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Original article

# Transepidermal water loss and skin hydration in healthy cats and cats with non-flea non-food hypersensitivity dermatitis (NFnFHD)

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## Abstract

Allergic skin diseases in cats are amongst the most prevalent dermatological conditions in this species. The objectives of this study were to evaluate different types of skin barrier measurements in healthy cats and cats with non-flea non-food hypersensitivity dermatitis (NFnFHD). 24 clinically healthy and 19 NFnFHD cats were included in this clinical trial. In each animal, the transepidermal water loss (TEWL) and skin hydration (SH) were assessed on six clipped body sites by VapoMeter SWL 4605 and Corneometer ®CM 825, respectively. Results of TEWL measurement were significantly higher in one of the six examined body sites, namely on the lumbar area ( $p=0.0049$ ). Furthermore, a statistically significant difference was found between the average TEWL values ( $p=0.019$ ). Statistically notable differences were measured at least in one certain body site for SH: in the groin ( $p=0.02$ ), where the values in the affected cats were lower than in the healthy individuals. These results may suggest that in NFnFHD cats transepidermal water loss is higher than in healthy cats. Skin hydration is, at least, in certain body sites, lower in atopic feline patients than in healthy individuals.

**Key words:** cats, atopic dermatitis, transepidermal water loss, skin hydration

## Introduction

Allergic skin diseases in the cat are amongst the most prevalent dermatological conditions in this species. It is believed that it is underlying cause for over a dozen percent of all skin conditions in this species

(Hobi et al. 2011). Allergic diseases in feline patients may show one of the following clinical signs: head and neck pruritus, symmetric non-inflammatory alopecia, miliary dermatitis and/or eosinophilic granuloma complex (Hightower et al. 2010, Noli and Cena 2015).

The evaluation of cutaneous barrier integrity involves measurements of biophysical parameters such as transepidermal water loss (TEWL), skin hydration (SH), skin surface pH or erythema severity (Shimada et al. 2008, Szczepanik et al. 2011, Zajac et al. 2014, 2015). The first of the above-mentioned methods, namely TEWL, is commonly used and considered to be directly related to skin barrier dysfunction; this is also a commonly used method of evaluating skin barrier functions in the dog correlating well with the degree of lesions assessed clinically and histopathologically (Shimada et al. 2008, Zajac et al. 2014). For TEWL measurements, two types of evaporimeters were used: with open and closed chambers. Studies on animals have been conducted, both with open-chamber (Hightower et al. 2010, Ohmori et al. 2010, Szczepanik et al. 2011, Marsella 2012, Zajac et al. 2014) and closed-chamber (Hester et al. 2004, Shimada et al. 2008, Oh and Oh 2009, Marsella et al. 2012, Momota et al. 2013, Pellicoro et al. 2013, Pin et al. 2014). As judged by some authors, closed-chamber instruments may be more reliable because in this type of device body-induced airflow around the chamber is avoided, while in open-chamber evaporimeters turbulent airflow around the probe may affect the accuracy of the measurement. Open-chamber evaporimeters are more sensitive to minor changes in TEWL (De Paepe et al. 2005, Momota et al. 2013).

Biophysical skin parameters have been investigated in healthy dogs, cats and horses (Oh and Oh 2009, Lau-Gillard et al. 2011, Szczepanik et al. 2011, 2012, 2013, Momota et al. 2013). Evaluation of TEWL has been carried out on allergic animals (dogs and cats). Some studies conducted in these species have demonstrated a statistically significant increase in TEWL in allergic individuals compared to healthy animals (Shimada et al. 2009, Cornegilani et al. 2013, Zajac et al. 2015). In atopic dermatitis (AD) dogs, it has been shown that there is a correlation between the severity of clinical symptoms and TEWL (Marsella 2012, Zajac et al. 2014). Furthermore, it has been demonstrated that TEWL is reduced in AD dogs during the remission phase, after cyclosporine treatment (Zajac et al. 2015). The decrease of ceramide content was reported in AD dogs and TEWL correlated with the relative amount of ceramide. These findings suggest that a decrease in ceramide content accelerates TEWL in AD (Shimada et al. 2009).

The other biophysical parameters are tested less commonly. In human medicine, it is known that skin hydration is lower in AD patients (Rudolph et al. 2004, Holm et al. 2007). This parameter has been investigated in healthy horses, cats and dogs (Young et al. 2002, Hester et al. 2004, Oh and Oh 2009, Szczepanik et al.

2011, 2012, 2013, 2018b). SH was also investigated in atopic cats (Szczepanik et al. 2018a). Correlations between this parameter and the severity of clinical symptoms in some of the body sites in cats and dogs have been proven (Zajac et al. 2015, Szczepanik et al. 2018a).

The objective of the study was to determine whether biophysical skin parameters (examined on 6 different body sites), namely TEWL and SH, differ between healthy and NFNFHD cats.

## Materials and Methods

The measurements were taken on 24 clinically healthy European cats: 16 females (9 spayed) and 8 males (3 neutered), aged 6 months to 7 years (with a median of 5 years) and on 19 atopic-like European short-haired cats: 12 females (6 spayed) and 7 males (all neutered), aged 2 to 7 (with a median of 3.75 years). In case of healthy cats the study was approved by the University Ethics Commission (resolution number 32/2009 21.04.2009). All procedures used in this study (TEWL and skin hydration measurement, clinical assessment) were non-invasive. In case of atopic cats all procedures can be classified as routine veterinary procedures in ill animals and do not require special permission. Pet owners provided consent for each cat to participate in the study. The diagnosis of non-flea, non-food allergic dermatitis (NFNFAD) was made based on the clinical diagnostic criteria according to Favrot et al. (2011). Other pruritic diseases were ruled out based on trichoscopic examination, skin scraping, cytology and fungal culture. Flea bite hypersensitivity and food allergy were excluded by appropriate anti-flea medications and a strict 8-week elimination diet, respectively.

The assessment of TEWL, SH and the calculation of SCORFAD and FeDESI were performed if the cats showed clinical symptoms before the treatment was initiated.

The animals were acclimatized to a room for, at least, 60 minutes before the measurement was recorded. Temperature in the room where evaluation was taken ranged from 21 to 25°C and humidity was between 41 and 60% (the recommended working parameters of a corneometer: temperature 10-30°C, humidity 30-70%, and recommended working parameters of VapoMeter: humidity 10-60% temperature 20-25°C)

The SCORFAD (Scoring Feline Allergic Dermatitis) (Steffan et al. 2012) and FeDESI (Feline Extend and Severity Index) (Schmidt et al. 2011) scores were calculated directly before TEWL and SH were determined. In the cat, two systems are used to determine the severity of cutaneous clinical signs: SCORFAD and FeDESI.

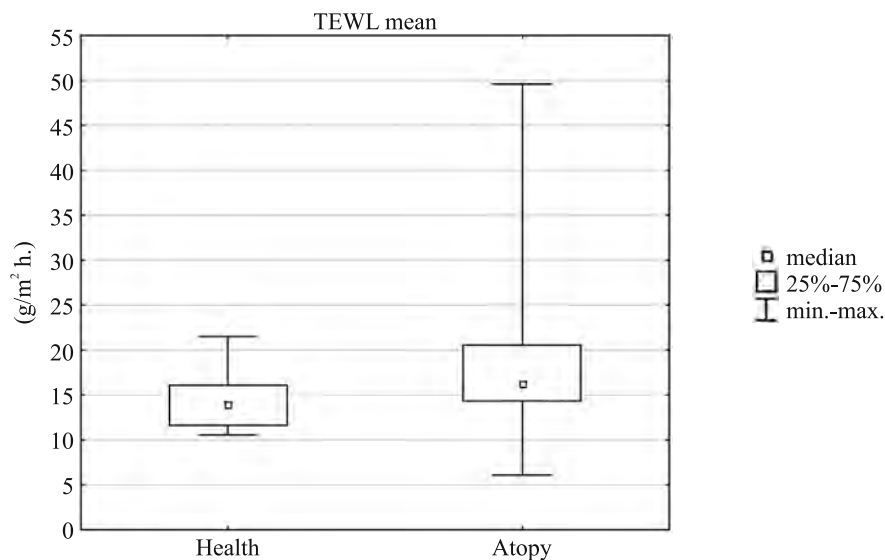


Fig. 1. Average TEWL in the NFNFHD cats and healthy cats, results in g/m<sup>2</sup> h.

The SCORFAD system assesses the severity of 4 lesion types: abrasions, eosinophilic plaques, military dermatitis, and post-pruritic alopecia based on the 0-to-4 scale. According to this system, an affected cat may be scored with maximum 16 points. The FeDESI system has been developed as a modification of the CADESI (Canine Atopic Dermatitis Extent and Severity Index) scheme used for dogs. The assessment in this systems applies to erythema, abrasions/erosions and post-pruritic alopecia on 42 body sites scored from 0 to 5 (a diseased cat can be thus scored 630 points at maximum).

The cats had not been administered glucocorticoids, cyclosporine, antihistamine medications, and polyunsaturated fatty acids for, at least, 2 months before the measurements were taken. Before the skin hydration and TEWL were measured, hair was clipped with an electric shaver (0.3mm blade). Hair was left unclipped in hairless areas (internal side of the pinna) and when the examined area included post-pruritic alopecia.

The measurements were taken on 6 body sites: abdomen, axilla, groin, internal side of the left pinna, lumbar area and the left lateral side of the thorax. In NFNFHD cats measurement was performed only on lesional areas. TEWL was assessed with a manual closed-chamber VapoMeter SWL 4605 (DELFIN Technologies Ltd, Kuopio, Finland) (results in g/m<sup>2</sup> h) (Momota et al. 2013). Each measurement was taken three times and the mean of three recordings was applied in the statistical analysis (Hightower et al. 2010, Cornegilani et al. 2012, Marsella 2012, Pin et al. 2014). Vamometer was lifted off the skin for 30 seconds to assure proper ventilation between consecutive measurements. Skin hydration was evaluated with a Corneometer ®CM 825; (Courage 1 Khazaka electronic GmbH Cologne, Germany) and the measured

values were given as arbitrary units (AU). Each analysis was performed three times and the mean of three recordings was applied in the statistical evaluation.

### Statistical analysis

The results were verified for normality with the Shapiro-Wilk's test. The average TEWL and the average skin hydration values from 6 assessed body sites were calculated for each cat (both healthy and atopic-like). Statistically significant differences between the investigated body sites in healthy and atopic-like cats were calculated with the U-Mann-Whitey rank test. In all cases Bonferroni correction was made. Average TEWL and SH values were compared between healthy and NFNFHD cats using the same statistical test. The values at  $p \leq 0.05$  were considered significant. All calculations were made with Statistica 10™ software (StatSoft, Tulsa, OK, USA).

### Results

The examined animals varied in their clinical condition with the SCORFAD scores ranging from 3 to 12 (median: 8) and the FeDESI scores from 10 to 211 (median: 50.5). A statistically significant difference between the average TEWLs (calculated as the mean of 6 examined body sites) between the affected cats and healthy animals ( $p=0.019$ ) was noticed. These results are presented in Fig. 1. The TEWL values in the diseased cats were higher than in the healthy individuals. Furthermore, in the case of TEWL, a statistically significant difference was found in the lumbar area ( $p=0.0049$ ). TEWL values from abdominal areas were higher in allergic cats than in healthy individuals, though not

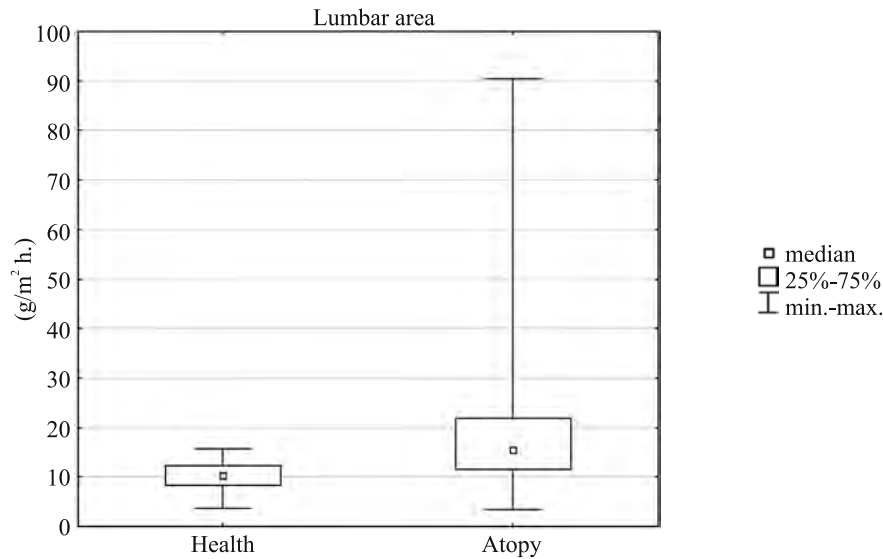


Fig. 2. TEWL in healthy and atopic cats on the lumbar area, results in  $\text{g/m}^2 \text{ h.}$

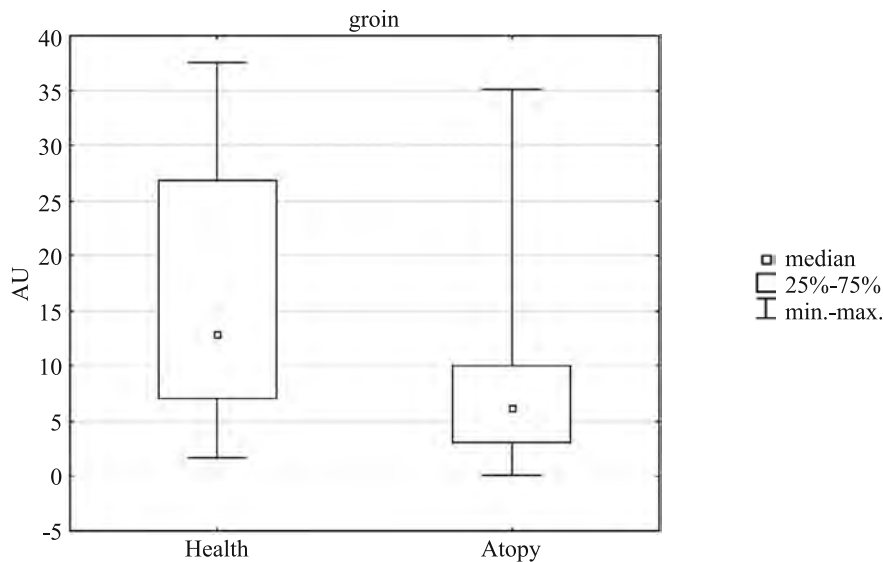


Fig. 3. Skin hydration in healthy and atopic cats on the groin, results in AU.

statistically significant. For SH measurements, statistically significant differences were recorded for one of 6 examined sites, namely in the groin ( $p=0.02$ ), where the values of diseased cats were lower than in the healthy individuals. No significant differences were recorded in combined SH mean values of healthy and allergic cats. The results are presented in Figs. 2-3.

## Discussion

The present study showed that there are higher TEWL and lower skin hydration values in “atopic-like” cats compared to healthy cats, although this only holds true for certain body areas. These findings could be explained by a disruption of skin barrier function in

allergic cats. The inflammation on lesional areas may also be responsible for these disorders.

In cats TEWL was assessed in healthy and atopic individuals. In this species it is known that this biophysical parameter varies in different body regions (Szczepanik et al. 2011, Momota et al. 2013). The influence of clipping on the results of TEWL was also investigated in healthy cats (Momota et al. 2013). Momota et al. (2013) revealed that TEWL demonstrates a reverse correlation with another non-invasive evaluation modality: corneocyte surface area measurement (Momota et al. 2016). Studies on alterations in transepidermal water loss in NFNFDH cats have been carried out by Cornegliani et al (2013). As for now, this is the only report of such kind on the biophysical parameters in allergic cats. The authors compared TEWL in healthy

and NFNFDH-affected cats and the conclusion was that allergic cats have higher values. This was demonstrated for the pinna. Unfortunately, we don't show such a change in this area. We demonstrated an increase of average TEWL (calculated for 6 body areas) in atopic-like cats, but Cornegliani and al. not made a similar calculation, for this reason our results are only partially comparable. Correlations between TEWL and the severity of clinical symptoms (assessed by FeDESI and SCORFAD) in some of the body sites in cats (thorax, axilla and forearm) have been proven (Szczepanik et al. 2018b). TEWL has also been investigated in dogs with atopic dermatitis and an increase of this parameter was shown in atopic animals (Shimada et al. 2009, Hightower et al. 2010). Moreover, it has been shown that TEWL decreases during treatment (Shimada et al. 2009, Hightower et al. 2010, Momota et al. 2013). It has also been reported that TEWL correlates with the severity of clinical lesions, assessed with the CADESI system, on some body sites (Marsella 2012, Zajac et al. 2014).

In cats, skin hydration was assessed in healthy and atopic individuals. In this species it is known that this biophysical parameter varies in different body regions (similarly to TEWL) (Szczepanik et al. 2011). Therefore, it is extremely important to compare results for the same body area. Skin hydration has been investigated in atopic cats (Szczepanik et al. 2018a). Correlations between this parameter and the severity of clinical symptoms (assessed by FeDESI and SCORFAD) in some of the body sites in cats (pinna, axilla, thorax, forelimb and lumbar sites) have been proven. This parameter has been also evaluated in dogs with atopic dermatitis by Shimada et al. (Shimada et al. 2009). The studies carried out by these authors demonstrated that skin hydration becomes reduced in atopic dogs with existing skin lesions. The authors demonstrate that TEWL decreases in the groin, and that is similar to our findings. Shimada et al. demonstrated a decrease of SH only in lesional skin and it may suggest that these disturbances are secondary. We made measurements only in lesional skin, which makes it impossible to compare values for lesioned and healthy skin for the same specific area (as in Shimada research). So far there has been no information concerning atopic cats in that respect. In atopic humans, skin hydration is also lower than in healthy persons (Rudolph et al. 2004).

We found the VapoMeter to be a very user-friendly device. In TEWL, significant site to site variation, animal to animal variation and day-to day variation was noted (Lau-Gillard et al. 2011). For this reason, a strictly standardized protocol (e.g. long acclimatization within the room, investigator training) would be required. We stated that this device is more useful for the researchers than to clinicians.

The results of our study indicate the usefulness of biophysical skin parameter measurements with respect to the integrity of the skin barrier in cats with NFNFDH. Further studies are warranted to determine whether these parameters correlate with the degree of skin lesion severity, assessed with the clinical evaluation systems, as it has been found in humans and dogs.

Examinations need to be conducted also during treatment to determine if changes in skin biophysical parameters are associated with a decrease in the severity of a disease. This type of examination in dogs indicates a decrease in TEWL with clinical improvement, so it can be expected that a similar relationship is present in cats (Cornegliani et al. 2012, Zajac et al. 2015). Since the correlation with the clinical evaluation systems was demonstrated, this parameters may be potentially used in clinical practice (together with clinical systems) to monitor the progress of treatment as it is done in humans.

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