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# Validation of GPSkin Barrier® for assessing epidermal permeability barrier function and stratum corneum hydration in humans

L. Ye[1] | Z. Wang[2] | Z. Li[3] | C. Lv[1] | M.-Q. Man[4]

[1]Dalian Skin Disease Hospital, Dalian, Liaoning, China

[2]Department of Dermatology, The 7th People's Hospital of Shenyang City, Shenyang, Liaoning, China

[3]Department of Dermatology, The 2nd Affiliated Hospital of Xi'an Jiaotong University, Xi'an, Shaanxi, China

[4]Dermatology Services, Veterans Affair Medical Center and University of California, San Francisco, CA, USA

**Correspondence**
M.-Q. Man, Dermatology Services, Veterans Affair Medical Center and University of California San Francisco, CA, USA.
Email: mqman@hotmail.com
and
C. Lv, Dalian Skin Disease Hospital, Dalian, Liaoning, China.
Email: dlpfb@163.com

## Abstract

**Background**: Measurements of transepidermal water loss (TEWL) and stratum corneum (SC) hydration are important for assessing epidermal functions. However, the availability of reliable and user-friendly devices, which can simultaneously measure both TEWL and SC hydration and can allow health providers to remotely access data in time, is limited.

**Materials and Methods**: GPSkin Barrier® was compared with MPA5 system in the measurements of TEWL and SC hydration on the cheek, the dorsal hand, and the forearm in 200 normal volunteers, including 126 females and 74 males, aged 1-78 years with an average age of 45.24 ± 1.04 years. Correlation of data measured with MPA5 system and GPSkin Barrier® was determined.

**Results**: Levels of both TEWL and SC hydration measured with the Barrie GPSkin Barrier® were lower than that with MPA5 system on all 3 body sites except for hydration on the cheek. The levels of both TEWL and SC hydration measured with GpSkin Barrier® were correlated well with that measured with MPA5 system on all 3 body sites

**Conclusions**: GPSkin Barrier® is a reliable, affordable, and versatile device for assessing epidermal permeability barrier function and SC hydration.

KEYWORDS

epidermal permeability barrier, epidermis, GPSkin Barrier®, hydration, stratum corneum, transepidermal water loss

## 1 | INTRODUCTION

Nowadays, the importance of measuring epidermal biophysical properties, including stratum corneum (SC) hydration and transepidermal water loss (TEWL) rates, is widely appreciated in both clinical and nonclinical settings. Both SC hydration levels and TEWL rates can reflect systemic conditions in humans. For example, both normal-aged humans and hemodialysis patients exhibit reduced levels of SC hydration.[1,2] SC hydration levels decline in postmenopausal women, while systemic administration of estrogen improves SC hydration in women. Likewise, SC hydration also reduces in growth hormone deficient patients. Moreover, the extent of reductions in SC hydration positively correlates with the levels of fasting plasma glucose in patients with diabetes.[3] In addition, both TEWL and SC hydration can serve as indicators of cutaneous conditions. Patients with either atopic dermatitis or psoriasis display elevated TEWL rates and reduced levels of SC hydration,[4,5] which both are associated with disease severity.[6] Similarly, sun exposure increases TEWL rates and lowers SC hydration levels depending on the doses of sun exposure.[7] Furthermore, radiotherapy can decrease SC hydration. Taken together, the measurements of TEWL and SC hydration are useful for assessing changes in both systemic and cutaneous conditions.

The measurements of TEWL rates and SC hydration levels are also valuable approaches in the development of many

pharmaceutical and skin care products.[8] Importantly, certain cutaneous adverse reactions induced by skin care products can be easily identified by the measurements of TEWL and SC hydration.[9] Finally, the measurements of TEWL and SC hydration have been used to assess the therapeutic efficacy for some skin disorders, such as atopic dermatitis and psoriasis. Among dermatoses, both atopic dermatitis and psoriasis are relapsing skin disorders, which are driven by epidermal dysfunction. Maintenance of TEWL rates and SC hydration at normal levels can prevent or delay the relapse of atopic dermatitis and psoriasis. Routinely monitoring TEWL rates and SC hydration levels are crucial to determine when regimen of improving epidermal function should be started. The measurements of TEWL rates and SC hydration levels are also helpful to dynamically assess the progress of therapeutic efficacy and to help physicians decide whether the therapeutic regimens, including dosage and type of treatment, should be changed, which is critical to reduce both medical costs and adverse events. For such sakes, home-based monitors of TEWL rates and SC hydration levels are essential for the management of certain dermatoses, such as atopic dermatitis and psoriasis. Although an MPA system with Corneometer® CM 825 and Tewameter® TM300 probes is available for the measurements of SC hydration and TEWL rates, this system is costly and a laptop is required. Closed chamber device, such as VapoMeter SWL4001TJ (Delfin Technologies), is portable and easy to use. However, it only measures TEWL rates, and healthcare providers cannot access data remotely if patients take measurements at home. For the measurement of SC hydration, many portable skin moisture analyzers are available on the markets. Again, the data are not readily available to healthcare providers in time, which will delay making decision on how to manage the diseases. Now a new developed device, GPSkin Barrier®, can simultaneously measure both the TEWL rates and SC hydration levels. The data can be instantly transmitted to an Internet server via a smartphone using bluetooth technology. In the present study, we compared Corneometer® CM 825 and Tewameter® TM300 with GPSkin Barrier® in assessing TEWL rates and SC hydration levels in a Chinese population.

## 1.1 | Subjects

A total of 200 volunteers, 74 males and 126 females aged 1-78 years, were enrolled in this study (Table 1). All subjects had no skin lesions on the measurement sites. No skin care products were applied to the measured sites 24 h prior to the measurement being taken, and the measured sites were not washed with soaps or detergents for at least 12 h prior to the measurements.

**TABLE 1** Demographic characteristics of subjects

| Gender | Number | Mean age | Median age |
|---|---|---|---|
| Females | 126 | 44.59 ± 1.25 | 41 |
| Males | 74 | 46.34 ± 1.83 | 46.5 |
| Total | 200 | 45.24 ± 1.04 | 43 |

## 1.2 | Instruments

### 1.2.1 | TM300® and Corneometer CM 825® probes

Both the Corneometer® CM 825 and Tewameter® TM300 probes are manufactured by Courage-Khazaka Electronic GmbH (Köln, Germany). The Corneometer® CM825 measurement is based on capacitance measurement of a dielectric medium in the skin. It uses fringing field capacitance sensors to measure the dielectric constant of the skin. The dielectric constant of skin will change with water content. This allows any changes in skin hydration to be measured. These changes in SC water content are converted into arbitrary units. Measurement frequency ranges from 0.9 to 1.2 MHz. The measurement time is about 1 s.[10] The Tewameter® TM300 uses opened chamber method to measure TEWL, based on the diffusion principle in an opened chamber. The probe consists of a hollow cylinder with 2 pairs of sensors measuring temperature and humidity, 1 pair slightly higher than the other. It measures the moisture at 2 different sites, and from this, the TEWL can be calculated.[11] Measurement time varies depending on the user's setting.

### 1.2.2 | GPSkin Barrier®

GPSkin Barrier®, sized 32 mm (W) x 32 mm (D) x 160 mm(H) and weighed 40 g, is made by GPOWER Inc, (Seoul, South Korea) (Figure 1A). Probe tip is a closed chamber with water loss sensor on the top and skin hydration sensors on the edge of the chamber (Figure 1B,C). Skin hydration sensors are composed of 2 probes (Figure 1C), measuring bioelectrical impedance. SC hydration is based on the same principle of Corneometer® CM825, except the measurement frequency of 1 kHz, while the principle of measuring TEWL is the same as the closed unventilated chamber made by Delfin Technologies. The data of measurements can also be transmitted to an Internet server via a smartphone. Authorized personnel can access data, including the values of TEWL and SC hydration, and the time of measurements taken, remotely via login the Internet server.

### 1.2.3 | Measurements

All measurements were performed by Ye L. TEWL and SC hydration were measured on the cheek, the dorsal hand, and the forearm (flexor site) with TM300® and Corneometer CM825®, respectively, attached to a Courage & Khazaka MPA5 system.[5] Readings were taken with a laptop connected to MPA5. When using GpSkin Barrier®, perpendicularly placing the device on the measurement site for 10 s (Figure 1D), both TEWL and SC hydration readings will be shown on a smartphone. The interpretation of results will also be shown on the smartphone. This work was performed during the month of August, 2017 at the Dalian Skin Disease Hospital, which is at latitude of 38°43′-40°10′ N. The study protocol was approved by

the Human Research Committee of Dalian Skin Disease Hospital, the People's Republic of China.

### 1.3 | Statistics

Data are expressed as the mean ± SEM. GraphPad Prism 4 software (San Diego, CA, USA) was used for all statistical analyses. Mann-Whitney test was used to determine the statistical significances between these 2 devices.

## 2 | RESULTS

### 2.1 | Comparison of corneometer CM825® and GpSkin Barrier® in assessing SC hydration

The levels of SC hydration measured with GpSkin Barrier® and Corneometer CM825® were comparable on the cheek. However, on the dorsal hand and the forearm, levels of SC hydration measured with GpSkin Barrier® were lower than that with Corneometer CM825® (Table 2). Notably, readings with both devices were within the normal range as previously reported in a Chinese population.[1] The readings with Corneometer CM825® were correlated well with that with GpSkin Barrier® (Figure 2). These results demonstrate that GpSkin Barrier® could be a reliable device for measuring SC hydration.

### 2.2 | Comparison of Tewameter TM300® and GpSkin Barrier® in measuring TEWL

Using Tewameter TM300®, the average reading of TEWL rates on 3 body sites ranged from 18 to 22 g/m$^2$/hr while with GpSkin Barrier®, TEWL rates ranged from 11 to 15 g/m$^2$/hr (Table 3). Again, the readings with Tewameter TM300® were correlated well with those with GpSkin Barrier® (Figure 3). These results indicate that GpSkin Barrier® is also a reliable tool to measure TEWL rates in humans.

## 3 | DISCUSSION

Although many devices are available for the measurements of TEWL rates and SC hydration levels, an availability of a single device simultaneously measuring both parameters is limited. In addition to its low cost and versatility, GpSkin Barrier® can instantly transmit the readings of both TEWL rates and SC hydration to an Internet server where authorized users can freely review and track both TEWL rates and SC hydration levels of each subjects. Moreover, with GpSkin Barrier®, the interpretations of TEWL and SC hydration results can be shown on a smartphone, allowing even ordinary people to understand their skin conditions. Regarding the reliability, Tewameter TM300® yields a higher

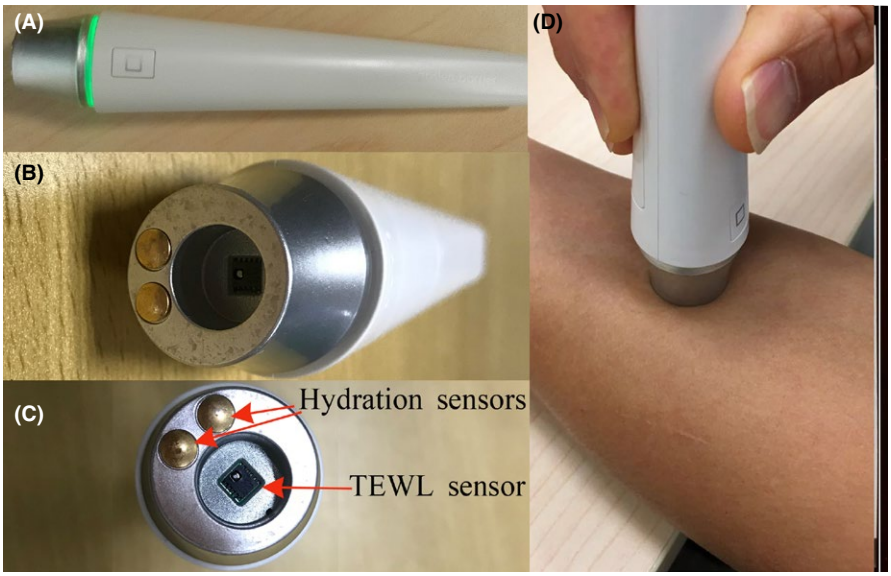


**FIGURE 1** GPSkin Barrier®. (A) is the picture of GPSkin Barrier®. (B) and (C) show the sensors of TEWL and SC hydration, while (D) shows how to make measurement

**TABLE 2** Comparison of CM825® and GPSkin barrier® for measuring SC hydration

| | Cheek | | Forearm | | Dorsal hand | |
|---|---|---|---|---|---|---|
| | CM825® | GPSkin barrier® | CM825® | GPSkin barrier® | CM825® | GPSkin barrier® |
| Median | 45.5 | 48 | 58.5 | 49 | 60 | 49 |
| 75% percentile | 56.5 | 56 | 67.5 | 55 | 69 | 54 |
| Maximum | 83 | 73 | 92 | 68 | 104 | 90 |
| Mean ± SEM | 46.18 ± 1.04 | 46.61 ± 0.89 | 58.22 ± 0.94 | 45.75 ± 0.87 | 60.00 ± 1.05 | 46.07 ± 0.88 |
| Significance | NS | | $P < .0001$ | | $P < .0001$ | |

TEWL readings compared with GpSkin Barrier®, consistent with previous findings that TEWL readings with closed unventilated chamber are lower than that with Tewameter. The higher readings with Tewameter TM300® could be due to the influence of ambient conditions because its opened chamber makes Tewameter TM300® more vulnerable to the effects of ambient conditions, such as ventilation, temperature, and humidity. In the present study, TEWL rates with Tewameter TM300® were ≈18-22 g/m$^2$/hr. In contrast, TEWL readings with GpSkin Barrier® were ≈11-15 g/m$^2$/hr, consistent with previous studies (≈10-15 g/m$^2$/hr) in normal humans at Dalian area.[5,12] Nevertheless, TEWL readings measured with GpSkin Barrier® were correlated with Tewameter

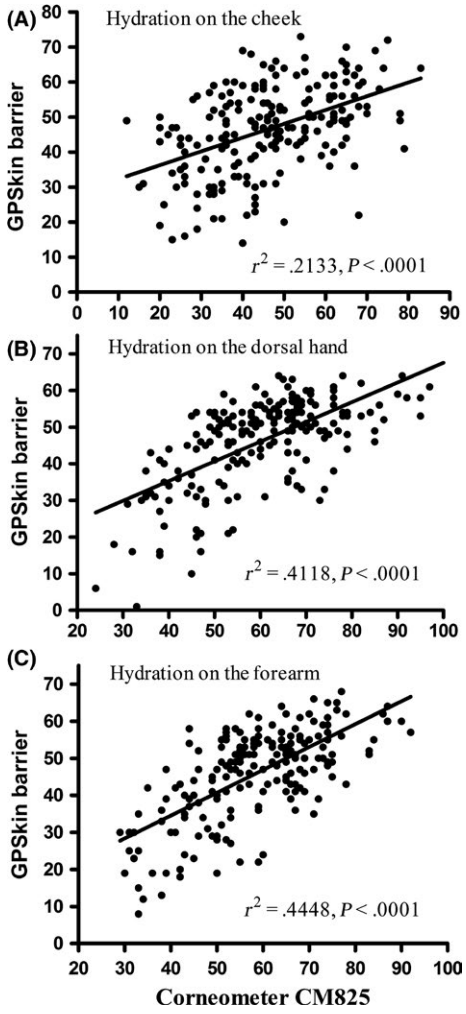


**FIGURE 2** Comparison of Corneometer CM825® and GpSkin barrier® for assessing SC hydration. (A) displays the correlation of Corneometer CM825® and GpSkin barrier® in assessing SC hydration levels on the cheek. (B) and (C) are the correlations of Corneometer CM825® and GpSkin barrier® in assessing SC hydration levels on the dorsal hand and the forearm, respectively

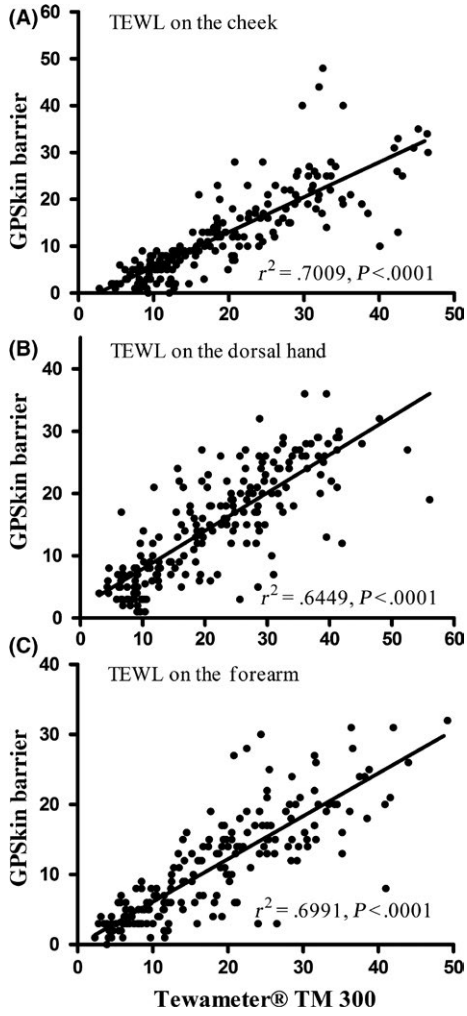


**FIGURE 3** Comparison of Tewameter TM300® and GpSkin barrier® for assessing TEWL. (A) illustrates the correlation of Tewameter TM300® and GpSkin barrier® in measuring TEWL rates on the cheek. (B) and (C) are the correlations of Tewameter TM300® and GpSkin barrier® in measuring TEWL rates on the dorsal hand and the forearm, respectively

**TABLE 3** Comparison of TM300® and GPSkin barrier® for measuring TEWL

| | Cheek | | Forearm | | Dorsal hand | |
|---|---|---|---|---|---|---|
| | TM300® | GPSkin barrier® | TM300® | GPSkin barrier® | TM300® | GPSkin barrier® |
| Median | 17.5 | 10 | 16.35 | 9.5 | 20.65 | 15 |
| 75% percentile | 26.15 | 17.5 | 25.2 | 15.5 | 29.55 | 22 |
| Maximum | 46.5 | 48 | 49.2 | 32 | 56.1 | 36 |
| Mean ± SEM | 19.08 ± 0.77 | 12.34 ± 0.65 | 17.80 ± 0.73 | 10.87 ± 0.54 | 21.57 ± 0.80 | 14.96 ± 0.61 |
| Significance | $P < .0001$ | | $P < .0001$ | | $P < .0001$ | |

TM300®. Regarding to SC hydration, GpSkin Barrier® appears less sensitive than Corneometer CM825®. However, data obtained with GpSkin Barrier® were comparable to that in previous studies with Corneometer CM825®.[1,5] It is unclear why the readings of SC hydration with Corneometer CM825® were higher than that with GpSkin Barrier®. One possibility is the difference in the frequency between these 2 devices (0.9-1.2 MHz vs 1KHz). Regardless of the differences in the readings of SC hydration, SC hydration levels measured with GpSkin Barrier® was positively correlated with that measured with Corneometer CM825®. Although GpSkin Barrier® yields lower readings in both TEWL and SC hydration in comparison with Tewameter TM300® and CM825®, these readings still fall in the normal ranges. Thus, GpSkin Barrier® can be a reliable device for assessing SC hydration and TEWL in humans.

In conclusion, GpSkin Barrier® is a reliable and versatile device for assessing epidermal permeability barrier function and SC hydration. It could be used to monitor TEWL and SC hydration in both clinical and nonclinical settings.

## AUTHOR CONTRIBUTIONS

LY and CL performed the experiments and supervised the clinical studies; ZW, ZL, CL, and MQM interpreted data; MQM originated the concept, designed experiments, analyzed, and interpreted data. CL and MQM wrote the manuscript.

## ORCID

*Y. Li* http://orcid.org/0000-0002-7834-9048
*M.-Q. Man* http://orcid.org/0000-0002-0957-4903

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