperhidrotic subject. *Br J Dermatol* 90: 277, 1974.
2. Bang Pedersen, N.: Topical treatment of a "ruster". *Br J Dermatol* 96: 332, 1977.
3. Buckley, W. R. & Lewis, C. E.: The "ruster" in industry. *J Occup Med* 2: 23, 1960.
4. Burton, J. L., Pye, R. J. & Brookes, D. B.: Metal corrosion by chloride in sweat. *Br J Dermatol* 95: 417, 1976.
5. Darling, R. C.: Some factors regulating the composition and formation of human sweat. *Arch Phys Med* 29: 150, 1948.
6. Eisler, S. J. & Faigen, H. L.: Investigation of synthetic fingerprint solutions. *Corrosion* 10: 237, 1954.
7. Evans, U. R.: *An Introduction to Metal Corrosion*, pp. 28-32. E. Arnold, London, 1963.
8. Fisher, A. A.: *Contact Dermatitis*, p. 94. Lea & Febiger, Philadelphia, 1973.
9. Flensburg, E. W.: Iontophoresis apparatus. Description of the technique, and a Danish test material. *Dansk Laboratorieudstyr*. Copenhagen, 1971.
10. Gibson, L. E. & Cooke, R. E.: A test for concentration of electrolytes in sweat in cystic fibrosis of the pancreas utilizing pilocarpine by iontophoresis. *Pediatrics* 23: 545, 1959.
11. Huff, W. J.: Corrosion protective action of certain colloidal solutions. *Chem Met Eng* 25: 865, 1921.
12. Johnson, B. B., Johnson, R. E. & Sargent, F.: Sodium and chloride in eccrine sweat of men and women during training with acetyl-B-methylcholine. *J Invest Dermatol* 53: 116, 1969.
13. Lobitz, W. C. & Osterberg, A. E.: Chemistry of palmar sweat. II. Chloride. *Arch Dermatol Syphil* 56: 462, 1947.
14. Robinson, S. & Robinson, A. H.: Chemical composition of sweat. *Phys Rev* 34: 202, 1954.
15. Sato, K., Feibleman, C. & Dobson, R. L.: The electrolyte composition of pharmacologically and thermally stimulated sweat. *J Invest Dermatol* 55: 433, 1970.
16. Shelley, W. B. & Hurley, H. J.: Studies on topical antiperspirant control of axillary hyperhidrosis. *Acta Dermatovener (Stockholm)* 55: 241, 1975.

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O. Jensen, M.D.  
 Department of Dermatology  
 The Municipal Hospital  
 Ø. Farimagsgade 5  
 DK-1399 Copenhagen K  
 Denmark