Received: 16 January 2020 | Accepted: 29 February 2020

DOI: 10.1111/srt.12862

WILEY

ORIGINAL ARTICLE

Self-recording the skin hydration and Trans-Epidermal Water Loss parameters: A pilot study

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Funding information
The costings of the present work were entirely met by the L'Oréal Research & Innovation Department.

Abstract

Objective: To evaluate the reliability of data self-recorded by subjects enrolled in a study for skin surface hydration and Trans-Epidermal Water Loss (TEWL).

Methods: A connected device, previously described, simultaneously records both the hydration status and the TEWL on the same skin site. The effects of a Xanthane-based gel containing low concentrations of glycerol (3% or 7%) applied on both face and forearms of Caucasian women, were self-recorded at various times for 24 hours, outside of Research facility.

Results: In the first-hour post application, the skin hydration and TEWL values show a sharp increase and decrease, respectively. They progressively recover their initial values 24 hours post washing, on both skin sites. A significant dose effect of glycerol (ie, 3% vs 7%) was obtained on both skin sites. The repeatability of data was found acceptable in both parameters, although more precise on arms than face, probably linked to an easier handling of the device.

Conclusion: The use of this skin measuring connected device outside of Research facility, following a training of subjects, leads to reliable data. Such approach could be extended to other connected devices.

KEYWORDS

clinical study, connected and digital, hydration, nomad device, trans-epidermal water loss

1 | INTRODUCTION

Three recent papers[1-3] described a new Instrument—GPkSin® (GPOWER) represented in Figure 1—that records, in vivo, both the skin hydration status and the TEWL on the same skin site (a small skin area, ≈1 cm^2) within seconds, since integrating two probes within the same body. As this instrument is connected to a smartphone application via a Bluetooth system, the provided data are immediately transferred, together with date, time of the recording and environmental Temperature (C°). Not only the skin hydration status and TEWL values given by the GPSkin® were found highly correlated to other validated instruments[4,5]—Corneometer® (Courage and Khazaka Company™), Tewameter® (Courage and Khazaka Company™), Aquaflux AF200® (Biox systems™)—but they were accurate enough to significantly differentiate two formulae containing slightly different and low Glycerol contents (eg, 7% and 10% w/w). In addition, as important finding, this instrument showed that the skin hydration provided by a formula with a very high glycerol content (40%), reduced the TEWL by about 50% on the same skin site.

Although of an easy handling (ergonomic, light, etc), the GPSkin® body has nevertheless to be gently applied perpendicularly onto the skin surface, a positioning needed by the TEWL probe to fully perform. Such verticality is less a limiting factor in the recording of the skin hydration as the two impedance-measuring electrodes (located in the skin-contacting crown) are always closely connected to the skin surface. These conditions were met in two previously quoted studies[1,3]

FIGURE 1 Illustrations of the GPSkin probe from different views. The two yellow circles represent the surface hydration sensors; the black square is the RH% sensor located at the bottom of the chamber

since performed by skilled technicians, fully aware of this requirement in the handling of the instrument and its combined probes.

As this instrument and its associated smartphone application could in theory suit to self-recordings by subjects under test (ie, in a nomad way), a pilot study was organized to check the accuracy and the reproducibility of the data, when self-measured by a panel of women, following the application onto their faces and forearms of the same hydrating gel. The latter, Xanthane-based, was the same previously used,[3] formulated with two different but low concentrations of Glycerol (3% and 7% w/w), aiming at assessing the accuracy and significance of self-measurements when performed under less controlled conditions. The results of this study are the objects of the present paper.

2 | MATERIAL AND METHODS

2.1 | Subjects

Healthy Caucasian (French) women, aged 45-60 years, were recruited through an agency specialized in part-time occupations. Among them, 20 were selected and enrolled by a dermatologist for presenting a moderate dry skin on both cheeks and ventral forearms. They were fully informed about the purpose of the study, the description of the instrument, its necessary handling, stored the blue tooth application on their smartphones, and signed an informed consent.

2.2 | Protocol

The adopted protocol was designed as an "after vs before" (T_x vs T_0) procedure, needing no control, such as a glycerol-free Xanthane gel, as the latter was previously shown of a weak influence on both parameters.[3]

Subjects came to our facility with bare skin and performed two successive measurements (T_0) on two close regions of their two cheeks and forearms. Then subjects applied themselves either the 3% (Product A) or 7% glycerol (product B) Xanthane-based gel onto whole face at a free dose and ventral forearm (areas previously delimited by carton frames) at doses of 2 mg/cm^2.

Before returning to their occupations or at home, they were asked not to wash their faces and forearms during the day and overnight and each subject left our Research facility with a GPSkin® instrument having stored the blue tooth application on their smartphones. Two successive measurements were self-performed at 1, 2, 3, 4, 5, and 6 hours (T_1 to T_6) on two close sites of right and left cheeks and forearms. As for TEWL recordings, subjects were asked, for measurements performed on the cheeks, to adopt among all times of measurements same position, to have similar positioning of the instrument, ideally vertical, and to not apply pressure on skin with the probe. They were asked to perform the same measurement the next morning (T_7, ie, about 20 hours after T_6) before washing their faces and forearms with their own routine cleanser. Fifteen minutes later, they were asked to repeat the same measurements (T_{7b}). The same morning, when arriving in our facility (ie, about 24 hours after T_0), they immediately repeated the same procedure (T_8) and, again, 15 minutes later (T_{8b}). T_{8c} then gathered the average values of T_8 and T_{8b}. At all times, values recorded by the instrument were automatically transmitted to our secured web site though the smartphone application.

This protocol thus allowed to integrate, in theory, 1760 individual data (11 timings, 4 areas, 2 repetitions, 20 subjects). However, as one subject failed at transmitting her measurements at T_2, her other recorded values were not taken into account, thereby leading to 1672 exploitable values.

2.3 | Statistics

All paired comparisons (product A vs product B or between skin sites) were calculated through the Student *t* test, using SPSS® software package (IBM). A $P < .05$ was taken as threshold of significance.

3 | RESULTS

3.1 | Skin hydration

Figures 2 and 3 illustrate the changes in skin hydration (mean ± confidence interval, C.I) along the 24 hours, brought by products A & B in both face and forearm. A sharp and significant increase in hydration (ranging 10-26 units according to sites and products) is recorded at T_1 that progressively diminishes thereafter. The effects of the two glycerol concentrations (3% and 7%) are significantly differentiated on both skin sites from T_1 to T_7 ($P < .001$ to $P < .05$) according to timings. The

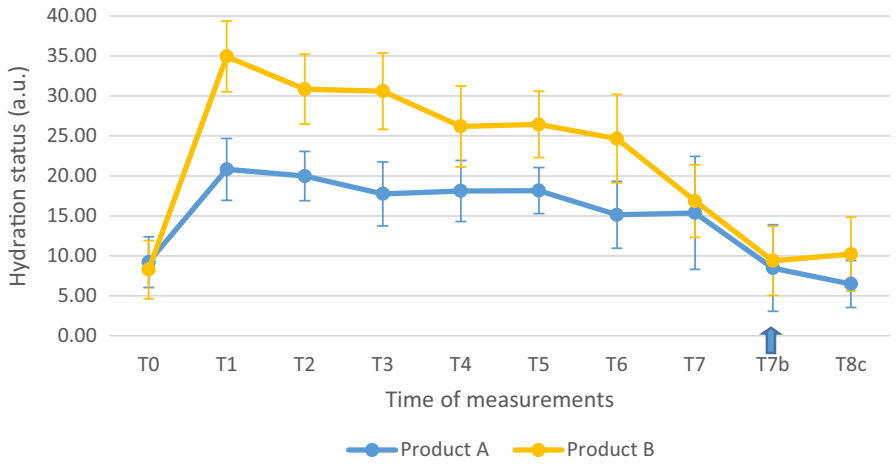

FIGURE 2 Changes in hydration with time (Mean ± C.I) on face brought by products A and B. The blue arrow refers to washing moment

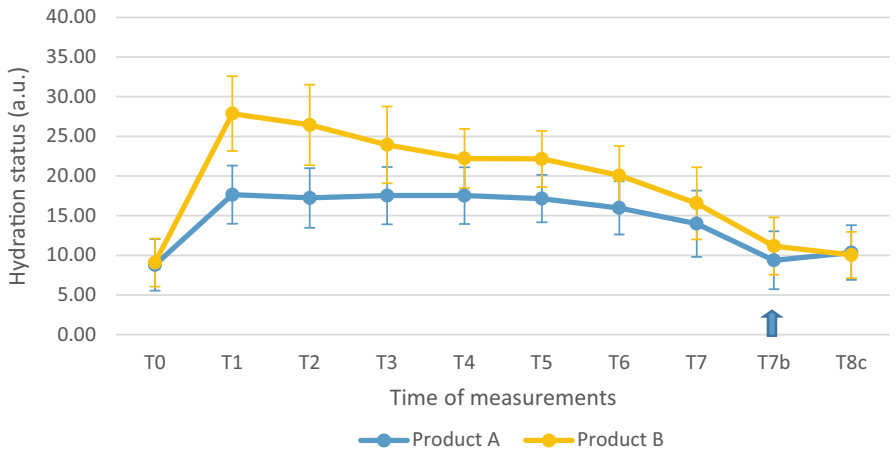

FIGURE 3 Changes in hydration with time (Mean ± C.I) on forearm brought by products A and B. The blue arrow refers to washing moment

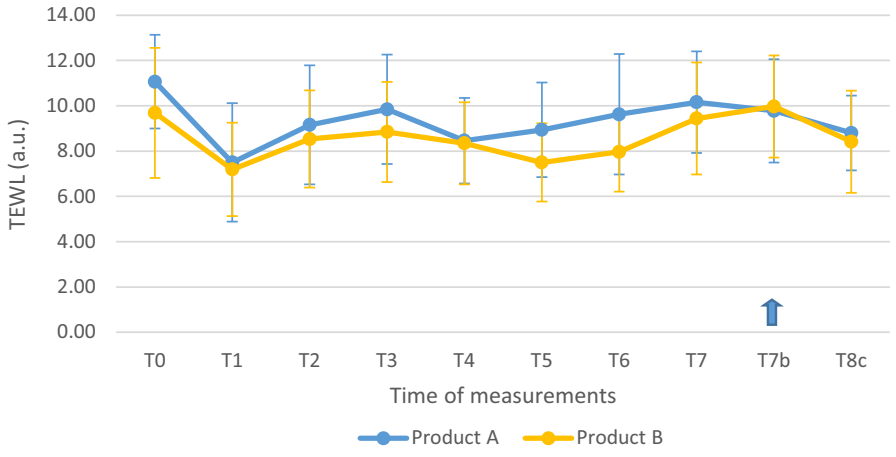

FIGURE 4 Changes in the TEWL (Mean ± C.I) with time on face induced by products A and B. The blue arrow refers to washing moment

hydrating effect of both product B appears significantly of a higher amplitude on the cheeks than that of forearm. Post wash (T_{8c}), all values of both skin sites, recovered their initial T_0 levels. Surprisingly, the hydration brought by product B (7% glycerol) applied on the face, although higher, shows a faster rate of decreasing efficacy in 20 hours from T_1 to T_7. Albeit of a lesser hydrating effect, product A (3% glycerol), shows a rather more lingering pattern along this same 20 hours-time frame.

With regard to skin sites, Figures 1 and 2 strongly show that the skin hydration of the cheeks brought by product B, is significantly of a larger amplitude ($P < .02$) than that of forearm. This finding is not statistically confirmed with product A (lower glycerol content). These differences suggest different hydrating "needs" between these two skin regions, that is, that hydrating the arm does not require a high concentration of glycerol, as compared to face.

3.2 | Trans-Epidermal Water Loss (TEWL)

Figures 4 and 5 illustrate the changes in TEWL with time on both skin sites. From T_0 to T_1, a sharp and significant drop ($P < .02$) by

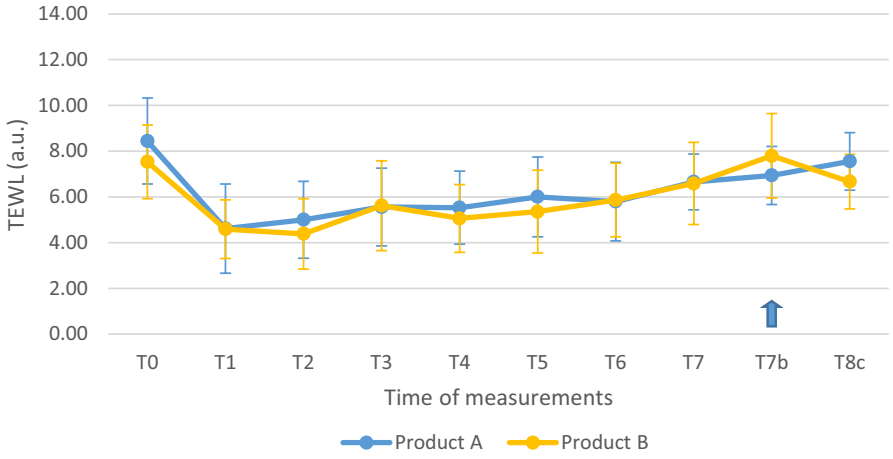

FIGURE 5 Changes in the TEWL (Mean ± C.I) with time on forearm induced by products A and B. The blue arrow refers to washing moment

Absolute differences	TEWL/Arm	TEWL/Face	Hydration/Arm	Hydration/Face
Mean	2.96	3.85	5.21	6.22
S.D	4.49	7.06	11.00	11.72

TABLE 1 Average absolute differences and variabilities (S.D) between two successive measurements on both skin sites

about 4 units is observed in both skin sites, dose dependent according to products B and A, noting that the TEWL of the face shows higher values than of the forearms. From T_1 to T_7, both skin sites progressively recover their ante values. Of note, the TEWL of forearms does not present significant differences between products B and A.

There again, similarly to hydration, the two skin sites respond differently to the impact of glycerol. Of note, the sharp increase in hydration in the first hour has is associated with a comparable sharp decrease in TEWL in the same period of time for both products.

3.3 | Repeatability of the measurements

As subjects performed two successive measurements on the same skin site, their average absolute differences and variability (S.D), in their own units, can be calculated. These are illustrated by Table 1 that clearly shows that the variability (S.D) of the self-measurements of both parameters is weaker on arms than face, especially since hydration presents a larger range of variability (0-40) than TEWL (0-15).

4 | DISCUSSION

As pilot study, the present work suggests that some investigations could be carried out in a nomad way, avoiding displacements in a given Research facility. In brief, taking the GPkSin® as model, thanks to its smartphone application, subjects can record and transmit some of their skin parameters in real time with, in the studied case, an acceptable reliability.

As a matter of fact, the low concentrations of glycerol were deliberately chosen for best assessing the limits of accuracy of the measurements performed under less controlled conditions. In brief, such a methodological approach could concern both cosmetic and physician researchers in their needs of a long-term follow-up of the cutaneous impact of a product or a given medical treatment.

However, the present study owns intrinsic limitations since carried out within a 24-hours period, where subjects were likely very respectful to the protocol.[6] Hence, their own respect of long-term protocols (weeks, months), with regard to their daily-life occupations, may well be impaired, therefore possibly leading to questionable data. The two skin parameters that were simultaneously recorded unsurprisingly obeyed to some rationale where an increase in skin hydration is rapidly obtained (within 1 hour), in agreement with previous findings where the *Stratum Corneum* (S.C) barrier has been shown playing a major role.[7-12] The sharp but limited drop of TEWL, during this 1-hour period, likely reflects the capacity of glycerol to bind and to slightly decrease the water flux issued by deeper skin structures (epidermis, dermis), at least provisory. Attempts to correlate the two parameters, at each timing, failed. According to previous results,[3] only high concentrations of glycerol (ie, 40%) show highly significant impacts on TEWL, possibly linked to a modification of the lamellar structure of the S.C intercellular lipids, toward a more crystalline structure.[13,14]

Whatsoever, the present study suggests a new approach in skin research where autonomous/nomad measurements by subjects under study could simplify many aspects in the practical organization of the adopted protocol. The tremendous and recent advances made in the connecting processes through smartphones, developing skin measuring connected devices (skin color, sebum production, mechanical properties…) seems a realistic future step. Merging nomad devices, wearable sensors,[15,16] and new A.I-based algorithms for automatic clinical grading of smartphones images[17-20] seems a new pathway for monitoring of women and men in their

real environments and lifestyles. However, to ensure a collection of reliable data, this approach strictly requires the subjects enrolled in a given study to be fully informed and trained about the proper handling of these connected devices.

ACKNOWLEDGEMENTS

Authors want to thank Mr Didier Saint-Leger, Mr Olivier Coubard, Mrs Celine Cornillon, Mrs Muriel Monot, Mr Steeve Victorin, Mr Alexandre Nicolas, Mr Damien Velleman, Mrs Delphine Kerob, Mrs Caroline Negre, Mr Salim Chibout, and Mr Benoit Muller for their help in the completion of the study described in this paper.

CONFLICT OF INTEREST

The authors report no conflicts of interest.

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How to cite this article: Cointereau-Chardon S, Caberlotto E, Vicic M, Flament F. Self-recording the skin hydration and Trans-Epidermal Water Loss parameters: A pilot study. *Skin Res Technol*. 2020;00:1–5. https://doi.org/10.1111/srt.12862