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Original article

The examination of biophysical skin parameters (transepidermal water loss, skin hydration and pH value) in different body regions in Polish ponies

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Abstract

The purpose of this study was to evaluate transepidermal water loss, skin hydration and skin pH in normal polish ponies. Twelve ponies of both sexes were examined in the study. Measurements were taken from seven different sites: the neck region, the shoulder, thorax, lumbar, inguinal, lip region and the pinna. In each of the regions transepidermal water loss (TEWL), skin hydration and skin pH were measured. For transepidermal water loss, the lowest values were observed in the pinna (10.54 g/hm²), while the highest values were observed in the lip region (30.98 g/hm²). In the case of skin hydration the lowest values were observed for the thorax region (1.96 CU), and the highest for the lip region (48.28 CU). For skin pH, the lowest results were obtained in the pinna (7.03), and the highest in the lumbar region (8.05).

Key words: skin biophysical parameters, TEWL, corneometry, skin pH, horses

Introduction

In the past years the assessment of biophysical parameters has gained considerable attention in the process of assessing skin condition. These methods include the examination of transepidermal water loss, corneometry, as well as measuring skin pH and

erythema intensity. The methods were at first used in human medicine (Fluhr et al. 2006, Grupta et al. 2008,) and are now widely applied in various diseases such as topic dermatitis (Eberlein-König et al. 2000, Choi et al. 2003, Rudolph et al. 2004, Grupta et al. 2008), contact dermatitis (Laudańska 2003) and in assessing the efficiency of locally applied medicines

(Biro et al. 2003, Lofler et al. 2003, Aschoff et al. 2008). Recently, much research involving the assessment of skin biophysical parameters has been published (Dirschka et al. 2005, Fluhr et al. 2006, Hightower et al. 2008 and 2010, Oh and Oh 2009, Cornegliani et al. 2011). Much attention has been given to the assessment of these parameters in dogs (Beco et al. 2000, Matousek et al. 2002, Watson et al. 2002, Young et al. 2002, Hester et al. 2004, Yoshihara et al. 2004, Oh and Oh 2009, Shimada et al. 2009, Hightower et al. 2010, Lau-Gillard et al. 2010, Ohmori et al. 2010, Cornegliani et al. 2011, Marshala 2012). Some papers tackled the issue of measuring the parameters in cats (Bourdeau et al. 2004, Vidal et al. 2009, Szczepanik et al. 2011) and horses (Meyer and Neurand 1991, Szczepanik et al. 2012). As regards dogs, most of the research concentrated on assessing biophysical skin parameters in atopic dermatitis, where mainly TEWL and less frequently skin hydration were taken into consideration (Hightower et al. 2008, Shimada et al. 2009, Cornegliani et al. 2011, Marsella 2012). Skin pH and its changes connected with the treatment applied were assessed in cases of pruritis in dogs (Popiel and Nicpoń 2004).

The most popular method of assessing biophysical skin parameters is the analysis of transepidermal water loss (TEWL). Water passively moves from better hydrated skin layers to the less hydrated epidermis. TEWL measures the speed of water loss by the skin, and the measurement is subsequently used to estimate the water retention ability of the skin. The method is assumed to be a sensitive indicator of skin lesion, and a growth in the parameter is associated with epidermal damage (Oh and Oh 2009, Shimada et al. 2009, Grupta et al. 2008, Shah et al. 2005, Fluhr et al. 2006, Marsella 2012, Videmont et al. 2011).

An increase in the parameter indicating epidermal damage was observed in cases of atopic dermatitis in humans (Eberlein-König et al. 2000, Rudolph et al. 2004, Grupta et al. 2008). Similar changes were also observed in dogs, where it was found, among others, that the value of the parameter increases with the severity of the changes assessed with CADESI (Hightower et al. 2008 and 2010, Shimada et al. 2009, Cornegliani et al. 2011, Marsella 2012).

The next method used in assessing biophysical skin parameters is corneometry. The method involves the measurement of the electrical capacity of the stratum corneum and reflects the relative hydration of this layer. The method allows for assessing water content in the stratum corneum at the depth of 10-20 μm to 60-100 μm (Rudolph et al. 2004, Aschoff et al. 2008). Changes in the parameter were observed in cases of damage, metabolic dysfunctions and when local treatment was applied as well as in cases of atopic dermati-

tis in humans and dogs (Rudolph et al. 2004, Aschoff et al. 2008, Shimada et al. 2009).

Another parameter used widely in the assessment of skin condition is the analysis of skin pH. Changes in this parameter were investigated in humans and changes in skin pH were observed in the course of atopy, seborrhoeic dermatitis, acne, ichthyosis, contact dermatitis and *Candida albicans* infections (Eberlein-König et al. 2000, Matousek 2002, Schmid-Wendtner 2006). Changes in skin pH were also observed in the course of pyoderma in dogs (Popiel and Nicpoń 2004). The changes mentioned, related to both feeding method and sex, were also examined in cats (Bourdeau et al. 2004).

Various factors such as age and sex may influence the values of biophysical skin parameters. The parameters may also take different values for different dog breeds. Variations in the value of the parameters also depend on the body region, therefore the place of measurement should be taken into consideration in the interpretation of results. Changes in the values of parameters caused by these factors were examined in dogs (Meyer and Neurand 1991, Matousek et al. 2002, Watson et al. 2002, Young et al. 2002, Hester et al. 2004, Yoshihara et al. 2007, Gillard et al. 2009, Oh and Oh 2009, Shimada et al. 2009), in cats (Bourdeau et al. 2004, Szczepanik et al. 2011), and horses (Szczepanik et al. 2012).

Apart from few publications pertaining to the assessment of skin pH (Meyer and Neurand 1991, Matousek 2002) and one publication describing the assessment of skin pH, TEWL and skin hydration (Szczepanik et al. 2012), the information about the value of biophysical skin parameters in horses is scarce. The examination of the location of the values of the parameter (skin mapping) in clinically healthy animals is a necessary condition for the application of biophysical skin parameters assessment in the course of treating various diseases, including their application in horses. The aim of the present study was the assessment of the parameters such as transepidermal water loss, skin hydration and skin pH in healthy horses of both sexes, in specific locations.

Materials and Methods

Twelve "Polish" ponies from the experimental farm Florianka were included in the study. The experimental group comprised 6 males and 6 females. The age of the animals ranged from 2 to 14 years (mean age 5.33 years). All horses were given a complete physical and dermatologic examination prior to taking the measurements. Only clinically healthy animals with no history of skin disease were included

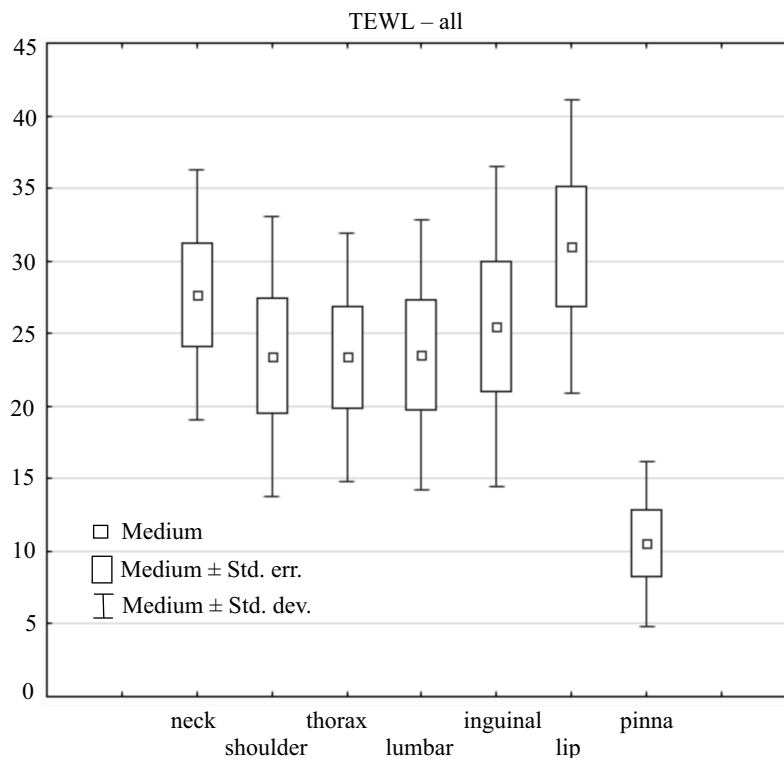


Fig. 1. Mean TEWL in different body regions of ponies.

in the study. The animals were acclimatized in the test room (stable) two hours before the measurements were taken. The temperature in the room ranged from 18°C to 27°C and the relative humidity from 45% to 65%. The examination was performed in the second half of 2012. Before the measurement, hair was clipped to 1 mm length using Metzenbaum scissors. In a study by Watson et al. (2002), clipping, as opposed to using a hair cutting machine, did not influence the results of TEWL. Care was taken not to damage the skin while clipping. The measurement was performed two minutes after hair clipping. Similarly, in earlier studies with cats and ponies hair was clipped before measurement in order to ensure better adherence of the probes to the skin surface (Szczepanik et al. 2011). Measurements were taken from seven different sites: the right side of the neck, the shoulder region, the right lateral thorax region, the lumbar region, the inguinal region, the lip region, the internal surface of pinna. In each of the regions, transepidermal water loss, skin hydration and skin pH were measured. For each parameter six successive measurements were taken and the mean value was calculated. The assessment of the parameters was made by means of the Courage Khazaka Multi Probe Adapter 5 and the appropriate probes: the Tewameter[®]TM 300 probe (to measure TEWL, results given in g/hm²), Corneometer[®]CM 825 (to measure skin hydration, results in corneometer units), Skin-pH-Meter[®]PH 905

(to measure skin pH, results on the pH scale). The same instrumentation was used in previous studies in dogs, cats and ponies (Young et al. 2002, Hester et al. 2004, Yoshihara et al. 2004, Shimada et al. 2009, Hightower et al. 2010, Szczepanik et al. 2011, Szczepanik et al. 2012). For all parameters, the mean, standard deviation and median were calculated. Statistical analysis was conducted by the Student's t-test at P-values of $p = 0.05$ (Statistica 6.0 software). For each parameter, statistically significant differences were calculated between the results obtained in different regions. Additionally, statistically significant differences between the results for females and males were calculated, taking into consideration the distribution of parameters in the regions.

Results

For transepidermal water loss, the lowest values were observed in the pinna, while the highest values were observed in the lip region. The statistical analysis revealed that transepidermal water loss was statistically significantly lower in the pinna as compared to the neck region ($p=0.002259$), the shoulder region ($p=0.01785$), thorax ($p=0.01872$), lumbar ($p=0.015074$), inguinal ($p=0.014687$) and lip region ($p=0.001521$). The results are presented in Fig. 1.

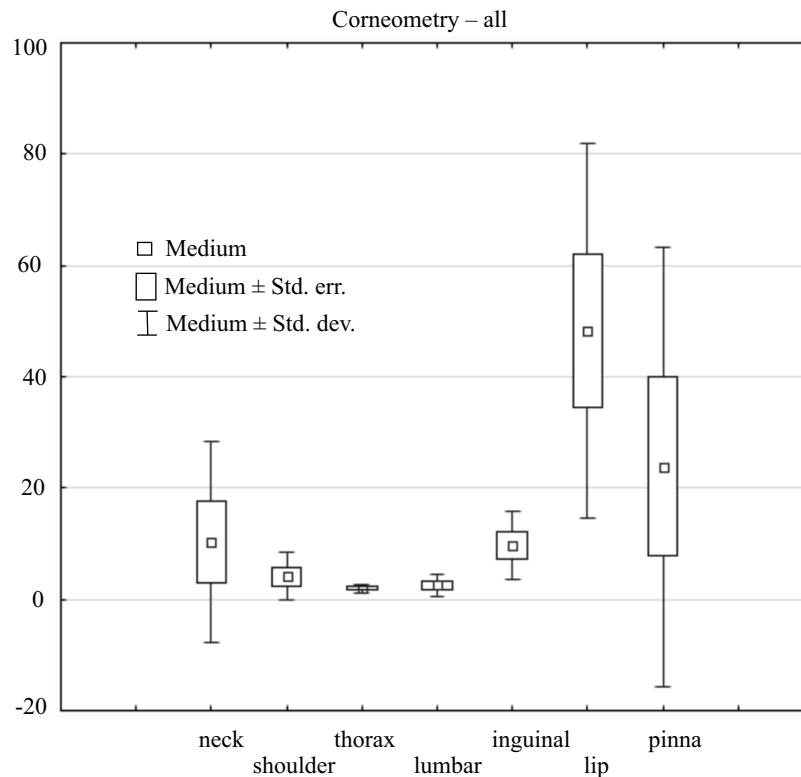


Fig 2. Mean skin hydration (CU) in different body regions of ponies.

TEWL was slightly higher in males (24.70) than in females (22.45), but the difference was not statistically significant. No statistically significant differences were observed for the results between males and females for TEWL in corresponding body regions (the neck $p=0.382$, the shoulder $p=0.08$, the thorax $p=0.662$, the lumbar region $p=0.19$, the inguinal region $p=0.662$, the lip $p=1$, the pinna $p=1$).

In case of skin hydration the lowest values were observed in the thorax region (1.96 CU), and the highest in the lip region (48.28 CU). It was found that the value for this parameter is statistically higher in the lip region compared to the neck region ($p=0.035$), the shoulder region ($p=0.0098$), the thorax region ($p=0.0071$), the lumbar region ($p=0.0078$), the inguinal region ($p=0.02$). Statistically significant differences were also found between the inguinal region and the thorax ($p=0.011$) and lumbar region ($p=0.022$). The results obtained are presented in Fig. 2.

Similarly to TEWL, there were no statistically significant differences between the values in males and females although skin hydration value in females (19.63) was higher than in males (9.15).

No statistically significant differences were observed between the results in males and females when comparing the results of skin hydration for the corresponding body regions (the neck region $p=1$, the

shoulder region $p=0.19$, the thorax region $p=0.66$, the lumbar region $p=0.08$, the inguinal region $p=0.38$, the lip region $p=0.19$, the pinna region $p=0.66$).

For skin pH, the lowest results were obtained in the pinna (7.03), and the highest in the lumbar region (8.05). Statistical analysis revealed that skin pH was statistically significantly different in the pinna when compared to the thorax region ($p=0.011$), lumbar region ($p=0.003$), shoulder region ($p=0.045$), lip region ($p=0.025$). The results are presented in Fig. 3.

Similarly to the abovementioned parameters, no statistically significant differences were observed between males (pH 8.01) and females (pH 7.39). No statistically significant differences were found between the results in males and females comparing skin hydration in corresponding body regions (the neck region $p=0.383$, the shoulder region $p=0.383$, the thorax region $p=0.126$, the lumbar region $p=0.08$, the inguinal region $p=0.08$, the lip region $p=1$, the pinna region $p=0.827$).

Discussion

The assessment of biophysical skin parameters such as transepidermal water loss, skin hydration and skin pH are commonly used in the analysis of skin

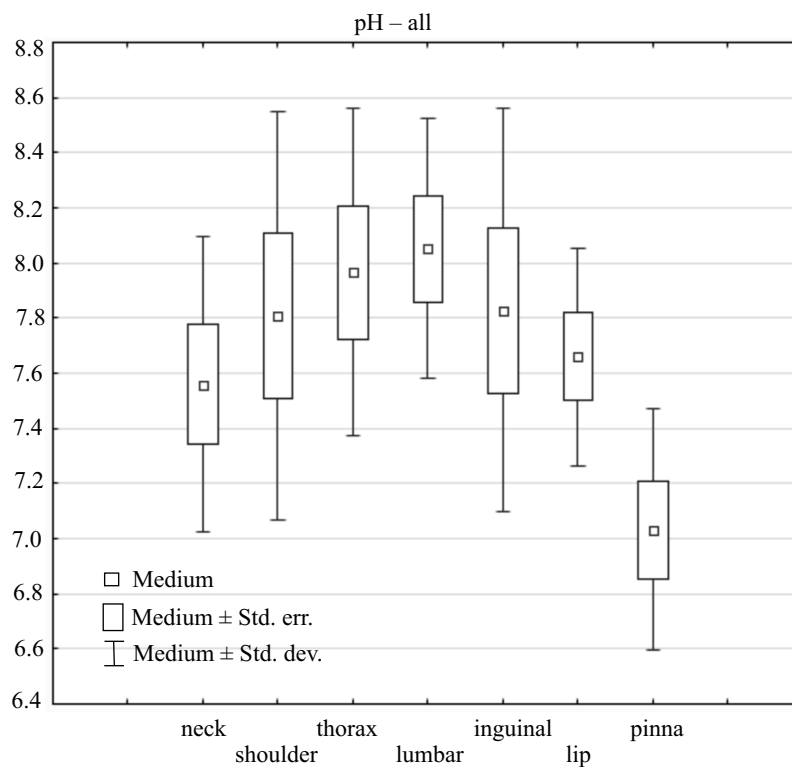


Fig. 3. Mean skin pH in different body regions of ponies.

condition in human medicine. In case of human patients, they are used, among others, is assessing skin dysfunction in the course of atopic dermatitis as well as in order to determine the efficiency of locally applied treatments, including those used in atopic dermatitis (Dirschka et al. 2004, Rudolph and Kownatzki 2004, Aschoff et al. 2008, Gupta et al. 2008, Hon et al. 2011). The measurement of the aforementioned parameters, mainly transepidermal water loss, has recently also attracted the attention of veterinary dermatologists. The research with the use of these parameters for the most part concentrated on dogs and involved examining skin condition and monitoring the efficiency of treatment in the course of atopic dermatitis and septic bacterial infections (Popiel and Nicpoń 2004, Hightower et al. 2008, Shimada et al. 2009, Hightower et al. 2010, Corneigliani et al. 2011, Marsella 2012).

Information concerning the physiological values of the biophysical skin parameters is abundant in relation to dogs, with a reference made to different body regions, age and breed (Shimada et al. 2009, Hightower et al. 2010, Corneigliani et al. 2011, Oh and Oh 2009). As far as other species are concerned, some research was conducted with cats (Bourdeau et al. 2004, Vidal et al. 2009, Szczepanik et al. 2011) and horses (Meyer and Neurad 1991, Szczepanik et al. 2012) but the information is relatively scarce.

As regards dogs, many authors have observed statistically significant differences in the values of the parameters for different breeds. Hester et al. (2004) found that TEWL values differed significantly between beagles and basset hounds. Similar differences were also observed for various breeds (beagles, fox terriers, Labrador retrievers and Manchester terriers) by Young et al. (2002). Gillard et al. (2009) reported statistically significant differences between long- and short-haired breeds. When comparing the results obtained in the present study with the results obtained for "Felin" ponies (Szczepanik et al. 2012), higher values were observed for the parameter in all regions assessed, which may mean that, similarly to dogs, TEWL values may depend on horse breed as well.

Another factor potentially influencing TEWL results is the body region investigated. Numerous studies have shown that transepidermal water loss may differ significantly depending on the location. Research has confirmed such a differentiation in human patients (Marrakchi et al. 2007) as well as dogs (Watson et al. 2002, Yoshihara et al. 2007, Gillard et al. 2009, Oh and Oh 2009), cats (Szczepanik et al. 2011) and horses (Szczepanik et al. 2012). In case of dogs, it has been found that the value of this parameter in beagles is the lowest in the lumbar region and differs significantly from values obtained in other regions (Oh and Oh 2009). In case of cats, the lowest values of the parameter were also observed in the lumbar re-

gion and they differed significantly from the remaining locations (Szczepanik et al. 2011). Studies conducted in 2012 with ponies revealed a variation in TEWL in different body regions – the lowest values were found in the lumbar region and they differed significantly from the results obtained in other regions. In the “Polish” ponies examined in the present study, the lowest TEWL value was observed in the pinna and differed statistically significantly from the remaining locations. Thus, the interpretation of the results obtained should always take into account the body region under examination.

Skin hydration, similarly to TEWL, appears to depend on breed. Research into the relationship in dogs has shown, for example, that the parameter has divergent values in basset hounds and beagles (Hester et al. 2004). Similar relationship was observed for skin hydration in four different dog breeds – beagles, fox terriers, Labrador retrievers and Manchester terriers (Young et al. 2002). The comparison of our results with the results obtained for “Felin” ponies (Szczepanik et al. 2012) also suggests the presence of such differences, as the skin hydration value in most body regions assessed in “Polish” ponies is higher compared to the “Felin” ponies. The two studies suggest that in the examination of skin hydration, similarly to TEWL, animal breed should be taken into consideration.

Body region-related variation in skin hydration values was shown both in humans and in dogs (Marrakchi et al. 2007, Oh and Oh 2009). The highest value of this parameter in dogs was found in the pinna and the lowest values in the coccygeal region. There were also differences observed in skin hydration according to the body region. The best hydrated region was the lip and the pinna was the second best hydrated location. The lowest values were observed in the thorax (Szczepanik et al. 2012). The same relationship was found for “Polish” ponies – the best hydrated region was the lip and the worst hydrated region was the thorax.

The variation in skin pH in different body regions was the object of investigations in dogs (Oh and Oh 2009) and horses (Meyer and Neurad 1991, Szczepanik et al. 2012). The authors confirmed statistically significant differences in skin pH in different body regions. As regards horses, Meyer and Neurad (1991) investigated the relationship between skin pH value and body regions for several breeds. The results obtained ranged from 5.9 to 7.04, depending on the region assessed, which values are lower than those obtained in the present study. However, their results corresponded with ours in that skin pH was found to differ according to the body region. The highest pH value was noted in the nasal/lip area and the lowest in the back. In a study of “Felin” horses, the highest pH value was observed in the lip area and the lowest in the lumbar region. In the “Polish” ponies we examined, the values in various body parts proved different,

as the highest values were noted in the lumbar region and the lowest in the pinna. Like in the case of other parameters, breed appears to affect the value of this parameter.

The influence of sex on the biophysical parameters was investigated in dogs, cats and horses. Young et al. (2002) examined the impact of sex on the parameters in dogs (TEWL, skin hydration and skin pH). It was found that for the following breeds: beagles, fox terriers, Labrador retrievers and Manchester terriers sex did not influence the parameters. Also Meyer and Neurad (1991) (for skin pH) and Szczepanik et al. (2011) (for TEWL, skin hydration and skin pH), assessing the parameters in horses, found no statistically significant differences between sexes. Similarly, Bourdeau et al. (2004), who assessed TEWL in cats, did not observe statistically significant differences between males and females. These results are in accordance with the present findings in that sex does not cause statistically significant differences in the biophysical skin parameters which have been assessed. Conflicting results appeared in a study of cats, where statistically significant differences were found for males and females. Yet, the differences were only present for skin pH (Szczepanik et al. 2011).

In conclusion, the values of biophysical parameters in horses, similarly to dogs and cats, appear to depend on the body region assessed. Breed is also considered to be a factor determining the parameters. Sex, however, seems to play a marginal, if any, role in assessing biophysical skin parameters. Further research is necessary in different horse breeds in order to determine the occurrence of the parameters discussed according to breed as well as the referential values. Additionally, the research should focus on the assessment of changes in the parameter in the course of various skin diseases.

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