Transepidermal Water Loss after Water Immersion

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ABSTRACT

Objective: To observe changes in transepidermal water loss (TEWL) at different times after water immersion.

Materials and Methods: TEWL values were measured before water immersion and at 3, 5, 10, 15, 20, and 30 minutes after immersion of the skin in water for 5 minutes.

Results: Forty-one healthy volunteers were enrolled with an average age of 30.4±5.5 years. Twenty-five subjects were female and sixteen were male. The TEWL value before water immersion ($TEWL_{baseline}$) was 13.16±7.27 g/m^2/h and TEWL values at 3, 5, 10, 15, 20 and 30 minutes after immersion were 23.21±7.67, 16.12±3.42, 14.76±6.36, 14.45±6.67, 13.53±4.67 and 12.96±5.18 g/m^2/h, respectively. After immersion, TEWL values at 3 and 5 minutes statistically increased compared to $TEWL_{baseline}$ (p<0.001). TEWL values between 10 to 30 minutes gradually dropped with no statistically significant difference compared to the previous period and $TEWL_{baseline}$. Although total water loss from the skin occurred within 30 minutes, 56.9% of it occurred within 10 minutes after immersion. There was no significant difference between $TEWL_{baseline}$ in males and females but the TEWL values at 3, 5 and 15 minutes after immersion in males was higher than in females (p<0.05).

Conclusion: TEWL statistically increased after water immersion for only 5 minutes. The cumulative percentage of TEWL was high within 10 minutes. Gender did not affect TEWL values before immersion; however, males experienced more water loss from the skin than females after immersion. Therefore, moisturizer should be applied immediately before TEWL occurs.

Keywords: Immersion; TEWL; transepidermal water loss (Siriraj Med J 2021; 73: 386-390)

INTRODUCTION

The skin has multiple defensive and regulatory functions. However, its most important function is to act as barrier against external stresses and the percutaneous penetration of chemicals, allergens, and organisms. This barrier function is almost entirely present in the epidermis and in particular the stratum corneum (SC). The skin also maintains water and electrolyte homeostasis and thermoregulation.[1,2]

The functional state of the skin can be investigated by assessing non-invasive biophysical parameters which are influenced by several factors.[2-5] For example, in vivo evaluation by measurement for TEWL has proven to be a reliable indicator of the function of the skin barrier.[3-9] A defective skin barrier leads to increased TEWL along with dry skin.[9,10] Therefore, TEWL values are directly related to the clinical severity of lesions in various skin diseases with altered barrier function such as atopic dermatitis, ichthyosis, contact dermatitis, and psoriasis.[1] To manage dry skin, bathing and application of moisturizer is necessary. How the skin changes at different time periods after bathing can provide useful information for skin care recommendations.

The purpose of this study was to characterize the function of skin barrier as evaluated by TEWL values at different time points after immersion.

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MATERIALS AND METHODS

A prospective study was conducted at the Department of Pediatrics, Faculty of Medicine Siriraj Hospital, Mahidol University. The study protocol was approved by the Siriraj Ethical Review Board (Si 702/2015) and the written informed consent was obtained from all participants.

Healthy participants with no pre-existing dermatoses or any systemic disorders that could alter the biophysical parameters were enrolled. The participants were asked not to apply any skin product for at least 12 hours prior to testing and to avoid washing the area to be tested on evaluation day. Before any measurements were made, participants were asked to rest for 15 minutes in a room with controlled environmental conditions to help them acclimatize. All measurements were made in highly comparable temperatures and humidity-controlled conditions in accordance with the guidelines for standardized skin parameter measurements in the European Group on Efficacy Measurement and Evaluation of Cosmetics and Other Products (EEMCO) guidelines and by the Standardization Group of the European Society of Contact Dermatitis.[11] The TEWL value was measured using a Tewameter™ TM 300 (Courage and Khazaka electronic, Köln, Germany) and expressed in g/m^2/h. Participants were asked to immerse the test area in water rather than bathe. The volar region of the forearm, which is often selected as the test site in dermatological research, was selected as the test area. After baseline TEWL readings were recorded, the volunteer's forearms were immersed in the water bathtub for five minutes followed by pat drying with towels and then measuring TEWL again at 3, 5, 10, 15, 20, and 30 minutes later. To avoid inaccuracies, each measurement was repeated three times at the nearby areas and the mean value was used for analysis. The patients were monitored for side effects after the measurements were completed.

The data was analyzed using SPSS Statistical software, version 20 (IBM, Chicago, IL, USA). A normal distribution of the data was examined by Kolmogrov-Smirnov test. The demographic data was presented through descriptive statistics with an average ± standard deviation (SD) for normally distributed values and median and range for non-normally distributed data. For normally distributed data, an independent t-test was used to compare the age between genders (Mann-Whitney U test for non-normal distribution). To compare TEWL values at each time point and between genders, an analysis of variance (ANOVA) with Bonferroni post-hoc test was used (Friedman's test with Bonferroni post-hoc test for non-normal distribution). A *p*-value of less than 0.05 was regarded as being statistically significant.

RESULTS

This study contained forty-one healthy volunteers (61% female and 39% male) with an average age of 30.4±5.5 years. There was no statistical difference in age between both genders (p=0.190). The average room temperature was 23.20±0.89°C, and the relative humidity was 47.00±7.38%.

The TEWL value before water immersion ($TEWL_{baseline}$) was 13.16±7.27 g/m^2/h. After immersion, the TEWL value statistically increased at 3 minutes, and 5 minutes, (p<0.001) before rapidly decreasing during 10 to 30 minutes after immersion when it showed no statistical difference compared to the baseline (Table 1).

Cumulative TEWL after immersion, which reflects total water loss from the skin, was 23.2, 39.3, 54.1, 68.5, 82.1, 95.0 g/m^2/h at 3 minutes, 5 minutes, 10 minutes, 15 minutes, 20 minutes, and 30 minutes, respectively (Fig 1). Regarding the percentage of cumulative TEWL at different time points, 24.4%, 41.4% and 56.9% of TEWL occurred within 3 minutes, 5 minutes, and 10 minutes after immersion, respectively.

The baseline TEWL value in males was the same as in females (p=0.121). The TEWL values in both male and female volunteers increased after immersion in water (p<0.001), however, it became equal to before immersion at 10 minutes (p>0.05). The TEWL values in males were statistically higher than in females at 3 minutes, 5 minutes, and 15 minutes after immersion (Table 2). No side effects were reported from the testing.

DISCUSSION

Non-invasive biophysical skin parameters such as TEWL are widely accepted as a reliable tool for assessment of the skin barrier function. Dry skin is a common condition in many skin diseases. Regular bathing and application of moisturizer to hydrate the skin and prevent water loss is necessary. This study demonstrated a significant increase in TEWL post water immersion compared to the baseline, however, the value returned to the baseline levels after 10 minutes. The cumulative TEWL value within 10 minutes of testing was 56.9% of all water loss in 30 minutes. The baseline TEWL values showed no statistical difference between male and female, but TEWL values in males was higher than females until at least 15 minutes after immersion.

Our data confirmed results from previous studies which showed that TEWL increased after water application.[10,12-14] Although an increase in TEWL values usually relate to impairment of the skin barrier,[7-9,15] the increased in TEWL after immersion was not only due to an impaired skin barrier function. It is assumed that the skin absorbs

TABLE 1. Comparison of TEWL values at different time points.

Time	TEWL (mean±SD) g/m²/h	*p*-value compare to baseline	*p*-value compare to previous measurement
Before immersion (baseline)	13.16±7.27	-	-
3 min after immersion	23.21±7.67	<0.001*	<0.001*
5 min after immersion	16.12±3.42	<0.001*	<0.001*
10 min after immersion	14.76±6.36	1.000	0.166
15 min after immersion	14.45±6.67	1.000	0.656
20 min after immersion	13.53±4.67	1.000	1.000
30 min after immersion	12.96±5.18	1.000	1.000

*p-value <0.05 = statistical significance

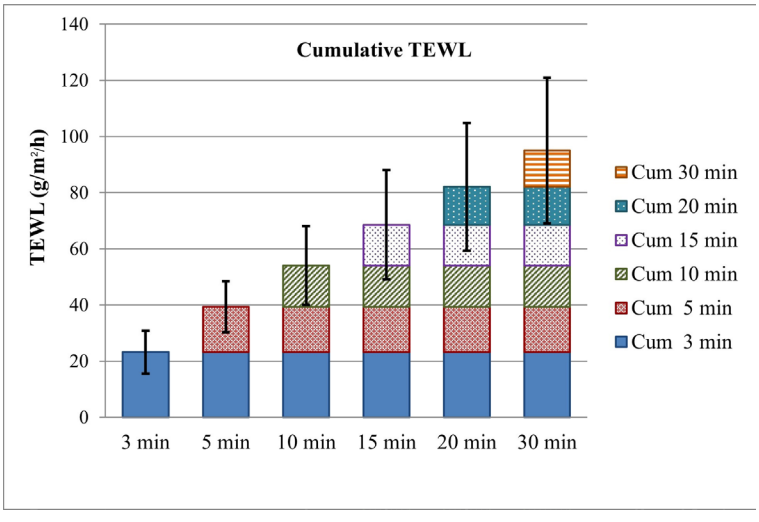

Fig 1. Cumulative TEWL at every time point after immersion.

TABLE 2. Comparison of TEWL values between genders at different time points.

Time	TEWL (mean±SD) g/m²/h		*p*-value compare between genders
	Male	Female	
Before immersion (baseline)	14.77±9.09	12.05±5.55	0.121
3 min after immersion	25.93±10.34	21.34±4.32	0.012*
5 min after immersion	16.84±3.34	15.61±1.79	0.048*
10 min after immersion	16.14±8.25	13.80±4.50	0.130
15 min after immersion	16.78±9.14	12.84±3.53	0.013*
20 min after immersion	14.32±4.84	12.98±4.53	0.237
30 min after immersion	12.94±2.52	12.97±5.18	0.979

*p-value <0.05 = statistical significance

water instantaneously after being immersed; however, the water-holding capacity of the SC is maintained only for a short period of time after which the remaining excess water evaporates from the skin leading to a gradual return to baseline levels.[10,14,16,17]

According to results obtained, immersion increased TEWL values and its accumulation correlates to an absolute total amount of water loss from the skin was high (56.9%) within 10 minutes after immersion.[15] If the TEWL continues, dry skin will get worse. Apply occlusive moisturizer as soon as possible after bathing to maintain SC water content should be recommended as part of the skin care regimen.[1,10,18] Patients with dry skin will benefit from occlusive moisturizer application when skin hydration is still retained.[10,18,19]

Although a precise definition of normal TEWL value does not exist,[8,20] variations in TEWL values have been well-documented.[2,5-7,20] A wide ranges of TEWL values are influenced by several endogenous, exogenous, and environmental factors.[8,20] There is insufficient evidence to conclude that gender affects TEWL.[20] While some studies did not observe much of a difference in TEWL values between genders,[4,15,21] others noticed higher TEWL values in males.[2,4,5,9,21] The baseline TEWL value in our study was not different between genders but the TEWL value after immersion was significantly higher in males who experienced more water loss from the skin than females, possibly due to different hormonal effects, skin conditions, barrier functions, and outdoor working habits and activities.[21]

This study has limitations because the duration of water exposure was only five minutes, which may be too short to reveal profound effects of skin barrier function structurally and functionally. Furthermore, this study measured only TEWL values, other biophysical parameters such as skin capacitance and pH might add more information about dynamic changes in the skin after water immersion. Hence, future studies with longer immersion duration, more frequent measurements, and a range of biophysical skin parameters should provide more helpful information.

CONCLUSION

In conclusion, this study evaluated the effects of the routine practice of water exposure through water immersion of the skin. Since the TEWL value increased significantly for a short period, it is reasonable to encourage the application of moisturizer immediately after bathing to prevent water loss from SC

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