



Transonychial Water Loss and Transepidermal Water Loss in Healthy Fingernails

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Abstract

The structure of the nail plate is different compared with the epidermis. It mainly comprises hard keratin and sulfur, which makes the nail plate thick and hard, resulting in different amounts of water loss. The study aimed to measure transonychial water loss (TOWL) and transepidermal water loss (TEWL) in order to collect data on healthy fingernails. To compare associated factors, such as age group, gender, and smoking, with the values of TOWL and TEWL. This research recruited 300 volunteers with healthy fingernails and measured thumbnails and dorsal hands using open-chamber Tewameter®. The mean value of TOWL on the left and right thumbnails was 3.36 g/m²h and 4.13 g/m²h, respectively. The mean value of TEWL on left and right dorsal hands was 8.57 g/m²h and 9.18 g/m²h. Both TOWL and TEWL significantly decreased with increasing age. TEWL in males was higher than in females. TEWL in smokers was higher than in non-smokers. The data could be used as a basis for comparison between normal and abnormal nail or skin conditions. TOWL and TEWL could benefit applications in diseases that involve stratum corneum breakdown, such as eczema or psoriasis, due to high water loss.

Keywords: *Transonychial Water Loss, Transepidermal Water Loss, TOWL, TEWL, Tewameter, Skin Hydration*

1. Introduction

The nail plate is a hard and convex structure, primarily composed of hard keratin containing a large amount of sulfur. The amino acid cysteine, which creates disulfide bonds, is concentrated in the nail plate, providing strength and rigidity compared to the skin (Baswan et al., 2017). The structure of the nail plate differs from that of the skin, resulting in different levels of transonychial water loss (TOWL) compared to transepidermal water loss (TEWL).

TOWL is defined as the insensible water loss from the body through the nail plate, while TEWL is defined as the insensible water loss from the body through the epidermal layer. Previous studies, such as those by Spruit (1971), reported higher TOWL values than TEWL values due to the higher transpiration rate of the nail compared to the epidermis. However, statistical significance was not observed due to the small number of participants recruited. Jemec et al. (1989) measured TOWL in 21 healthy volunteers and found that median TOWL was higher than TEWL due to differences in permeation patterns between the nail and epidermis, allowing water to pass through the nail approximately ten times faster than through the stratum corneum.

Various techniques have been developed to measure water loss from the nail and skin, resulting in different and wide ranges of TOWL and TEWL values. Two types of machines are commonly used for measuring water loss: open-chamber evaporimeters, as used by Jemec et al. (1989), Pinnagoda, and Sweden (1990) by G.E. Nelson, and closed-chamber vapometers, as used by Murdan et al. (2008). TOWL and TEWL values reported in the literature vary widely; for example, median TOWL was reported as 19.4 g/m²h, while TEWL from the dorsal left arm was reported as 5.6 g/m²h (Jemec, 1989), and TOWL values ranged from 28-

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75 g/m²h for fingernails and 26-48 g/m²h for toenails (Murdan, Hinsu, & Guimier, 2008). The wide range of results could be attributed to differences in measuring devices and techniques. Zaun (1977) suggested that the probe size and the contact between the probe and the nail plate might interfere with results if not fully concealed within the nail plate.

This research aims to collect TOWL and TEWL data from individuals with healthy fingernails using the open-chamber method and explore associations related to TOWL and TEWL.

2. Objectives

1) The aim is to collect data on transonychia water loss (TOWL) and transepidermal water loss (TEWL) from individuals with healthy fingernails using the Tewameter®.

2) Various factors such as age group trends, gender, and smoking habits are associated with transonychia water loss (TOWL) and transepidermal water loss (TEWL).

3. Materials and Methods

3.1 Study population

Healthy volunteers with no history of nail diseases were recruited to participate in this study. Participants were recruited for the TOWL and TEWL measurement prior to engaging in other activities. After obtaining informed consent, 300 volunteers were divided into two groups: 150 males and 150 females. The inclusion criteria were as follows: all participants were above 18 years old, had no history of nail or skin diseases upon clinical examination, and presented to the Out Patients Department (OPD) of Dermatology at Thailand Tobacco Monopoly Hospital. Volunteers were instructed not to use nail polish or varnish for at least 20 days prior to examination. Exclusion criteria included volunteers who refused to participate in the study, those with abnormal nails or nail diseases, and those with unreliable conditions or poor compliance.

3.2 Skin and nail barrier function measurements

Before measurement, volunteers were instructed not to immerse their hands in water, use alcohol, or apply cream for at least 1 hour (due to the COVID-19 pandemic). They were allowed to acclimatize for 20 minutes in a controlled room with a temperature range of 22-26°C and relative humidity of 40-70%. Transonychia water loss (TOWL) and transepidermal water loss (TEWL) were measured using the Tewameter® (TM300), all manufactured and calibrated by Courage and Khazaka (CK) electronic GmbH, Germany.

Thumbnail and dorsal hand measurements were taken from both hands. Thumbnails were chosen due to their thick and large nail plate area, which provided ample space for the probe and minimized the entry of water vapor from the perionychium. The dorsum of the participants' hands was selected as it was the closest area to the thumbnail and allowed for comparison between TOWL and TEWL. The probe included an open chamber with dimensions of 10 mm in diameter and 20 mm in height, connected to the Cutometer Dual MPA580®, which included sensors for determining temperature and relative humidity. Water loss values were calculated and expressed as g/m²h. Each measurement lasted 25 seconds and was repeated twice with a 20-second interval between measurements. The average value was used for interpretation. The probe was fixed in position and placed centrally on the nail plate within its proximal 1/3 and central part, while the finger was supported on a flat surface.

3.3 Statistical analyses

Descriptive statistics were used to summarize patient demographics. Transonychia water loss (TOWL) and transepidermal water loss (TEWL) were described using mean (g/m²h) and standard deviation

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(SD) for continuous data with a normal distribution and median for non-normally distributed data. The mean TOWL and TEWL values per skin and nail area were considered the primary outcome, with a 95% confidence interval for each summary measure. Since the data were non-normally distributed, the Mann-Whitney test was used for comparisons. To detect the possible influence of age, we created subgroups based on age and used Spearman's correlation to find associations.

3.4 Ethical consideration

The study protocol was approved by the Human Research Ethics Committee of Thammasat University (Medicine) (MTU-EC-OO-0-029/66), which is in full compliance with the International Guidelines for Human Research Protection such as the Helsinki Declaration of 1975, as revised in 1983.

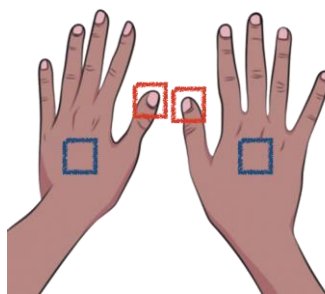


Figure 1 Measurement locations

4. Results

Table 1 Among the 300 participants, TOWL was consistently lower than TEWL. The average transonychia water loss (TOWL) in the left thumbnail (3.36 g/m²h) was significantly lower than the average transepidermal water loss (TEWL) in the left dorsal hand (8.57 g/m²h). Similarly, the TOWL in the right thumbnail (4.13 g/m²h) was lower than the TEWL in the right dorsal hand (9.18 g/m²h).

Table 2 Participants were categorized by age group, revealing a consistent decrease in nail and skin water loss with advancing age. Nail water loss, represented by TOWL in the left and right thumbnails, gradually decreased with age (from 4.09 g/m²h to 1.89 g/m²h on the left and from 4.50 g/m²h to 3.12 g/m²h on the right). Similarly, skin water loss exhibited the same trend, with TEWL of the left and right dorsal hands decreasing as age advanced (from 9.72 g/m²h to 4.85 g/m²h on the left and from 9.91 g/m²h to 6.50 g/m²h on the right). Spearman's correlation analysis revealed a negative correlation between water loss values and age, with p-values less than 0.05 for all parameters.

Table 3 Gender differences were observed, with males exhibiting higher water loss than females in both nails and hands.

Table 4 Smokers demonstrated higher water loss values than non-smokers in both nails and skin. However, statistically significant differences were observed only in TEWL.

5. Discussion

The results indicated that the dorsal hand's transonychia water loss (TOWL) was lower than transepidermal water loss (TEWL) from the thumbnail. This discrepancy could be attributed to the absence of sweat glands in both the nail plate and nail bed, resulting in imperceptible water loss from the nails (Jemec et al., 1989). The nail plate consisted of three layers—dorsal, intermediate, and ventral—composed mainly

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of hard keratin. The alignment of keratin fibers, particularly in the intermediate layer, contributed to the toughness of the nail plate, making it thicker than the epidermis and resulting in a lower rate of water loss (Baswan et al., 2017).

Water loss from the nail plate decreased with age, corresponding to lower TEWL from the dorsal hand in ageing individuals compared to younger ones. Age-related alterations in nail plate thickness, including increased transverse convexity and structural changes such as fissuring and striation, contributed to the decrease in TOWL (Abdullah et al., 2011). Additionally, changes in baseline skin hydration could explain the negative trend in TEWL with age. Ageing skin exhibited reduced moisture content and hyaluronic acid levels, resulting in decreased water loss due to diminished water-retaining capacity (Papakonstantinou et al., 2012).

Males demonstrated higher water loss than females in skin and nails, potentially due to greater outdoor activities, increased sun exposure, and less frequent use of hand creams. However, this finding contradicted previous studies that reported equal TEWL in both sexes, suggesting further investigation was needed (Corballis, 2014; Purnamawati et al., 2017).

There was no significant difference in TOWL between smokers and non-smokers in both hands, but smokers exhibited higher skin water loss. This was attributed to the direct impairment of skin barriers by reactive oxygen species present in smoke, impacting keratinocytes (Kantor et al., 2016).

Limitations of the study included the small number of participants, most of whom were hospital staff potentially affecting TOWL and TEWL measurements due to frequent hand washing. Additionally, the selection of measurement locations—thumb fingernails and dorsal hands—was constrained by the probe size of the Tewameter® and may have introduced measurement inaccuracies. Finally, the use of an open-chamber Tewameter® could have been affected by external air during measurements, potentially influencing the results.

Table 1 Average TOWL and TEWL of 300 participants

Area	Mean TOWL and TEWL	
	Mean± SD.	p-value
Lt. thumb	3.36 ± 2.35	<0.001*
Lt. dorsum	8.57 ± 3.98	
Rt. thumb	4.13 ± 2.56	<0.001*
Rt. dorsum	9.18 ± 4.24	

Table 2 Average TOWL and TEWL by age group

Area	Age								Spearman's correlation	
	18-20	21-30	31-40	41-50	51-60	61-70	71-80	>80	p-value	r
	Mean± SD.	Mean± SD.	Mean± SD.	Mean± SD.	Mean± SD.	Mean± SD.	Mean± SD.	Mean± SD.		
Lt. thumb	3.58 ± 0.84	4.09 ± 2.55	3.61 ± 2.49	3.58 ± 2.14	3.06 ± 2.17	3.17 ± 2.47	2.84 ± 2.01	1.89 ± 1.7	<0.001*	-0.229
Lt. dorsum	9.72 ± 5.93	9.26 ± 3.59	9.49 ± 3.23	9.68 ± 4.02	8.35 ± 3.82	8.32 ± 4.74	7.23 ± 3.65	4.85 ± 2.7	<0.001*	-0.299
Rt. thumb	3.32 ± 2.83	4.5 ± 2.84	4.64 ± 2.34	4.2 ± 2.84	4.07 ± 2.59	4.05 ± 2.32	3.38 ± 2.47	3.12 ± 2.01	0.014*	-0.142
Rt. dorsum	9.91 ± 3.68	9.74 ± 3.96	10.13 ± 3.08	9.35 ± 4.2	9.91 ± 5.11	8.43 ± 4.51	8.15 ± 4.61	6.5 ± 3.69	<0.001*	-0.265

**Table 3** Gender

Area	Intrinsic factors			
	Gender			
	Gender	n	Mean± SD.	p-value
Lt. thumb	Male	150	3.62 ± 2.45	0.061
	Female	150	3.11 ± 2.23	
Lt. dorsum	Male	150	4.36 ± 2.68	0.116
	Female	150	3.89 ± 2.41	
Rt. Thumb	Male	150	9.40 ± 4.10	<0.001*
	Female	150	7.74 ± 3.69	
Rt. Dorsum	Male	150	9.88 ± 3.99	<0.001*
	Female	150	8.48 ± 4.37	

Independent t-test

Table 4 Smoking

Area	Extrinsic factors			
	Smoking			
	smoking	n	Median	p-value
Lt. thumb	No	263	2.75	0.050
	Yes	37	3.50	
Lt. dorsum	No	263	7.55	<0.001*
	Yes	37	11.45	
Rt. Thumb	No	263	3.75	0.250
	Yes	37	4.55	
Rt. Dorsum	No	263	8.20	<0.001*
	Yes	37	11.05	

Mann-Whitney test

6. Conclusion

The results revealed variations in sample groups in transonychia water loss (TOWL) and transepidermal water loss (TEWL). Factors such as age group, gender, and smoking were found to be associated with water loss. This data could serve as a valuable reference for comparing water loss patterns in healthy adults versus individuals with nail or skin diseases. It is anticipated that the ratio between TOWL and TEWL might be higher in individuals with abnormal nails and skin due to structural abnormalities in the nail, stratum corneum, and skin barriers. This suggests potential implications for assessing and managing conditions affecting the nails and skin.

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