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INFLUENCE OF HUMIDITY ON ULTRAVIOLET INJURY

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High humidity enhances the injurious effect of ultraviolet radiation. This was demonstrated in experiments in which hairless mice were irradiated with Westinghouse FS-40-T-12 sunlamps while maintained in an environmental chamber allowing controlled conditions of relative humidity and temperature. Hairless mice given 10 MED (minimal erythemal dose) while maintained at 80% relative humidity had markedly greater exfoliation, crusting, and erosion of skin than did mice maintained at 5% and 10% relative humidity. Animals kept at 50% humidity had damage intermediate to those kept at high and low humidity. These morphologic observations were confirmed histologically.

Additionally, water immersion enhances ultraviolet injury. Animals immersed in water for 6 hr prior to irradiation with 3 MED had more damage than animals irradiated but not immersed. Similarly, albino rabbits irradiated with 300 nm radiation from a xenon arc grating monochrometer had lower erythemal energy requirements on that part of their skin that had been hydrated with wet packs compared to nonhydrated skin.

Considerable effort has been devoted to the study of the adverse effects of ultraviolet light. The role of environmental factors such as heat, wind, and humidity in ultraviolet injury have been largely ignored. Previous work from our department [1,2] has shown that heat and wind have an adverse effect on ultraviolet injury. This report describes the influence of humidity, water immersion, and wet packs on acute ultraviolet damage.

MATERIALS AND METHODS

Environmental Chamber Studies

A previously described environmental chamber [2] was utilized. The chamber allowed housing of young adult male and female hairless mice under controlled conditions of temperature and humidity while they received ultraviolet irradiation from Westinghouse FS-40-T-12 sunlamps, mounted within the chamber 30 cm from the skin surface. During exposure, the animals remained in a cage with top and sides of ½ inch wire mesh. They were given water and laboratory chow ad libitum. In all experiments, the chamber temperature was maintained at 35°C without wind flow.

Several experiments were performed which are summarized in Table 1. Comparisons of ultraviolet damage were made between animals maintained at high, mid, and low humidities. In the first experiment, 12 hairless mice were maintained for 96 hr in the chamber at 80% relative humidity, then irradiated with 10 MED (minimal erythemal dose) from the sunlamp (1 MED = 275 mJ/cm²). Following irradiation, the animals were maintained in the chamber under the same conditions for 72 hr and observed for damage. The chamber was then allowed to adjust to 5% humidity and 12 hairless mice were kept for 96 hr and then irradiated with 10 MED.

A second experiment was performed in a similar fashion but, additionally, a group of animals kept at mid humidity (50%) was studied.

In a third experiment, a more moderate dose of ultraviolet was used (3 MED) and comparisons were made between animals kept at high and low humidity.

A group of animals totally immersed in water for 6 hr, then irradiated with 3 MED in the chamber at 80% humidity were compared to the animals given the same irradiation at high and low humidities. Control animals maintained at 80% and 10% relative humidity, but not irradiated, were observed for skin changes.

Influence of Hydration on MED Determinations

Male and female adult albino rabbits were depilated (Surgex depilatory, Crookes-Barnes Laboratories, Inc., Wayne, N. J.) 24 hr prior to irradiation with serially increasing amounts (from 2 to 20 mJ/cm² at 2 mJ/cm² increments) of ultraviolet at 300 nm emitted from a high-pressure xenon arc grating monochromator. The MED was determined in 7 animals whose abdomens were treated on one side with wet packs (tap water) for 4 hr prior to irradiation; the nonhydrated irradiated side served as the control. The irradiated sites were examined at 24 hr for erythema.

RESULTS

All animals from both high-humidity and low-humidity groups show erythema at or before 24 hr post irradiation. We found it difficult to numerically grade differences in erythema between animals in a single experiment or between animals in different experiments.

However, by 72 hr, differences in damage were maximal with the high-humidity groups from experiments 1 and 2 having prominent exfoliation,

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crusting, and erosion of skin, and the low-humidity groups having much less visible damage (Fig. 1). These observations were confirmed by histologic study (Fig. 2). The mid-humidity animals had distinctly less scaling and crusting than the high-humidity group, but more than the low-humidity group.

The only animals who died were from the high-humidity groups that received 10 MED of ultraviolet. Seven of 12 mice from the first experiment, and 5 of 12 mice from the second experiment expired within the week of irradiation, presumably due to acute ultraviolet injury.

Animals in both high-humidity and low-humidity groups sustained only slight skin damage from the lower dose (3 MED) of ultraviolet. There appeared slightly greater damage in the high-humidity mice but this was questionable and not definitive from either a morphologic or histologic standpoint. Of interest, however, was the finding that animals immersed in water for 6 hr prior to

TABLE I. *Environmental chamber studies*

Experiment	Number of Mice (per group)	MED	Humidities
1	12	10	80%, 5%
2	12	10	80%, 50%, 10%
3	12	3	80%, 10%
	6	3	water immersion

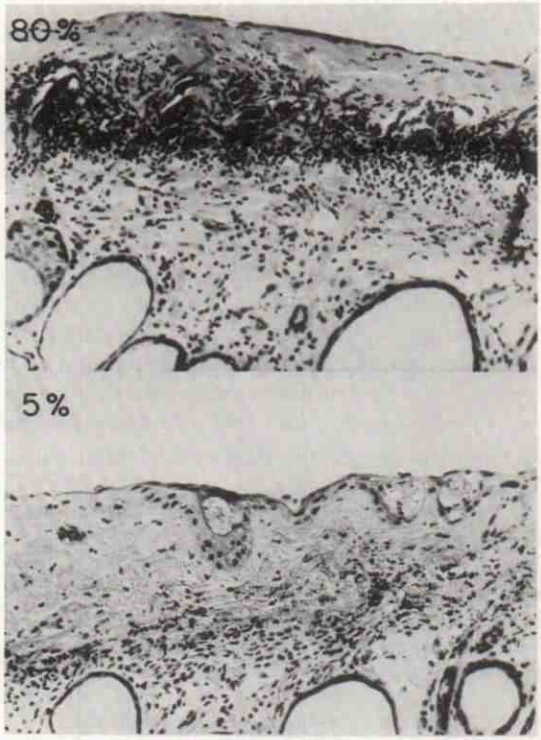

FIG. 2. Biopsies from mice 72 hr after irradiation with 10 MED at 80% relative humidity (*top*), and 5% humidity (*bottom*) (× 160).

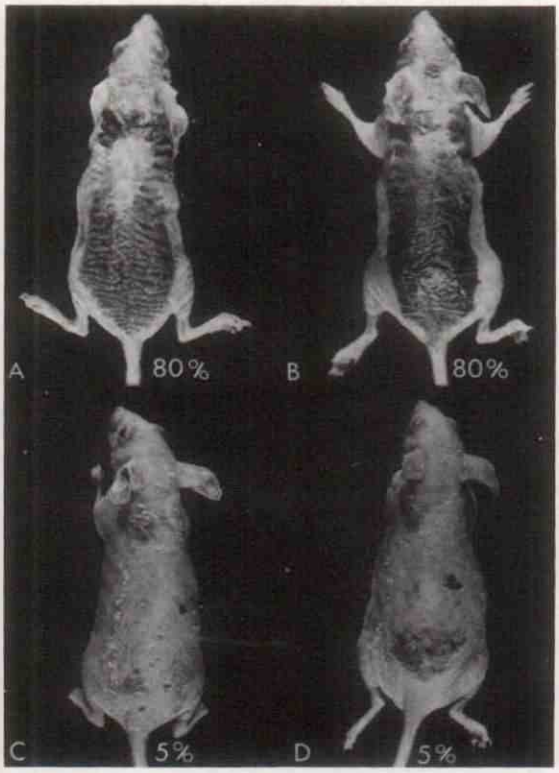

FIG. 1. Mice 72 hr after irradiation with 10 MED while maintained at 80% relative humidity (*top*), and 5% humidity (*bottom*).

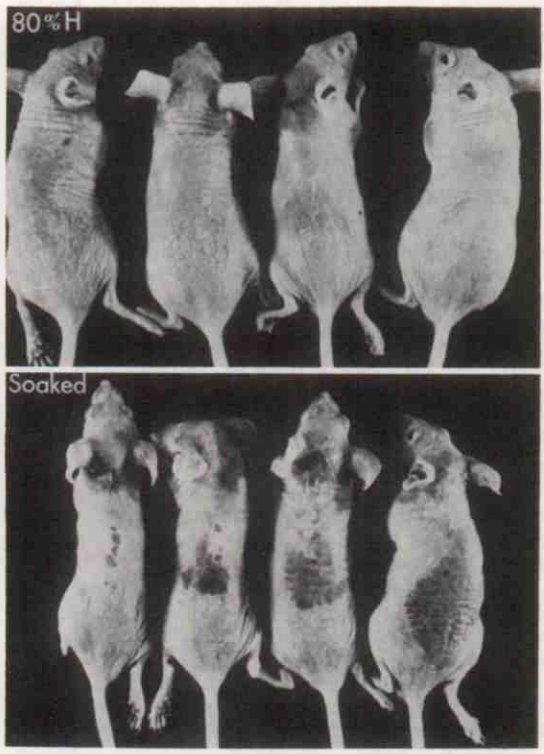

FIG. 3. Mice 72 hr after irradiation with 3 MED while maintained at 80% relative humidity (*top*), and after immersion in water (*bottom*).

TABLE II. *MED determination in hydrated and dry rabbit skin*

Animal Number	Hydrated	Dry
1	4mJ/cm²	6 mJ/cm²
2	4 "	6 "
3	6 "	10 "
4	6 "	8 "
5	6 "	10 "
6	6 "	8 "
7	6 "	8 "
	Mean 5.4	Mean 8.0
	Standard error 0.369	Standard error 0.617

receiving the same ultraviolet dose (3 MED) had marked skin damage (Fig. 3).

Differences were not seen between unirradiated control animals kept at high and low humidities.

In the MED studies with the monochromator, each of the 7 albino rabbits had lower energy requirements for erythema production on the hydrated side of their abdomens (Tab. II). The differences are statistically significant with $p < 0.01$.

DISCUSSION

Our studies demonstrate that increasing humidity, water immersion, and application of wet packs intensify acute ultraviolet-induced skin damage, suggesting that these influences should be considered in any biologic experiment on ultraviolet injury.

As shown in the environmental chamber, experimental mice maintained at high humidity and given 10 MED of ultraviolet had more marked skin damage than did those maintained at low humidity. Animals maintained at mid humidity had skin damage intermediate between those kept at high and low humidity.

Among animals exposed to lower amounts of ultraviolet (3 MED), changes were difficult to visualize between the high-humidity and low-humidity groups. Interestingly, in mice whose bodies were hydrated by immersion in water, the lower dose of ultraviolet promoted marked skin damage.

Similarly, MED determinations in rabbits showed that hydrated skin had less energy requirements for erythema production than did nonhydrated skin.

One can only speculate on the mechanism of humidity in these experiments. Harber and Baer [3] showed a marked augmentation of the phototoxic reaction to topically applied 8-methoxypsoralen at high humidity. Although they attributed the effect to increased percutaneous absorption of the compound, our observations on the effect of humidity and ultraviolet alone may partially explain their findings. Blum and Terus [4] stated that in 5 trials application of water to skin during sun exposure did not significantly effect the erythemal threshhold, while Cattano [5] concluded that application of plastic occlusive dressings made the skin become more sensitive to sunlight. Kahn [6], in discussing Cattano's article, reported a lower MED in two subjects whose arms had been immersed in water prior to irradiation. It might be proposed that hydration of stratum corneum allows penetration of light that is normally scattered and reflected.

We are not equating increased relative humidity, water immersion, and wet compresses as the same phenomena. It is possible that they each potentiated ultraviolet injury by different mechanisms. They were selected because each is a way of exposing experimental animals to moisture.

Of clinical importance is that wet skin burns more easily than dry skin. This may offer an explanation to concerned patients who burn easily as they swim or perspire while pursuing outdoor activities.

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