A Study on Skin Humidity in Leprosy Patients Using a New Type of Humidity Meter[1]

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A leprosy patient with partial loss of sensation and accompanying inability to sweat can be expected to have skin of varied humidity. It would be of interest to be able to test this varied humidity objectively and rapidly, as well as the effectiveness of various measures aimed at curing the dryness of the skin. Recently, one humidity meter that exactly suits this purpose has become available, the Vaisala Humicap humidity meter. With this, we can quickly get an idea of the moisture of the skin in different areas of the body.

MATERIALS AND METHODS

Apparatus

The Vaisala Humicap humidity meter (Vaisala OY, PL 26, SF-00421, Helsinki 42, Finland) consists of an indicator HMI 14 with analog display unit and a probe HMP 14 (Fig. 1). The relative humidity is detected by a thin-film humidity sensor, the Humicap. The sensor is a small capacitor, with an organic polymer dielectric, capable of changing the capacitance value of the Humicap sensor. This capacitance change is directly proportional to the surrounding relative humidity ([4, 5, 7]). The Humicap sensor is built into a hand-held probe which can be used to measure the relative humidity in various applications.

In order to measure the humidity of the skin, the probe was especially adapted by fitting a cylindrical plastic hood to enclose the sintered filter, thus protecting the Humicap sensing element. The hood is 40 mm in length and has an inner diameter of 22 mm. The open end of the hood extends 9 mm beyond the end of the sintered filter, thus preventing the skin from soiling it. When the probe is not in use between measurements, the hood aperature is protected by a plastic cover.

When testing, the plastic hood of the probe is held lightly but firmly against the skin. One-minute tests were made with readings every 15 sec timed by a stopwatch. The difference between the one-minute reading and air humidity at the beginning of the test was a manifestation of the evaporation rate, the one-minute relative evaporation (OMRE). When two areas were compared at the same time, the one-minute relative evaporation was also an expression of the difference in the humidity of the skin. Continued measuring beyond one minute gave higher readings, although at a gradually decreasing rate, until saturation occurred. For our purpose, however, the one-minute test was adequate. When the evaporation was high, it was observed that the humidity meter responded even when the probe came within a few centimeters of the skin. After each one-minute test, it usually took only a few seconds before the relative humidity inside the plastic hood returned to the level of the surrounding air. Sometimes, however, a few quick waves of the probe was useful in speeding up the return.

All tests were made in one of the wings of the leprosy ulcer ward. When the wind was high there was a fresh breeze blowing through the wing, since the walls reached only halfway to the roof. Since the tests went on over a 1½-year period, the climate varied considerably—from the rainy season with high air humidity to the dry season, from cool to very hot weather.

The tests were performed on inpatients on areas of apparently healthy skin. The areas generally tested were without sensation. When this was not the case, it was pointed out. When testing the feet, only those without marked deformity were accepted for the study.

Principally, the study dealt with three questions:

1) What is the humidity of skin with sen-

[1] Received for publication on 7 April 1983; accepted for publication in revised form on 27 July 1983.

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FIG. 1. The indicator and probe of the Vaisala Humicap humidity meter. Probe is equipped with a cylindrical plastic hood.

sation compared with skin without sensation?

2) In the routine treatment of dry skin with soaking followed by Vaseline rubbing, how important is the soaking?
3) How effective are ordinary zinc oxide adhesive tape and a latex sock in treating dry skin?

Procedures

To test the humidity of skin with and without sensation. Selected areas of the upper or lower extremities were studied. Frequently the areas selected by normal sensory tests did not show the sweating or lack of sweating expected at sun exposure. The study then had to be done again on another day in the correctly defined areas. The palms were not included in any part of this study, since their one-minute relative evaporation readings were very erratic even when there was no sensation.

The first humidity tests were made in the morning while the temperature in the ward was still cool and before the patient had been outside. After that, the selected areas of the patient's skin were exposed to the sun for 10–20 min until the sensation area showed profuse sweating. The humidity tests were then repeated inside the ward, and once again after a 20-min rest in the ward.

To test the importance of soaking in the customary soaking and Vaseline treatment. The first tests were made in the morning at five specific skin sites: on the dorsum of the feet, medially and laterally on the heels, and medially and laterally just above the ankles. One foot was then put in a bucket of water (without soap), immersing over half the lower leg. At the same time the selected sites of the other foot were rubbed with Vaseline. The coating had to be fairly thick, since a thin one was not reliably effective in retaining moisture for the required length of time. After 20 min, the soaking was discontinued, excess water wiped off, and Vaseline rubbed over the appropriate sites. The patients were allowed to move about but told to be careful with the treated areas.

After 4 hr the humidity tests were made again. By means of a wooden spatula the Vaseline was scraped off the corresponding marked-out sites in order. Great care was

devoted to performing the scraping in a uniform way on both sides. The test was made immediately after each site was cleaned. In order to prevent invisible organic disorders from causing misleading readings if only one foot was soaked, the procedure was repeated on another day with soaking of the other foot.

To test the efficiency of ordinary adhesive tape (Molnlycke Company, S-43501 Molnlycke, Sweden) **and a latex sock** (Nolato Company, S-26093 Torekov, Sweden) **in treating dry skin** (Fig. 2). How rapidly did the skin humidity increase after application of the zinc tape?

On the lateral side of the one lower leg, five pieces of tape (5 cm × 5 cm) were applied one below the other after the different sites had first been tested for humidity. The tape pieces then were removed at 2-min intervals; the last one had then been on for 10 min. Immediately after each piece of tape was removed the humidity test was carried out again.

How long did the skin humidity continue to increase after application of zinc tape?

First, four sites one below the other were tested in the lateral side of both lower legs. Then pieces of zinc tape (5 cm × 5 cm) were applied to all four sites of one lower leg. After 1 hr, the first piece of tape was removed and the hydration of the skin immediately tested. The other pieces of tape were removed at 1-hr intervals. After each test of the taped lower leg, the corresponding site of the control leg was tested.

How much does zinc tape increase the skin humidity in comparison with soaking of a lower leg?

First, humidity tests were performed on both legs on marked sites of the dorsal surface of the foot, the medial side of the heel, and the medial side just above the ankle. Then three pieces of zinc tape (5 cm × 5 cm) were applied on the appropriate sites of one leg while, at the same time, the other leg was placed in a bucket of water (without soap) for 20 min. After excess water was wiped off, the tests were performed again, first on the soaked sites to minimize their evaporation loss, before the taped sites were tested.

How effective is a latex sock in increasing the skin humidity in comparison with zinc tape?

Both feet were tested on the plantar areas of the forefoot and the heel and on the medial and lateral sides of the heel. Then a latex sock was applied on one foot and four pieces of zinc tape (5 cm × 5 cm) on the marked sites of the other. After 2 hr, the hydration of the skin was tested in the corresponding sites.

RESULTS

Table 1 shows that areas with and without sensation had very much the same humidity both at the beginning and at the end of the test, while the sweat glands were inactive. Sun exposure accompanied by sweating brought about a substantial rise in the humidity. Also the anesthetic areas without sweating showed a marked increase of the one-minute relative evaporation.

In Table 2 both feet were treated one time with soaking and Vaseline rubbing, and the next time with Vaseline rubbing alone. It was interesting to find that Vaseline rubbing alone effected a slightly superior hydration of both feet. Thus soaking was not an important component of the treatment.

Zinc tape application for 10 min more than doubled the one-minute relative evaporation. A 20-min application resulted in equal hydration with soaking for the same period of time. Within 2 hr of application the skin humidity ceased to increase and saturation occurred. The latex sock was as efficient as the zinc tape to increase skin humidity and thus to treat dry skin. After 2 hr it had effected about a fivefold rise in the one-minute relative evaporation.

TABLE 1. *One-minute relative evaporation (OMRE) in areas with and without sensation for 11 patients.*

	Area with sensation			Area without sensation		
	Median	Mean	S.D.	Median	Mean	S.D.
Before sun exposure	6.0	7.0	2.0	6.0	6.2	2.1
After sun exposure	25.0	24.4	9.4	9.0	8.5	2.3
20 min later	6.0	6.4	0.8	7.0	6.9	1.9

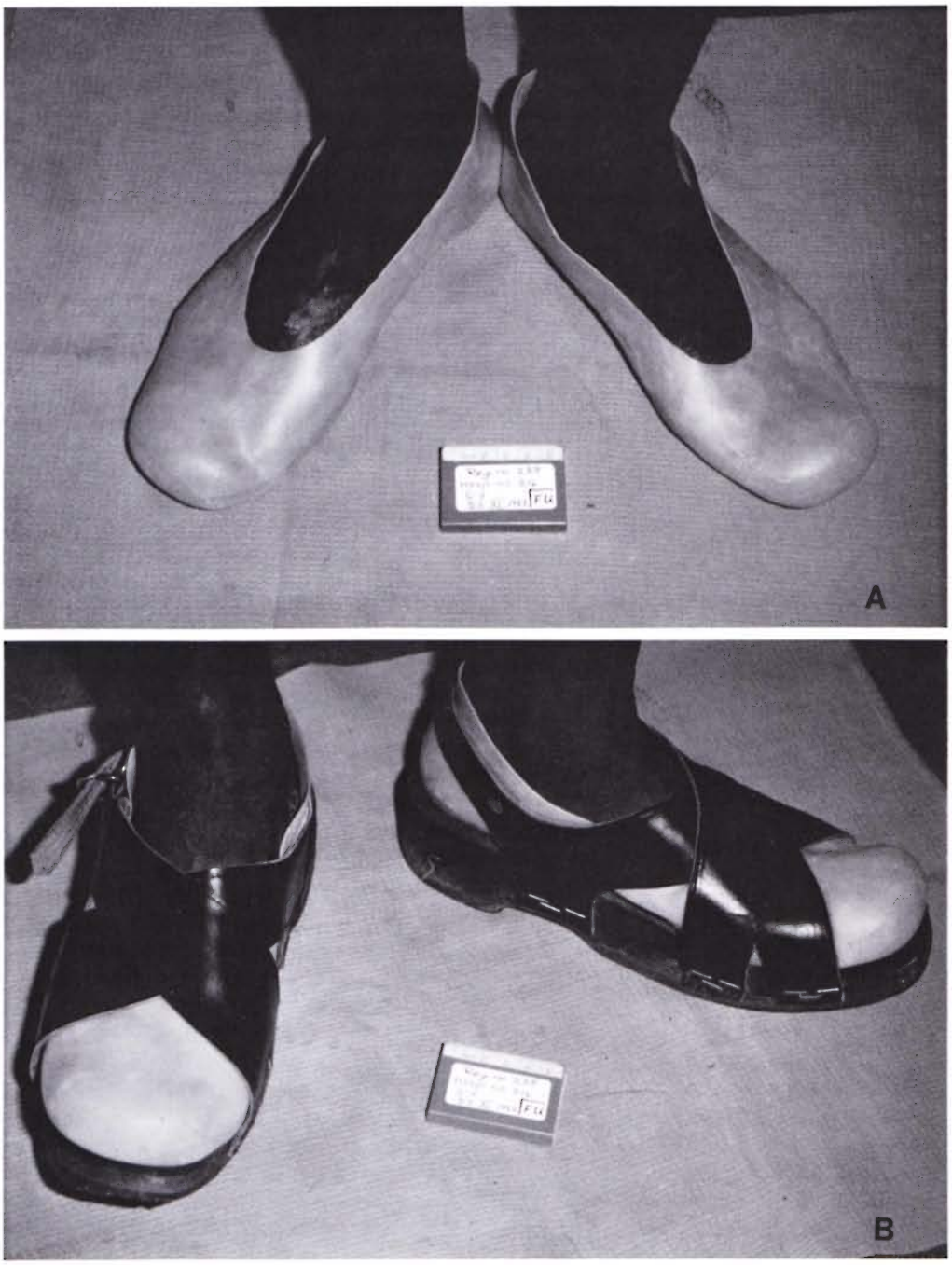

FIG. 2. (A) Latex socks keep their shape without any filling and therefore missing toes are concealed. (B) They go well with chappals, here with rigid (wooden) sole and "rocking" bottom.

TABLE 2. *One-minute relative evaporation (OMRE) after soaking and Vaseline rubbing of one foot and after Vaseline rubbing alone of the other for ten patients.*

	Soaking and Vaseline			Vaseline alone		
	Median	Mean	S.D.	Median	Mean	S.D.
Before treatment	5.5	6.1	2.3	6.5	5.7	2.1
After treatment	16.5	16.2	7.4	16.5	18.2	8.3
Before treatment[a]	4.0	4.5	2.0	4.0	4.6	1.7
After treatment[a]	12.5	12.7	8.3	12.5	13.6	6.8

[a] Contralateral foot in same patients.

DISCUSSION

Transepidermal water loss is a diffusion process and the rate of it depends, among other things, upon the relative humidity of the ambient air, the air temperature, the wind velocity, and the skin temperature. Since all of these changed from day to day, and even within the same day in the field conditions under which the study was made, no absolute values were taken into account; this was only a comparative evaporation study.

At the beginning of this paper, it was taken for granted that patients with a partial loss of sensation would have varied skin humidity in areas with and without residual sweating capacity. This was not confirmed for periods when the sweat glands were inactive. Instead, quite surprisingly, there was great conformity. Sweating by sun exposure, of course, brought about a great rise in the one-minute relative evaporation, but areas without sweating also showed a considerable increase. The fact that the elevated readings, even after only a short rest indoors, dropped to approximately the equal starting point indicated that the sweating had no obvious residual effect. A similar fall in the elevated humidity was observed after soaking, when no Vaseline rubbing followed.

Thus the significance of sweating in the humidity of the skin appears to be somewhat exaggerated. Perhaps more attention should be paid to the skin lipids which control the moisture loss. The intercellular lipids of the stratum corneum not only maintain the cellular adhesion but also have a great influence on the water permeability ([8]). The skin surface lipids are derived both from the sebaceous glands (under endocrine control) and from the keratinizing epidermis ([2]). The contribution of the sebaceous glands in this matter of hydration is open to discussion. Normally, there are no such glands on the palms and soles, and they are found only sparsely on the dorsal surfaces of the hand and foot. Furthermore, they are undeveloped in the prepubertal child and yet the epidermis is smooth and flexible ([3]). In any case, the skin surface lipids are reduced or removed by frequent and prolonged baths and detergents increase their destruction ([10]). Hypertonic salt soaks have no role in the management of anesthetic feet without ulcers. The sole becomes dry instead of supple ([6]). If the water content of the stratum corneum drops below 10% by weight, the layer becomes brittle, cracks easily, and allows potential irritants, such as soap and detergents, to penetrate it in increased amounts. The resulting mild inflammation then impairs maturation and chapping occurs ([3]). Our leprosy patients generally show the most striking dry skin in the feet and lower part of the lower legs, areas which we obstinately continue to soak. How much of the dryness is a consequence of our treatment?

Evidently frequent foot soaks can be harmful. This study, in addition, has shown that there are no rational grounds for their use. Vaseline rubbing alone gives as much hydration as soaking and Vaseline rubbing together. It is said that Vaseline or oil is not a treatment for dry skin, it is water it needs ([1]). This is true, if one realizes that water also comes from the inside, the insensible perspiration. Vaseline traps this just as well as it traps the water soaked into the skin. A disadvantage of Vaseline is that the effect is of short duration.

For limited areas, a more lasting effect can be achieved by applying zinc oxide adhesive tape. It is excellent for hydration of the soles and for the elimination of deep cracks (Figs. 3 and 4). The zinc tape is also very useful for the treatment of ulcers in leprosy patients (Fig. 5). The scars left after zinc tape treatment are remarkably smooth

FIG. 3. Multiple cracks on both feet. One foot was treated with zinc oxide tape and made perfectly smooth, soft, and clean in a couple of weeks.

and soft and have little tendency to shrink. In animal experiments, this was attributed to the fact that the collagen fibrils were especially thin and had a very regular course (9). The hydration caused by the tape is a contributing factor to the softness and pliability. It is good practice, therefore, to keep plantar scars continuously covered by a piece of tape, particularly in areas with marked strain, for instance, in the flexion crease of the big toe. (In this study a Swedish adhesive tape was employed but any other good zinc oxide tape may be equally useful.)

The ideal thing for a more permanent restoration of the humidity of the skin would, of course, be if we could equip the most exposed foot areas, the soles and the margins of the soles, with a thin, waterproof covering of some suitable material. Such a covering would also be indicated for another important reason, namely, protection. Although we are well aware that anesthetic soles are defenseless against external injuries, we are surprised to see how roughly treated they actually are. A waterproof "extra skin" would ward off a lot of unnecessary lesions. Prevention is better than cure, and the cost may turn out to be a paying investment. Our patients almost always are discharged before their ulcers are completely or adequately healed. At home, even if they are wearing their chappals (sandals) constantly during the day, they are in the habit of taking them off in the evenings and going barefoot. Gross soiling and recurrence of ulcers are almost unavoidable. A thin, protective covering could prevent this and make an otherwise costly and troublesome treatment lasting and worthwhile.

The low latex socks we have on trial are an attempt to realize the need for such an "extra skin" (Fig. 2). In the daytime they can be used with chappals, and in the evening they can be used alone, since the sole is 2 mm thick and the material is very durable. The socks should be cleaned once a day by simple rinsing. They should be worn only by patients with complete loss of sensation of their soles. Patients with partial loss may suffer maceration.

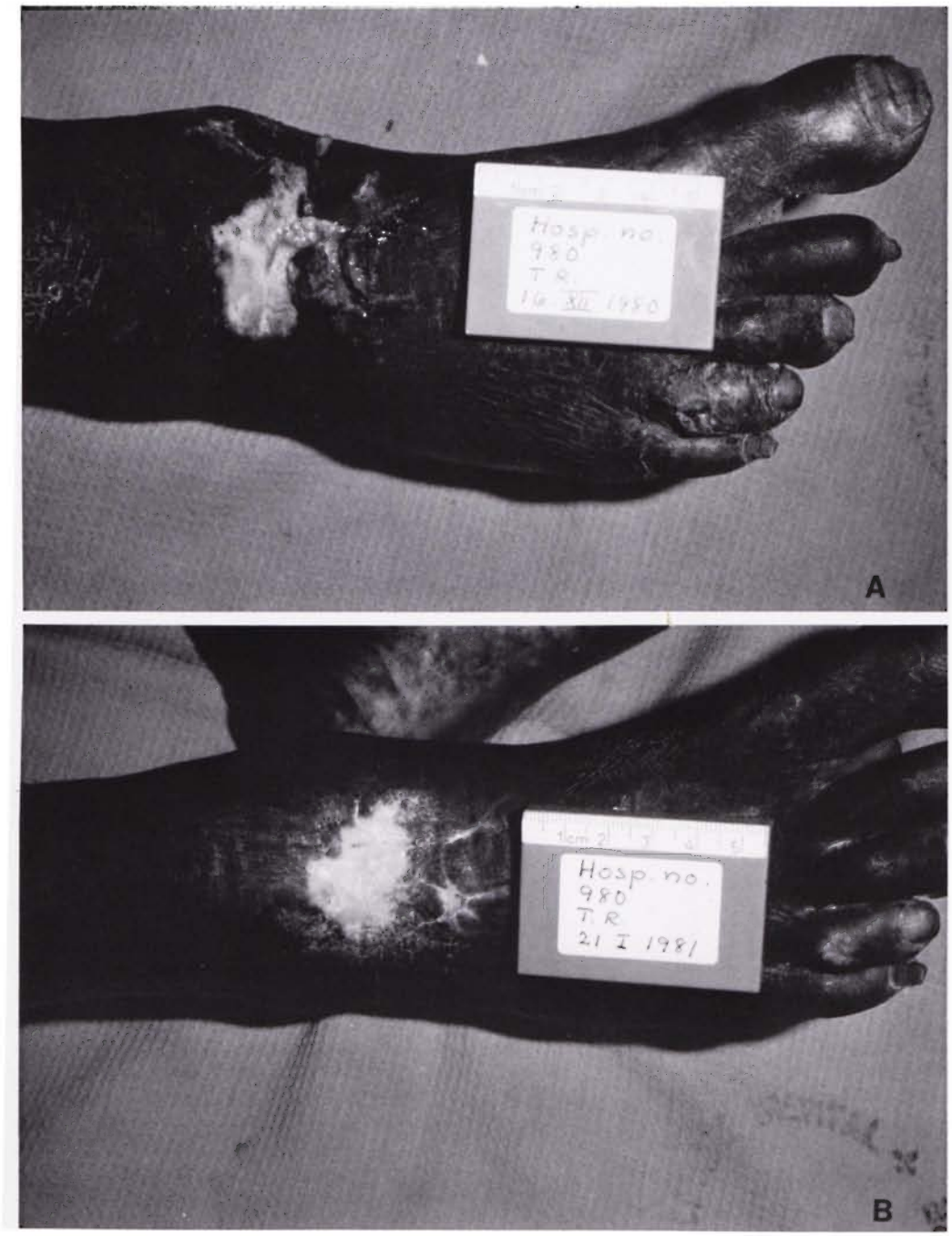

FIG. 4. Deep cracks on the ankle region (A) before and (B) after treatment with zinc oxide tape. Healing occurred in five weeks.

SUMMARY

The Vaisala Humicap humidity meter was used to estimate the moisture of the skin. The one-minute relative evaporation (OMRE) was regarded as a manifestation of the skin humidity and assessed in areas with and without sensation. When the sweat glands were inactive, the humidity on the

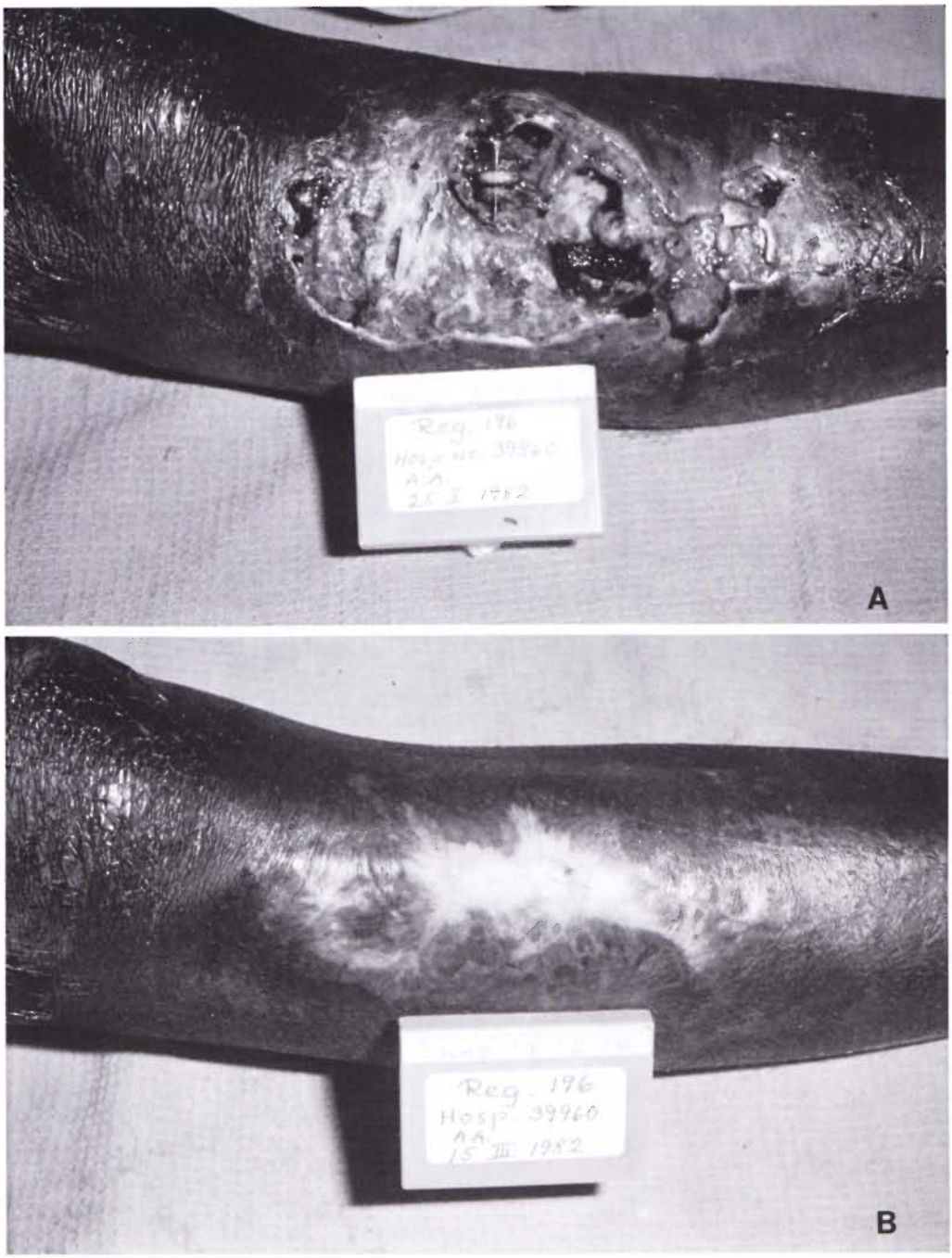

FIG. 5. Deep burn on one lower leg (A) before treatment with a zinc oxide tape (a lone maggot is all that remained of a large colony) and (B) after healing in seven weeks. The scar left was noticeably soft with good appearance.

whole was the same in both areas. After they were activated by sun exposure, there was a great rise in humidity in the sweating areas, but the nonsweating areas also had a marked increase. However, after 20 minutes' rest indoors, the patients' humidity returned from the increased level to the level before sun exposure.

Soaking the feet, followed by Vaseline rubbing, did not give more hydration than Vaseline rubbing alone. Thus foot soaks have no rational basis for restoring dry skin to normal. Application of ordinary zinc oxide adhesive tape, on the other hand, proved to be a very effective way to hydrate the skin, but for practical use only in limited areas. The urgent need of an "extra skin" for the soles and margins of the soles was stressed for two vital reasons: to prevent dryness and to provide protection.

RESUMEN

Se usó el medidor de humedad Vaisala Humicap para calcular el grado de humedad de la piel. La evaporación relativa por minuto se consideró como una manifestación de la humedad de la piel y se midió en áreas con y sin anestesia. Cuando las glándulas sudoríporas fueron inactivas la humedad global fue la misma en ambas áreas. Cuando se activó la función glandular por exposición al sol, ocurrió un gran incremento en la humedad en las áreas de sudoración, pero también hubo un marcado incremento en las áreas de no sudoración. Sin embargo, después de 20 minutos de reposo a la sombra, la humedad de los pacientes regresó del nivel incrementado al nivel previo a la exposición al sol.

El remojo de los pies, seguido por frotamiento con Vaselina, no dió más hidratación que el frotamiento con Vaselina sólo. Así, el remojo de los pies no tiene una base racional para restaurar la sequedad de la piel a lo normal. Por otro lado, la aplicación de cinta adhesiva con óxido de zinc ordinaria, demostró ser una forma muy efectiva para hidratar la piel, aunque de aplicación práctica limitada a ciertas áreas. Se señala la urgente necesidad de una "piel extra" para las plantas de los pies y sus márgenes, para evitar la resequedad y para conferir protección.

RÉSUMÉ

On a utilisé l'hygromètre Humicap de Vaisala pour estimer l'humidité de la peau. L'évaporation relative en une minute (OMRE) a été considérée comme la manifestation de l'humidité de la peau, et étudiée dans des zones avec conservation ou perte de la sensibilité. Lorsque les glandes sudoripares étaient inactives, l'humidité dans son ensemble était la même dans les deux zones. Après activation de ces glandes par exposition au soleil, on a constaté une forte augmentation de l'humidité dans les zones sudoripares, mais les zones non-sudoripares présentaient également une augmentation marquée. Toutefois, après 20 minutes de repos à l'intérieur, l'humidité des malades retournait au niveau constaté avant l'exposition au soleil.

Le fait de tremper les pieds, et de les frotter ensuite avec de la vaseline, n'a pas entraîné une plus grande humidité que l'application de vaseline seule. Dès lors, on peut conclure que le fait de tremper les pieds ne constitue pas une base rationnelle pour restaurer une peau sèche à des fonctions normales. L'application d'un ruban adhésif ordinaire d'oxyde de zinc, sur la main contra latérale, s'est révélée une méthode fort efficace pour humidifier la peau, mais d'utilisation pratique restreinte à des zones limitées. On souligne le besoin urgent d'une peau supplémentaire (extra skin) pour la plante des pieds et les bords de cette plante, est aussi pour deux raisons vitales: pour prévenir de la sécheresse, et pour assurer la protection.

Acknowledgments. I wish to express my gratitude to the Baptist Union of Sweden for sponsoring this study; to my wife Margot, for patient and skillful technical assistance; to Miss Heather Payne, for excellent revision of my English, and to Mr. Magnus Jacobsson, for the statistics.

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