

INVESTIGATIVE REPORT

Transonychia Water Loss in Healthy and Diseased Nails

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The objective of this study was to determine the transonychia water loss (TOWL) in both healthy and affected nails in different diseases and to compare it with the transepidermal water loss (TEWL). TOWL was measured by a new evaporimetric method: Plasticine® was used to fix the protection cover of the evaporimeter probe to the nails. The TOWL behaved contrary to the TEWL. Affected nails in patients with atopic eczema ($p < 0.01$), psoriasis ($p < 0.05$) and onychomycosis ($p < 0.001$) showed a significantly lower TOWL than did nails of healthy test subjects. The decrease in TOWL in diseased nails in comparison to healthy nails could be due to the formation of a stratum granulosum in atopic, psoriatic or fungus-affected nails, as this layer is normally absent in healthy nails. Key words: TOWL; TEWL; skin barrier.

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The structure and the function of the stratum corneum as skin barrier are well described. The low permeability of the stratum corneum is due to its unique morphology, with corneocytes embedded in the extracellular lipid matrix like “bricks and mortar” (1).

The most widely accepted method for measuring barrier function is the determination of transepidermal water loss (TEWL) by evaporimetry (2, 3).

Whereas determination of TEWL is routinely performed for characterizing epidermal barrier function as well as in the study of different therapeutic approaches, only a few investigations have studied transonychia water loss (TOWL). Most of these studies used healthy (4–6) or cadaver nails (7–9).

In the present study TOWL was measured not only in healthy individuals, but also in patients with atopic eczema, psoriasis and onychomycosis. TOWL was compared with TEWL in the same individual.

SUBJECTS AND METHODS

Subjects

The study population comprised 103 subjects (41 males and 62 females; age 16–79 years, median 44 years). As well as 10 healthy individuals (age 20–51 years, median 29 years), the study groups consisted of patients with atopic eczema ($n = 18$; age 17–68 years, median 32 years), psoriasis ($n = 25$; age 24–78 years, median 56 years) and onychomycosis ($n = 50$; age 23–79 years, median 54 years).

The nails of 8 patients with atopic eczema were affected by

longitudinal depressions or a polished appearance. In 10 patients no onychopathy was present.

Psoriatic nail disease was present in 11 patients with psoriasis and consisted of pits, oil spots, onycholysis and longitudinal or transverse depressions. Two patients had coexisting psoriatic and healthy nails, whereas 12 further patients in this group had no onychopathy.

All patients with onychomycosis had both involved and uninvolved nails. Mycotic nails showed transverse depressions, a yellow discoloration, deformation and subungual hyperkeratosis. The diagnosis was proven mycologically.

Healthy individuals were characterized by the absence of skin disease and onychopathy.

Measurement of transonychia and transepidermal water loss

TOWL and TEWL were measured using the Servo Med EPI® (Stockholm, Sweden) evaporimeter (10), following the guidelines from a working group of the ESCD (11). While the measurement was being taken, only the examiner and the test subject were present in the measuring room, with the door closed. The mean ambient air humidity was 29%. To avoid air convection, a Perspex box with an open top was used, which was covered with a cloth. The box had two holes for the examiner's and the subject's hand. The probe protection cover without a screen and grid was used for every measurement.

In addition to the protection cover, Plasticine® was applied to measure the TOWL. A small amount of Plasticine was placed around the aperture of the protection cover, which was stuck to the fingernail of the test subject. The use of Plasticine did not reduce the aperture area of the probe. After a person had put his/her hand into the box, the examiner introduced the probe carefully into the protection cover and held the probe by hand during the measurement. The Plasticine connected the probe closely with the nail plate, so that no water vapour escaped under the probe.

Four fingernails in total were examined from each patient. Measurements were performed in triplicate and the mean value of each nail was calculated. To study skin barrier function TEWL was measured on the dorsum of the hand in triplicate.

TEWL was determined in 17 patients with atopic eczema, 23 patients with psoriasis and 10 healthy volunteers. Within the group of patients with atopic eczema the skin of 7 patients was eczematous at the time of the investigation, while in 10 patients the skin was clinically unaffected. In the group with psoriasis 10 patients had affected skin and 13 patients had no skin lesions.

Statistical analysis

For statistical analysis the median values of all healthy and all involved nails from one patient were calculated. Comparisons were made using the Wilcoxon non-parametric test for paired and unpaired variables. For two-tailed tests, differences were considered significant at $p < 0.05$. It was not necessary to make corrections for multiple comparisons, because two groups were never compared with each other more than once.

RESULTS

The results of TEWL and TOWL are shown in Figs. 1 and 2, respectively.

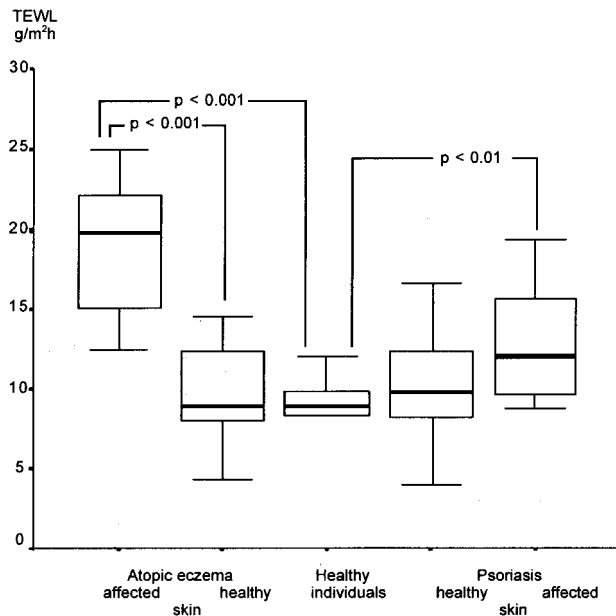


Fig. 1. Transepidermal water loss (TEWL) in healthy individuals and different groups of patients. Significant differences are specified. The boxes include 50% of the values in a group, and their upper and lower borders represent the 75th and 25th percentiles, respectively. The line within the box defines the median, whereas the lines above and below the boxes show the highest and lowest values, respectively.

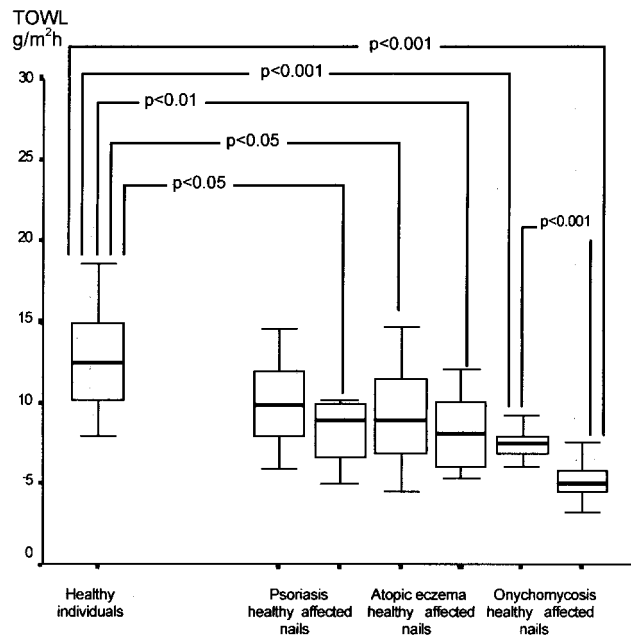


Fig. 2. Transonychia water loss (TOWL) in healthy individuals and different groups of patients. Significant differences are specified. The boxes include 50% of the values in a group, and their upper and lower borders represent the 75th and 25th percentiles, respectively. The line within the box defines the median, whereas the lines above and below the boxes show the highest and lowest values, respectively.

Healthy individuals

The TOWL in healthy individuals was significantly higher (mean 12.9 g/m² per hour) than the TEWL (mean 9.1 g/m² per hour) ($p < 0.01$).

Patients with atopic eczema, psoriasis or onychomycosis

The TOWL of involved nails in patients with atopic eczema, psoriasis and onychomycosis was significantly lower than that of healthy individuals (atopic eczema vs healthy individuals $p < 0.01$; psoriasis vs healthy individuals $p < 0.05$; onychomycosis vs healthy individuals $p < 0.001$) (Fig. 2).

The TOWL of uninvolved nails in atopic eczema ($p < 0.05$) and onychomycosis ($p < 0.001$) was significantly lower than in healthy subjects. The TOWL of uninvolved nails in patients with psoriasis did not differ from that in the healthy subjects.

The involved and uninvolved nails from patients with onychomycosis differed significantly ($p < 0.001$), whereas within the atopic eczema and psoriasis groups the difference was not significant.

DISCUSSION

This study shows that the TOWL of healthy individuals is significantly higher than the corresponding TEWL. In contrast to other investigations comparing TEWL and TOWL, the nail plate and measuring probe were connected with Plasticine. With this new measuring method no water vapour escaped under the capsule. This could contribute to the high TOWL values (in comparison to the TEWL). However, the greater thickness of the nail in comparison to the stratum corneum of the epidermis does not influence water permeability (12, 13).

Similarly to the present results, Jemec et al. (5) found that the median TOWL was slightly (but not significantly) higher than the TEWL from the back of the hand. Baden et al. (14) reported water flux values almost 10 times higher through the nail plate than through the abdominal stratum corneum. Burch & Winsor (7) evaluated the diffusion of water through cadaveric skin and toenails using brass cylinders for the measurements. The rate of diffusion through toenails was about equal to that through palmar and plantar skin.

Jacobi (4) measured the water loss from fingernails and from the skin of the dorsum of the fingers. In 70% the TOWL showed lower values than the TEWL, while in 30% the water loss in both locations was equal. Water loss through the sweat glands was not considered.

The present absolute TOWL values in healthy individuals are lower than those in the literature. In the same range are the results of Spruit (6), Burch & Winsor (7) and Baden et al. (14). The difference can be explained by the different techniques used to determine the TOWL. The TOWL values of Walters et al. (8) are many times greater than the present results and those of other studies (6, 7, 14), because they worked with hydrated and totally immersed nails. It is not possible to compare the present results with those of Jacobi (4), because he did not calculate the absolute quantity of water loss through the nail.

It may be speculated that the structure of dystrophic nails is more similar to that of the skin than to that of healthy nails. This could explain the lower TOWL of dystrophic nails in comparison to healthy nails. Mertin & Lippold (15) and Walters et al. (9) described the healthy nail as a "hydrophilic gel membrane", in contrast to the stratum corneum acting as a hydrophobic barrier. In nail dystrophies such as psoriasis, onychomycosis and atopic eczema, the nail develops a granular layer which is absent in disease-free nails (16). According to Fartasch (17) and Elias & Friend (18), the stratum granulosum

is an important part of the water barrier of the skin, because the lipids responsible for the barrier are secreted in this layer. Therefore, normal skin and dystrophic nails with a granular layer may have a lower water loss than healthy nails without a granular layer.

In this study, the TEWL over lesional skin in patients suffering from psoriasis or atopic eczema was significantly higher than that in healthy subjects. These findings are in accordance with the results of other groups measuring TEWL in atopic eczema (19, 20) or psoriasis (21, 22).

Measurement of TEWL is used to evaluate the function of the skin barrier, for example in skin diseases or after drug application. Measurement of TOWL would be more simple and objective, because of the lack of sweat glands. The most important result of this study is the fact that TOWL must be clearly distinguished from TEWL showing unexpected response patterns in patients with nail involvement: the water loss from dystrophic nails is lower than that of healthy nails, whereas affected skin loses more water than healthy skin.

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