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Change of Skin Roughness due to Lowering Air Humidity in a Climate Chamber

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Rough skin ("dry skin") is characteristic of atopy and thought to be a pre-stage of atopic eczema. Atopic eczema frequently deteriorates in winter, which may be related to low air humidity during the heating period. We have assessed skin roughness before and after decreasing air humidity to 30% in a climatic chamber. Replicas of clinically non-inflamed and not scaling skin from 10 patients with atopic eczema and 10 controls were taken before and after lowering air humidity for 3 h and were analyzed for the roughness parameters R_a, $R_{Z\,DIN}$ and $R_{Z\,ISO}$. After exposure to low air humidity there was a significant increase of $R_{Z\,DIN}$ from 61.5 µm to 66.9 µm ($p<0.05$) and of $R_{Z\,ISO}$ from 63.8 µm to 66.4 µm ($p<0.05$) in patients with atopic eczema, whereas no significant change occurred in controls. Development of skin roughness over 3 h under natural indoor environmental conditions did not indicate spontaneous variations. These quantitative data show that a short period of exposure to low air humidity increases skin roughness and may particularly influence the condition of patients with atopic eczema. ***Key words: atopic eczema; skin profilometry; skin surface; "dry" skin.***

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Atopic eczema is one of the most common skin diseases. It especially affects children and adolescents; the life time prevalence in this age group is above 10%. Atopic eczema is characterized by chronic or chronically relapsing, intensely pruritic, typically distributed eczematous skin lesions. The etiopathogenesis of atopic eczema has not yet been elucidated (1).

"Dry skin" is regarded as a pre-stage or even a mild form of atopic eczema (2–8). The "dry" feel of atopic skin is due to a rough surface pattern (9). This roughness corresponds to a change in the skin surface, from normally regular major and minor furrows into an irregular and coarse pattern (3).

There are clear seasonal influences on the course of atopic eczema (10). Atopic eczema frequently deteriorates during the winter season. A higher morbidity during the winter months has been found to be closely related to seasonal variations in skin moisture. A low relative air humidity indoors during the heating period may contribute to this (11).

By the use of a climate chamber we assessed the effect of a decrease of air humidity on skin roughness of patients with atopic eczema and controls. The surface topography of the skin was quantitatively recorded by a profilometry method.

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MATERIAL AND METHODS

Study population

The study population evaluated in the climate chamber comprised 10 patients (5 males, 5 females; mean age 26±7.3 years) affected by atopic eczema (12) and 10 controls (5 males, 5 females; mean age 25±2.4 years) without any indications of prior or present atopic disease (atopic eczema, rhinitis allergica, allergic asthma) and without prick test reactions to three common aeroallergens (housedust mite, grass pollen, cat epithelia). Additional measurements of skin roughness were made in 5 individuals (2 males, 3 females; mean age 28±4.3 years) exposed to natural indoor environmental conditions. Informed consent was obtained from all participants.

Exposure

The test persons stayed in a climate chamber at 22°C and 75% air humidity for 2 h. Air humidity was then lowered to 30% whilst temperature was kept at 22°C and exposure was continued for another 3 h (Fig. 1). In control experiments individuals stayed indoors for 3 h under unchanged natural environmental conditions.

Skin replicas

Before lowering relative air humidity to 30% and after another 3 h of exposure, replicas were taken from the middle of both volar forearms with silicone rubber dental impression material (Permadyne Garant, ESPE, Seefeld, Germany) at identical sites of the surface of non-inflamed and not scaling skin not covered by clothing. The skin area was marked and a thin layer of the impression material was applied to the surface with a commercially available "pistol", which mixes the two components of the material automatically free of bubbles or artefacts. The cured impression material was lifted from the skin after about 5 min. The orientation of the replica with regard to the arm axis was marked, and the replica was put in a plastic bag to avoid desiccation. Measurements were made within 24 h after application of the impression material.

Skin profilometry

A standard stylus profilometer (Hommel Tester T20S, Hommel-Werke, Villingen-Schwenningen, Germany) was used to assess the negative replicas. With this instrument, profiles of the skin's surface are obtained by tracing the surface of a skin replica with a stylus

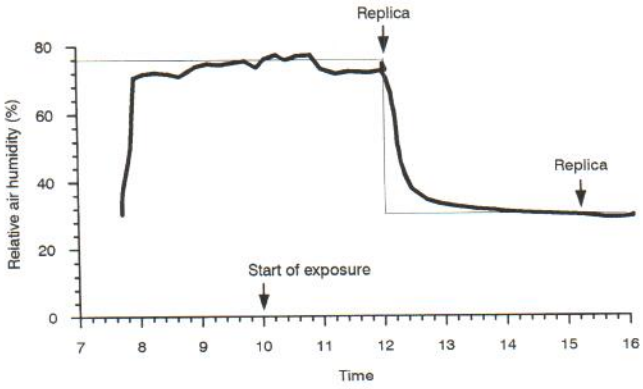

Fig. 1. Air humidity in the climate chamber.

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instrument. As the stylus is moved across the replica's surface, its vertical motion is converted into electrical signals. Positive casts are not necessary, since the instrument can invert the profile.

The scan length was 4.8 mm, the cut-off for filtering the waviness profile 0.8 mm. For each test site we performed 12 scans, which ran radially from the central point every 30 degrees. The data were recorded and processed electronically to yield the following roughness parameters (International ISO Standards):

R_a: the arithmetic mean roughness value, i.e. the arithmetic average value of the filtered roughness profile determined from deviations about the centre line within the evaluation length;

$R_{z\,DIN}$: the mean peak-to-valley height, i.e. the arithmetic average maximum peak-to-valley height of roughness value Z_1 to Z_5 of five consecutive sampling lengths over the filtered roughness profile;

$R_{z\,ISO}$: the ten-point height, i.e. the average height difference between the five highest peaks and five lowest valleys contained within a chosen evaluation length.

The surface roughness parameters were first calculated for each individual profile trace; afterwards, the medians of the 24 traces of the replicas of the left and right forearm were calculated.

Statistics

Wilcoxon's test for paired or unpaired comparisons was used to evaluate the change of roughness parameters during the test period or to determine differences between patients with AE and controls. The level of significance was chosen at 5% ($p<0.05$).

RESULTS

The individual median values for the parameters R_a, $R_{z\,DIN}$ and $R_{z\,ISO}$ before lowering relative air humidity to 30% and after another 3 h of exposure in the climate chamber are shown in Fig. 2. In patients with atopic eczema, statistically significant differences were found for $R_{z\,ISO}$ (medians: 63.8 µm vs. 66.4 µm) and $R_{z\,DIN}$ (medians: 61.5 µm vs. 66.9 µm), but not for R_a (medians: 14.1 µm vs. 14.4 µm). In controls all roughness parameters evaluated also increased but did not change significantly (medians: R_a: 14.3 µm vs. 15.5 µm; $R_{z\,ISO}$: 63.9 µm vs. 67.8 µm; $R_{z\,DIN}$: 62.8 µm vs. 66.8 µm). There were no significant differences of any roughness parameters between patients with atopic eczema and controls at any timepoint of measurement. The roughness parameters before and 3 h after exposure to indoor natural environmental conditions were not significantly different (medians: R_a: 15.5 µm vs. 15.5 µm; $R_{z\,ISO}$: 70.5 µm vs. 69.5 µm; $R_{z\,DIN}$: 68.0 µm vs. 68.0 µm).

DISCUSSION

In this study, we have investigated the influence on skin roughness of a short period of exposure to low relative air humidity of 30%. Within 3 h of staying at lowered air humidity a significant increase of skin roughness in patients with atopic eczema was demonstrable. Controls showed a tendency of increased skin roughness under these conditions in the climate chamber. The results of control measurements in individuals under natural indoor environmental conditions did not indicate any spontaneous change of skin roughness during 3 h.

Atopics and controls did not differ significantly with regard to roughness parameters, which is in accordance with another study showing the same results for roughness parameters of healthy skin of atopic eczema patients and controls under natural environmental conditions (13). In contrast, investigations on "dry" skin of atopic eczema patients, defined as a

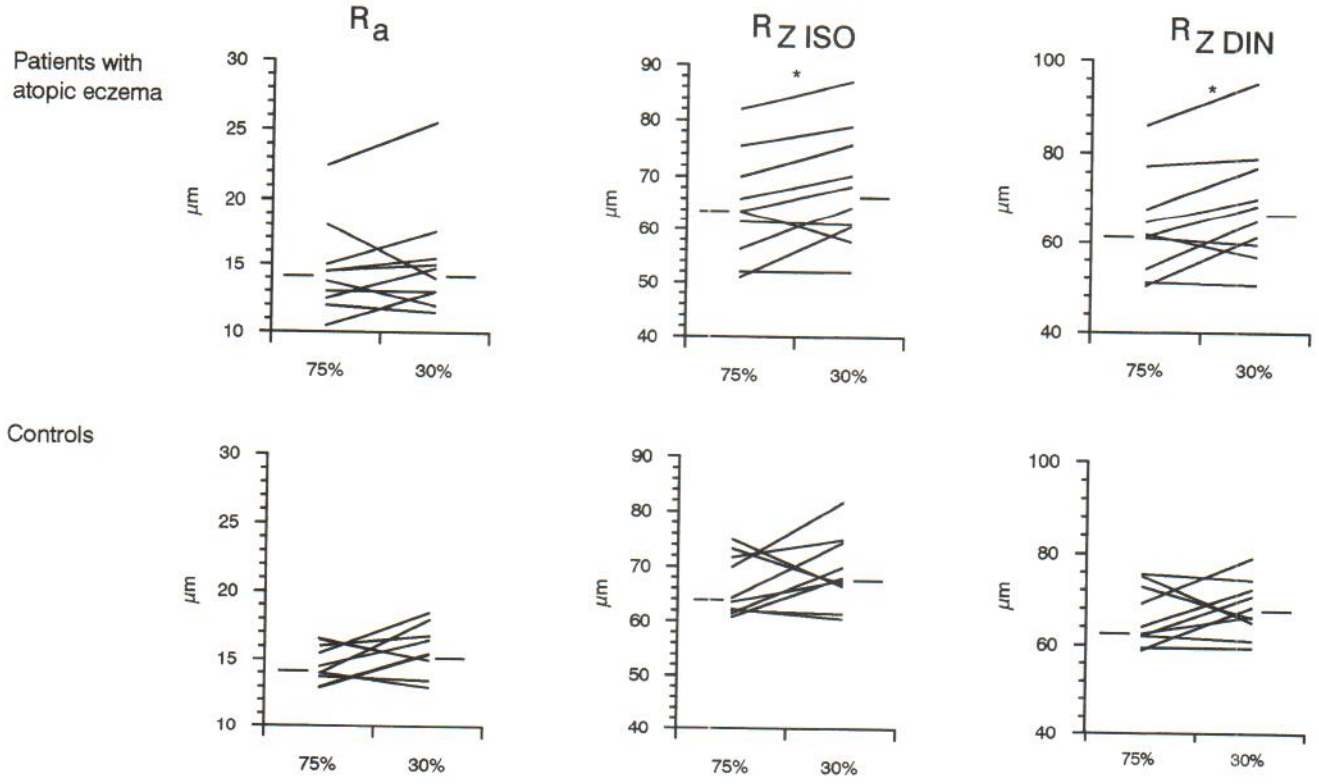

Fig. 2. Skin roughness parameters R_a, $R_{z\,ISO}$, $R_{z\,DIN}$ in patients with atopic eczema ($n=10$) or controls ($n=10$) before and after exposure to low relative air humidity. $*p<0.05$; —=median.

rough, finely scaling, non-inflamed skin surface, yielded elevated roughness parameters when compared with controls (9). Changes of the skin surface topography as an effect of treatment with skin care products, that is transition from the "rough" surface pattern to a pattern of non-rough skin, can be shown readily by means of profilometry, demonstrating the potential of the method (14, 15).

It is well known that there are seasonal changes in the course of atopic eczema, many patients having a tendency to deteriorate in winter and to improve in summer. Amelioration in the summer may be due to increased sebum and sweat secretion, sun baths, sea bathing or reduced exposure to dust and mold indoors (16); the inverse effect could explain a deterioration in winter. Particularly, it may also be closely related to reduced moisture (17). It has been shown that low environmental humidity due to heating is associated with aggravation of atopic eczema in young patients (11).

In our study we were able to show quantitatively that only a short period of low air humidity can increase skin roughness in patients with atopic eczema. As the roughness level of 5 persons outside the climate room was higher than at the end of the experiment in the climate chamber the absolute roughness value seems not to indicate a definite clinical state. Nevertheless, these results may be clinically relevant, since daily life would involve a number of repeated exposures adding up to a cumulative effect. As the increase of skin roughness was seen both in patients with atopic eczema and controls, low air humidity is probably one factor contributing to the etiopathogenesis of atopic eczema. Therefore, measures to avoid it or to prevent its sequel, i.e. increased skin roughness, may be worthwhile in the prevention of the disease. Using defined exposures and quantitative assessment of skin roughness, further studies will provide a rational basis to manage this issue.

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