THE INSENSIBLE PERSPIRATION OF THE SKIN IN HYPERKERATOTIC CONDITIONS

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INTRODUCTION

The cutaneous insensible perspiration may be defined as the water evaporation from the skin surface without the formation of visible sweat droplets. It originates from two sources: first, from the active and constant secretory function of the sweat glands; and second, from water loss through the epidermis (1). Observations with the capillary microscope have shown that the sweat glands secrete continuously at room temperature, the minute droplets evaporating immediately after their appearance on the skin surface (2). The administration of atropine decreases the total amount of cutaneous insensible perspiration due to paralysis of sweat gland function, but a considerable amount of insensible perspiration still remains. After atropinization, Moog (3) (1923) found decreased perspiration values as high as 50 per cent of normal, and Rothman (4) (1930) observed a variable decrease of 10 to 30 per cent in different individuals. It is probable that differences in the participation of sweat gland function in insensible perspiration at room temperatures depend on the nervous excitability of the test individuals.

The mechanisms involved in the passive transepidermal transport of water, excluding sweat gland activity, have long been a subject of discussion. By most authors a direct passive transfer of water from the blood vessels through the epidermis to the surface has been postulated, the amount depending on the outside temperature, humidity, cutaneous blood flow, and other physical factors. In contrast to this conception, Moog (5) (1926) found decreased insensible perspiration in erythema, caused by ultraviolet irradiation with greatly increased arterial blood flow. Rothman (4) (1930) found the insensible perspiration practically normal in ultraviolet light erythema, but markedly increased when the sunburned areas began to scale.

The keratinization process of the epidermis involves a proliferation of cells from the basal layer to the surface. The corneal layer is constantly renewed from the Malpighian layer below. Scales of microscopic dimension are shed off continuously. Keratinization itself involves loss of water since the cells of the Malpighian layer contain 70–80 per cent water, whereas the keratin layer has only 10 per cent in the average (6). In other words, keratinization is associated with a dehydration process. The water liberated from the epidermis during keratinization may be added to the insensible perspiration. If this is true, conditions in which the keratinization process is accelerated, with a hyper-

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production of keratin, must show increased insensible perspiration values. Some observations in this direction were made by Rothman (7) (1931), and lately by E. A. Pinsen (8), who found two to three fold values of insensible perspiration in dry, scaling skin. Further experiments on this subject are reported in the present study.

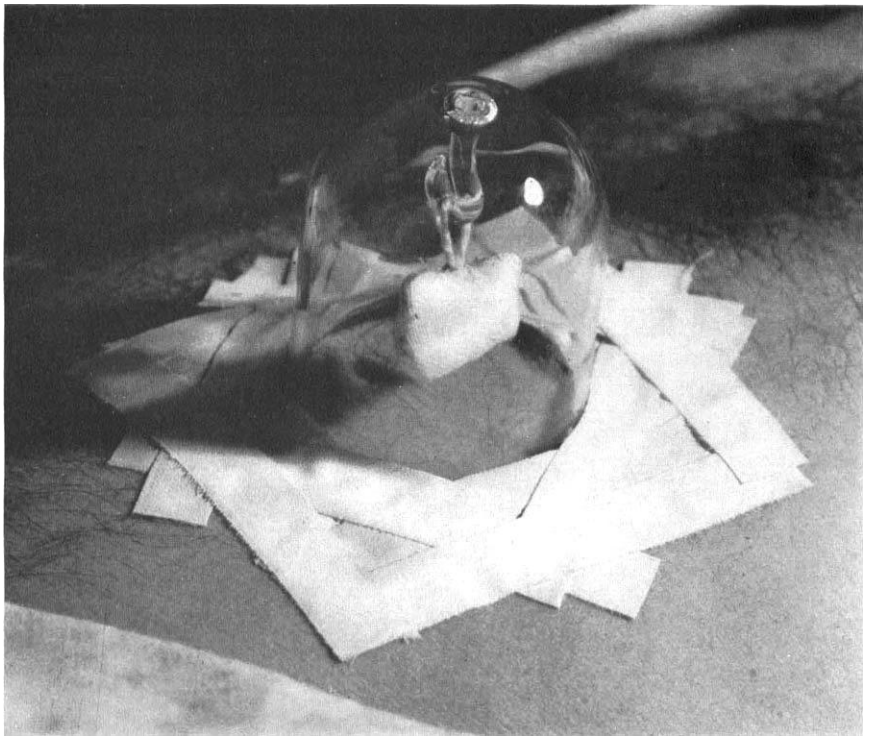

FIG. 1

EXPERIMENTAL

The Measurement of the Normal Insensible Perspiration

The insensible perspiration was measured by absorption of water vapor with anhydrous calcium chloride over a circumscribed area of the skin. Small linen bags were filled with calcium chloride, weighed and suspended on hooks under the domes of glass bells, each with a diameter of 4.71 cm. The bells were firmly fixed to the skin by waterproof adhesive strips, and allowed to remain attached for exactly one hour (Fig. 1).

The weight increase of the calcium chloride bags indicated the amount of insensible perspiration. The bags were weighed before and after the experiment in weighing flasks with ground glass stoppers, and were transported to and from the balance room in a desiccator. Suspension on and removal from the glass hooks of the bells were performed with clean, dry steel forceps. After some training, this transfer was done within a few seconds, and any absorption of moisture from the air during the manipulation became negligible. Under these conditions parallel values obtained in two simultaneous measurements of symmetrical skin areas varied from none to 10 per cent (Table 1). No particular attention was paid to the temperature and humidity of the room because comparative experiments

were carried out on symmetrical or adjacent areas simultaneously, under identical conditions. The values obtained on skin of patients without skin diseases varied from 20.1 mg. to 29.6 mg. The average value was 22.7 mg. with a standard deviation of ±3.0. It was rather surprising to see that in spite of our neglect of atmospheric conditions in the room, the values varied within such a narrow range.

TABLE 1

Insensible perspiration of normal skin

Simultaneous measurements of two symmetrical areas 4.71 cms. in diameter. Duration of experiment—60 minutes

DATE	NAME	AGE	SEX	REGION	I.P.		DEVIATION
					Left	Right	
					mg.	*mg.*	*per cent*
10-12-43	J. K.	38	M	Abdomen	21.0	20.1	4.5
10-13-43	C. N.	28	M	Abdomen	29.6	26.9	10
10-16-43	C. N.	28	M	Chest	22.5	22.4	—
10-31-43	P. B.	29	M	Abdomen	19.9	21.9	10
11- 7-43	P. B.	29	M	Chest	20.6	22.2	8

TABLE 2

Insensible perspiration in psoriasis

Measurement on adjacent areas of normal skin and psoriasis patches

DATE	NAME	SEX	AGE	REGION	ROOM TEMP.	I.P.		INCREASE OF I.P. IN PSORIASIS
						Normal	Psoriasis	
					F°.	*mg.*	*mg.*	
11-27-43	H. H.	M	42	Back	—	9.4	73.4	8×
12-28-43	L.	M	43	Abdomen	75	23.8	109.1	4×
2- 7-44	C. E.	M	77	Chest	77	—	92.3	—
2- 8-44	E. M.	M	56	Chest	76	13.1	88.9	6×
2-12-44	E. M.	M	56	Abdomen	74	—	58.4	—
2-19-44	D. S.	M	66	Sacrum	76	25.5	98.6	4×
2-22-44	—	M	—	Back	—	18.6	55.5	3×
3-11-44	A. K.*	M	33	Abdomen	77	—	97.4	—
3-11-44	A. K.*	M	33	Abdomen	77	—	90.8	—
4-17-44	M. R.†	F	40	Thighs	77	14.7	56.3	4×

* Two adjacent areas measured in generalized psoriasis.

† Symmetrical areas measured.

Psoriasis

It has been shown that the pathologic process in psoriasis involves hyperproduction of keratin due to increased proliferation of the prickle cells of the Malpighian layer (9). The amount of insensible perspiration obtained over hyperkeratotic psoriasis patches as compared with normal skin of adjacent areas, measured simultaneously, are tabulated in Table 2. The experiments showed an increase on psoriasis patches of 3 to 8 times normal. The average insensible

perspiration was 82.07 mg. and the average increase over the average normal was four fold.

The high values of insensible perspiration in psoriasis did not change essentially after atropinization. In 2 of our cases the insensible perspiration was measured comparatively before and one half hour after subcutaneous injection of 1.0 and 0.6 mg. atropine sulfate. In both cases after atropinization, the insensible perspiration of psoriasis patches remained 4 to 5 times normal as they were before. Thus it was demonstrated that the high values are not due to enhanced activity of sweat glands, but to increased transepidermal water transport. It may be mentioned that Kleinschmidt (10) found decrease of sweat gland function in psoriasis lesions.

TABLE 3

Insensible perspiration in exfoliative dermatitis

36-year-old white male suffering from generalized exfoliative dermatitis following arsphenamine medication. All measurements were made on abdomen.

DATE	I.P. VALUES		REMARKS
	Right	Left	
	mg.	*mg.*	
12- 6-43	216.5	—	Abundant lamellous scaling
12- 7-43	222.5	229.2	Same
12-24-43	60.5	68.7	Scaling greatly diminished
1-20-44	21.3	19.7	Skin completely cleared up. No scaling

Exfoliative Dermatitis

In exfoliative dermatitis the keratinization process is greatly accelerated, scaling often being so profuse that several grams of scales are lost daily in extreme cases (9). The patients complain of thirst and chilly sensations, although the temperature is not necessarily elevated.

The subject of this study G. F., white male, age 36, was admitted to the Albert Merritt Billings Hospital on December 2nd, 1943 with a severe generalized exfoliative dermatitis which developed after 5 injections of neoarsphenamine. There was dry lamellous scaling with no exudation and no other signs of disruption of the epidermis. Table 3 shows the insensible perspiration values at the height of the eruption, during improvement, and after complete recovery. It is seen that during abundant scaling, the insensible water loss was about 10 times the normal figures found after recovery. Because of the generalized nature of the eruption, normal values could not be obtained in this case at the height of the disease and parallel measurements were made on equally involved symmetrical areas.

Ichthyosis Vulgaris

In ichthyosis vulgaris there is a disturbance in separation of the scales which accumulate on the surface. The basal cell and Malpighian layer show no signs

TABLE 4

Insensible perspiration in ichthyosis vulgaris

DATE	NAME	SEX	AGE	REGION	I.P.	ROOM TEMP.	REMARKS
					mg.	*F.°*	
12-19-43	A. T.	F	51	Rt. Thigh Rt. Popliteal Fossa	23.3 24.8	77	Popliteal area free of Ichthyosis
1-20-44	A. L.	F	34	Left Thigh Left Leg	29.6 27.0	—	Adjacent ichthyotic areas
2- 7-44	M. S.	F	13	Rt. Thigh Left Thigh	34.4 34.2	77	Symmetrical ichthyotic areas

TABLE 5

Insensible perspiration in ultraviolet erythema

DATE	NAME	SEX	AGE	REGION	I.P.		ROOM TEMP.	REMARKS
					Normal	Erythema		
					mg.	*mg.*	*F.°*	
3- 1-44	M. M.	F	19	Abdomen	13.8	17.9	—	Mild erythema. Increase of I.P. in erythematous area 30%. Symmetrical areas used
3- 7-44	M. M.	F	19	Abdomen	20.9	28.9	—	Vivid erythema. Increase 38%. Symmetrical areas
3- 8-44	S. R.	M	50	Thighs	24.2	33.8	78	Mild erythema. Increase 40%. Symmetrical areas
4-21-44	S. R.	M	50	Abdomen	12.8	16.4	75	Increase 20%. Temp. of erythematous area 8°C. higher than that of normal skin

TABLE 6

Insensible perspiration in post-inflammatory scaling

DATE	NAME	AGE	SEX	REGION	I.P.		ROOM TEMP.	INCREASE IN SCALING AREA	REMARKS
					Normal	Scaling			
					mg.	*mg.*	*F.°*		
3-10-44	M. M.	19	F	Abdomen	19.5	44.8	77	2.3×	Measured 4 days after U.V.L. irradiation. No erythema. Moderate fine scaling
4-31-44	S. R.	50	M	Abdomen	19.0	42.1	71	2.2×	Measured 9 days after U.V.L. irradiation. Lamellous scaling. Temp. of scaling area same as that of normal area

of increased proliferation, on the contrary, it is often partially atrophic. The insensible perspiration was normal in 2 of our patients with ichthyosis, and slightly elevated in the third (Table 4). Loewy (11), who in 1914 first measured water vapor loss in ichthyosis, found no significant changes from his normals either.

Ultraviolet Erythema and Post-Inflammatory Scaling

Single intense ultraviolet irradiations were given to circumscribed areas of skin of normal subjects by the therapeutic Hanovia mercury arc lamp. The insensible perspiration was measured the following day after erythema had developed. Small increases of 20–40 per cent were obtained over the erythematous patches as compared with the normal (Table 5). When scaling began 4 to 9 days after the irradiation in our subjects, the insensible perspiration rose to over twice the normal figures (Table 6).

DISCUSSION

The normal values obtained from persons without skin diseases have shown only minor variations. If the values obtained in a 60-minute experiment on skin areas measuring 4.71 cm. in diameter are roughly calculated for the whole body surface, we obtain figures which are well within the range of earlier data on total cutaneous insensible perspiration of the entire body. The whole body surface is taken as 15000 cm.^{2} The measured area in our experiments is 17.4 cm.^{2}, representing 1/882 of the body surface. The average perspiration value 22.7 mg. times 24 hrs. times 882 yields 480 grams of water. Galeotti and Signorelli (12) found an average of 530 grams, and Benedict's (13) average values were in the same range.

The tremendously increased values of insensible perspiration in psoriatic lesions and in exfoliative dermatitis may be attributed to either the arterial hyperemia present or to the accelerated keratinization. The experiments on ultraviolet erythema with greatly increased arterial blood flow and increased skin temperature show that arterial hyperemia in itself without accelerated keratinization increases the insensible perspiration only slightly, if at all. After the hyperemia has subsided and post-inflammatory scaling set in, the perspiration rises. From the available data, the conclusion is drawn that hyperproduction of keratin contributes to the increase of insensible perspiration by dehydration of the prickle cells. It seems probable that physiologically, too, one part of the insensible perspiration is contributed by the keratinization process.

Some calculations, however, indicate that the tremendous increase of insensible perspiration found in exfoliative dermatitis and in some cases of psoriasis is not accounted for by increased keratinization alone. Experiments are being planned to measure the total loss of horny material in generalized psoriasis and in exfoliative dermatitis with greater accuracy than it was done in the past. In generalized psoriasis Shamberg, et al. (9) found a total daily loss of 1.7 grams

nitrogen in scales, corresponding with 10.3 grams of keratin. Our own preliminary data suggest that the keratin loss may be around 50 grams daily in a moderately scaling generalized psoriasis. However, even the shedding of 100 grams of scales in a day will not involve as much rete cell-dehydration as to account for 5 to 10 times normal perspiration values.

Probably, in addition to accelerated keratinization in psoriasis and exfoliative dermatitis, there is another factor enhancing the insensible perspiration, possibly an increased permeability for water in those lesions. It has been demonstrated (14) that the barrier for water absorption lies between the cornified and non-cornified epidermis. One may assume that the granular layer is inhibitory for water transportation from the inside as well as from the outside. It seems possible that discontinuity of the granular layer in psoriasis and exfoliative dermatitis contributes to the exorbitant perspiration values obtained in those conditions.

Be that as it may, the experiments clearly demonstrate that in patients with generalized psoriasis and with exfoliative dermatitis we have to deal with an extremely increased extrarenal cutaneous water output. The amounts of water lost through the skin are in the same range as in prolonged excessive sweating. However, in profuse sweating a salt solution is secreted through the sweat glands, and there is a compensatory decrease in urinary output with highly concentrated urine, a real shift in water metabolism to the extrarenal side. In psoriasis and exfoliative dermatitis pure water is lost passively through the epidermis without active secretory function of the sweat glands; the daily volume of the urine does not change essentially, and the excessive loss of water is taken care of by greater fluid intake by the patient. Thus the great increase in insensible perspiration offers an explanation for the well known chilly sensations and thirst of patients with exfoliative dermatitis.

SUMMARY

1. In cutaneous lesions with hyperproduction of keratin, such as psoriasis and exfoliative dermatitis, the insensible perspiration is increased three to ten fold normal values.

2. In ichthyosis vulgaris, where hyperkeratosis is not associated with increased and accelerated keratinization, the insensible perspiration is practically normal.

3. Arterial hyperemia, without increase of keratin formation is associated with only a slight increase in insensible perspiration.

4. It is concluded that physiologically, one part of the insensible perspiration is contributed by the keratinization process, because there is a dehydration of cells of the Malpighian layer during the keratinization process.

5. The enormous perspiration values in exfoliative dermatitis and in some cases of psoriasis is not accounted for by accelerated keratinization alone. It is assumed that in these conditions discontinuity of the granular layer increases the cutaneous permeability for water and thus contributes to the increase of insensible perspiration.

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