ORIGINAL ARTICLE

When to Reapply Moisturizers: Evidence-Based Intervals from a 24-Hour Hydration Study

Kawaiola Cael Aoki, MAS[1], Emily Deehan[1], Marissa Ruppe[1], Gregory Bartos, DO, FAAD[2], Harvey N. Mayrovitz, PhD[3]

[1] Dr. Kiran C. Patel College of Osteopathic Medicine, Nova Southeastern University, Fort Lauderdale, Florida, USA
[2] Imperial Dermatology, Hollywood, Florida, USA
[3] Dr. Kiran C. Patel College of Allopathic Medicine, Nova Southeastern University, Fort Lauderdale, Florida, USA

ABSTRACT

Introduction Hydration is essential for healthy skin, and humectants like glycerin, hyaluronic acid, and urea are often included in topical moisturizers to attract and lock in water within the stratum corneum. However, the duration of hydration provided by these ingredients is not well established, making the frequency of reapplication largely anecdotal. This study assessed the hydration effects and duration of four topical humectant formulations over 24 hours using Tissue Dielectric Constant (TDC) measurements of skin water content.

Methods Thirty participants had randomly assigned formulations applied to forearm sites—Ceramide and Hyaluronic Moisturizing Cream (CHMC), Glycerin and Petrolatum Moisturizing Cream (GPMC), Urea and Shea Butter Repair Cream (USRC), and Multi-Hyaluronic Acid and Botanical Serum (MHBS)—with TDC values recorded at baseline, 1 hour, 4 hours, and 24 hours. Generalized estimating equations (GEE) modeled epidermal hydration trends, and intersection analyses identified when hydration was no longer greater than untreated skin.

Results In the 24-hour GEE model, only MHBS showed a statistically significant increase in epidermal hydration compared to the control. At the same time, CHMC, GPMC, and USRC did not differ significantly over the entire 24-hour period. Intersection analysis found that hydration above baseline was temporary, lasting approximately 3–4 hours for CHMC, GPMC, and USRC, and nearly 5 hours for MHBS.

Conclusion These results suggest that, under the conditions tested, measurable above-baseline hydration from these formulations persisted for approximately 3-5 hours.

INTRODUCTION

Skin hydration is essential for optimal skin function, as an impaired barrier can lead to increased susceptibility to infections, oxidative stress, ultraviolet damage, and conditions like xerosis and atopic dermatitis.[1-3] The stratum corneum, which normally contains 10–20% water, is dependent on intercellular lipids and hydrolipids to maintain hydration.[4] Therefore, strategies to maintain hydration are clinically important, with moisturizers serving as the mainstay of barrier support.

Moisturizers support hydration through three main classes: natural moisturizing factors, humectants, and intercellular lipids.[2-5] Humectants, including urea, glycerin, and hyaluronic acid, are clinically important as they attract water into the stratum corneum and reduce transepidermal water loss.[4,5] Although these ingredients are recommended for xerosis and dermatitis, there is limited evidence on their duration of action, making the ideal reapplication interval largely anecdotal.

Although previous research has explored the effects of humectants and moisturizers, few studies have quantified hydration duration to guide clinical instruction. In this study, we utilized tissue dielectric constant (TDC) measurements, confirmed indicators of skin water content, to determine hydration duration from common commercial products. These time points may help estimate when reapplication is needed to maintain above-baseline hydration under controlled conditions and may have relevance for managing skin dryness.

METHODS

This study was approved by the University's Institutional Review Board (2023-550-NSU). Thirty healthy adult volunteers were enrolled from the university community. Five marked sites on each forearm (ten total) were designated for testing (**Figure 1**). Skin hydration was assessed using FDA-cleared MoistureMeter devices (MoistureMeterEpiD and MoistureMeterD, Delfin Technologies, Kuopio, Finland) that measure TDC, a validated index of skin water content.[6] TDC was measured at ~0.5 mm (MoistureMeterEpiD) and ~2.5 mm (MoistureMeterD) depths, corresponding to epidermal and deeper tissue hydration, respectively.

After baseline measurements, four commercially available moisturizers were applied to randomized forearm sites: Ceramide and Hyaluronic Moisturizing Cream (CHMC; CeraVe Moisturizing Cream), Glycerin and Petrolatum Moisturizing Cream (GPMC; Cetaphil Moisturizing Cream), Urea and Shea Butter Repair Cream (USRC; Eucerin Advanced Repair Crème), and Multi-Hyaluronic Acid and Botanical Serum (MHBS; SkinMedica HA5). Application sites were randomized across participants to minimize site-specific bias. A standardized amount (approximately 0.1-0.3 mL, depending on formulation consistency) of each formulation was applied to each site. TDC values were recorded at 1, 4, and 24 hours after application. Participants resumed normal daily activities between measurements and were instructed to avoid washing or scrubbing the test areas. Laboratory measurements were obtained under controlled ambient conditions (temperature and humidity monitored), whereas environmental conditions between time points were not controlled.

Statistical Analysis

Data was analyzed using IBM SPSS Statistics (Version 29.0, IBM Corp.). One-way ANOVA was used to compare mean hydration levels at baseline and 24 hours post-application by site and humectant. Generalized estimating equations (GEE) with linear regression were employed to analyze longitudinal hydration effects, accounting for repeated measures with an exchangeable correlation structure. The model examined the main effects of each humectant over 24 hours, adjusting for anatomical site and temporal changes. This model included site, time, and a quadratic term for time (time^2), as exploratory analysis indicated a non-linear hydration trend. A robust covariance matrix was used to account for the correlated nature of repeated measurements within subjects.

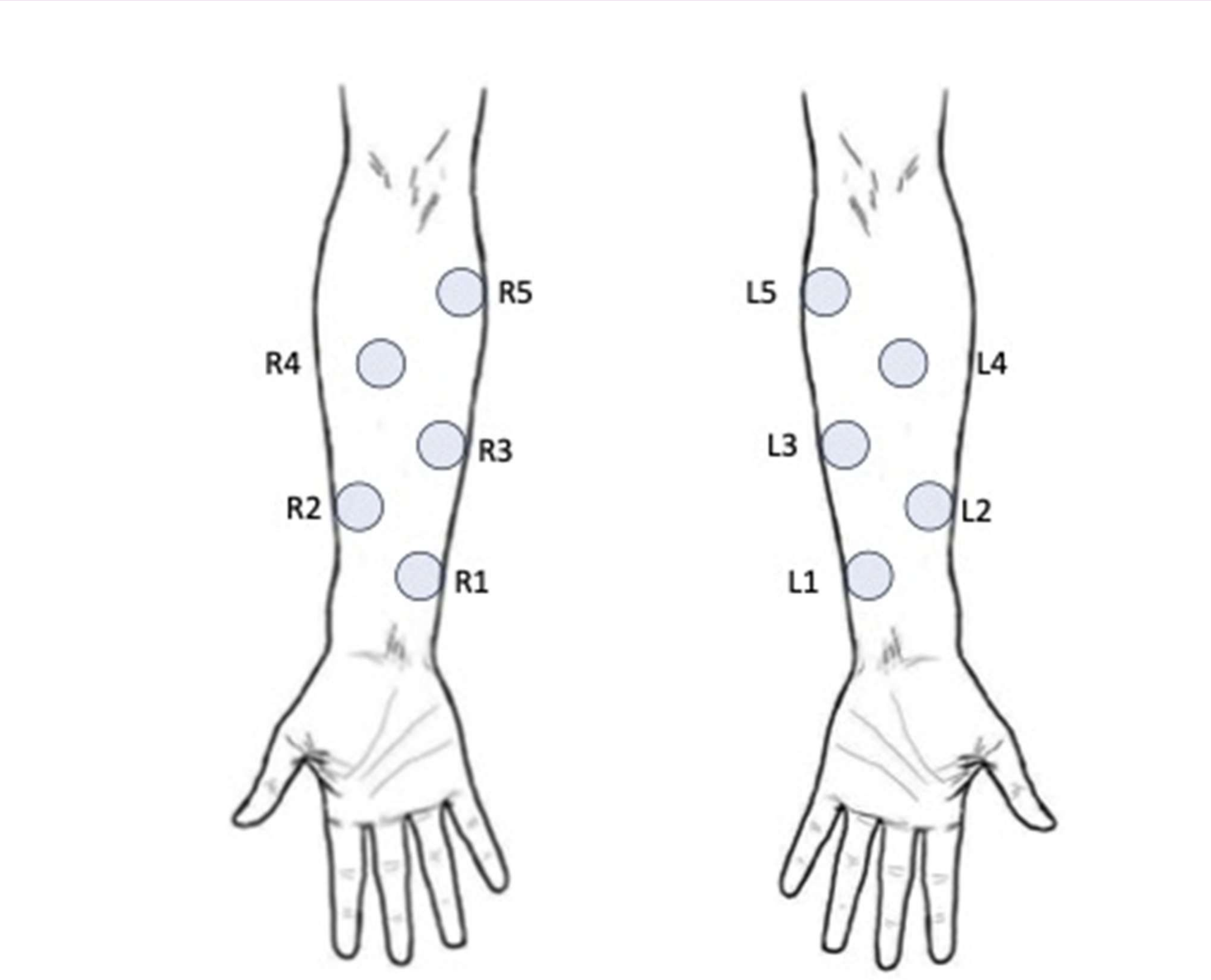

Figure 1. Arrangement of Measurement Sites on the Volar Forearm

To estimate hydration duration, predicted epidermal hydration values were generated from the fitted GEE models for each humectant and the control condition across the observed time range. These prediction equations incorporated regression coefficients for time and time^2, along with humectant-specific effects and interaction terms. Intersection points were then calculated as the time at which the predicted hydration curve for each humectant equaled that of the control condition. These points represent when the moisturizer-induced hydration was no longer greater than that of untreated skin. Due to the limited number of time points and the use of model-based extrapolation, confidence intervals for intersection points were not calculated.

RESULTS

Thirty participants completed the study with no loss to follow-up. There were no significant differences in baseline epidermal hydration between anatomical sites ($p = 0.845$). At the 24-hour mark, no significant differences in epidermal hydration were observed between the humectant types ($p = 0.898$) (**Table 1**). Dermal hydration values are presented in Table 1 for completeness; however, subsequent analyses focused on epidermal hydration, which is more directly relevant to surface barrier function.

In the 24-hour GEE analysis of epidermal hydration, significant effects were observed for humectant type ($p < 0.001$), time ($p < 0.001$), and time^2 ($p < 0.001$), indicating a non-linear (quadratic) hydration pattern where levels rose after application and then declined. Among the tested products, only MHBS produced a statistically significant increase in epidermal hydration compared with control, with a mean effect size of 2.51 units (95% CI 0.96–4.06, p = 0.002). CHMC, GPMC, and USRC did not differ significantly from control (all p > 0.6) (**Table 1**). The absence of a statistically significant effect in the 24-hour GEE model reflects the population-averaged (marginal) hydration across the full observation period and does not exclude the presence of short-term increases in hydration. Because several formulations demonstrated transient hydration effects that diminished within a few hours, these early increases may not be captured as significant when averaged over 24 hours.

Table 1. Coefficients and Significance for Long-term Humectant Effect Over 24 Hours

	Humectant	Coefficient	95% CI	P-Value
Epidermal	CHMC	-0.399	-2.475, 1.678	0.707
	GPMC	-0.417	-2.490, 1.657	0.694
	USRC	-0.533	-2.618, 1.551	0.616
	MHBS	2.508	0.958, 4.059	0.002*
	Control	0	.	.
Dermal	CHMC	-0.525	-1.986, 0.935	0.481
	GPMC	-0.315	-1.455, 0.826	0.589
	USRC	-0.821	-2.059, 0.418	0.194
	MHBS	0.674	-0.482, 1.829	0.253
	Control	0	.	.

*CHMC = Ceramide and Hyaluronic Moisturizing Cream, GPMC = Glycerin and Petrolatum Moisturizing Cream, USRC = Urea and Shea Butter Repair Cream, MHBS = Multi-Hyaluronic Acid and Botanical Serum; 95% CI = 95% Confidence Interval; *p <0.05*

To further characterize these time-dependent effects, prediction equations for epidermal hydration were generated for each humectant, illustrating the non-linear (quadratic) trends in hydration effects (**Figure 2**). We calculated the intersection points between each product's predicted epidermal hydration curve and the control curve, representing the time at which hydration was no longer greater than untreated skin. CHMC intersected control at ~0.4 and ~4.2 hours, GPMC at ~3.3 hours, USRC at ~0.1 and ~3.5 hours, and MHBS at ~4.7 hours. (**Table 2**).

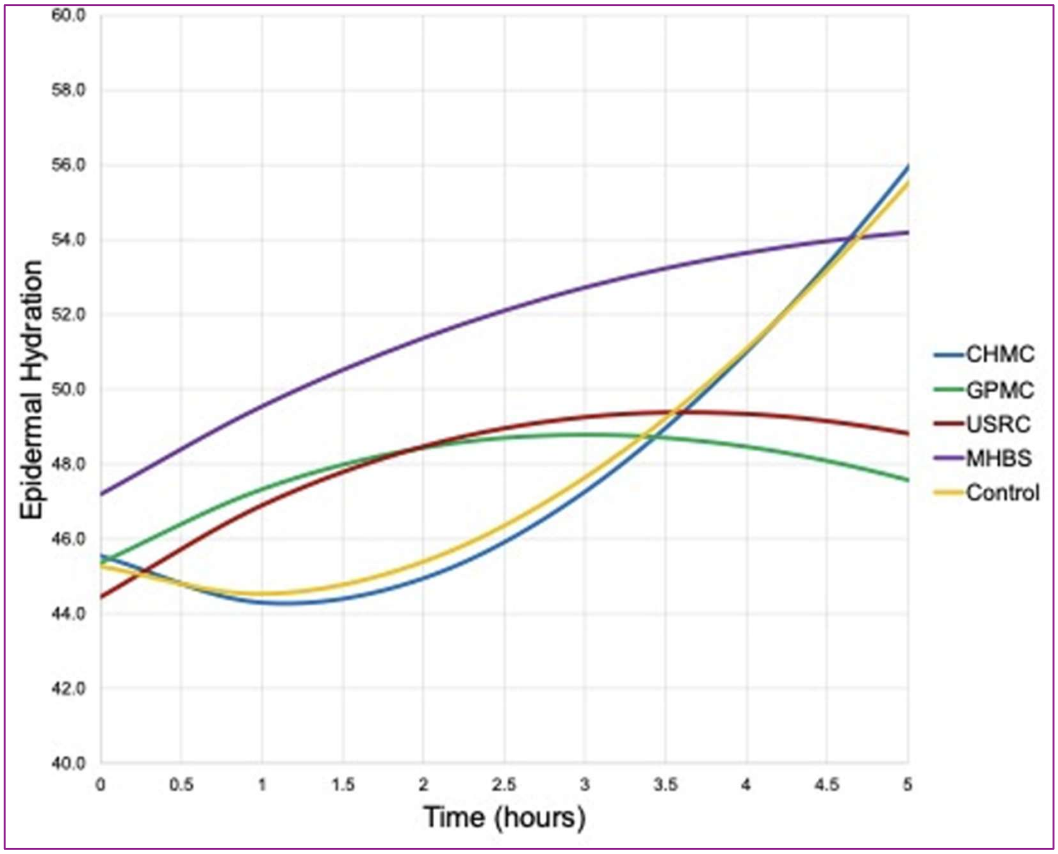

Figure 2. Time-Dependent Predicted Epidermal Hydration Curves by Humectant Type
CHMC = Ceramide and Hyaluronic Moisturizing Cream, GPMC = Glycerin and Petrolatum Moisturizing Cream, USRC = Urea and Shea Butter Repair Cream, MHBS = Multi-Hyaluronic Acid and Botanical Serum

Table 2. Epidermal Hydration Effects and Estimated Reapplication Intervals Based on 24-Hour GEE and Intersection Analyses

Product	GEE 24-hr Epidermal Effect vs. Control	Intersection with Control (hrs)	Interpretive Summary
CHMC	Not significant (p = 0.707)	~0.4, ~4.2 hrs	Hydration curve nearly indistinguishable from control; may reflect stabilization rather than measurable gain
GPMC	Not significant (p = 0.694)	~3.3 hrs	Hydration persists ~3 hrs; frequent reapplication may be needed
USRC	Not significant (p = 0.616)	~0.1, ~3.5 hrs	Early loss of effect; may require reapplication at ~3–3.5 hrs
MHBS	Significant (β = 2.51, 95% CI 0.96–4.06, p = 0.002)	~4.7 hrs	Longest-lasting effect; may require reapplication at ~5 hrs

CHMC = Ceramide and Hyaluronic Moisturizing Cream, GPMC = Glycerin and Petrolatum Moisturizing Cream, USRC = Urea and Shea Butter Repair Cream, MHBS = Multi-Hyaluronic Acid and Botanical Serum; 95% CI = 95% Confidence Interval; *p <0.05

DISCUSSION

This study demonstrated that the hydration effects of humectant-containing moisturizers are time-limited and vary by formulation. The intersection points between each moisturizer's predicted hydration curve and the control curve represent the point at which hydration is no longer greater than that of untreated skin, and therefore, when reapplication may be required to sustain the benefit. USRC kept hydration above baseline for about 3.5 hours, GPMC for roughly 3 hours, and MHBS for nearly 5 hours. These findings provide preliminary, evidence-informed estimates of hydration duration under controlled conditions, rather than definitive clinical reapplication guidelines.
Some formulations demonstrated very early intersection points (e.g., CHMC at ~0.4 and USRC at ~0.1 hours). These early crossings likely reflect model behavior rather than clinically meaningful loss of hydration. Given the limited number of observed time points and the use of polynomial modeling, small variations in the fitted curves near baseline may result in mathematically defined intersections that do not correspond to physiologically relevant changes. As such, later intersection points, which align more closely with observed hydration decline, are likely more clinically meaningful.

An additional finding demonstrated that CHMC closely paralleled the control trajectory, with its hydration curve nearly indistinguishable from untreated skin. This pattern may reflect a stabilizing effect, where hydration levels are maintained within a narrow physiological range. This could suggest that ceramide and hyaluronic acid components support barrier function in a way that limits fluctuations rather than producing transient increases; however, this interpretation remains speculative. The simultaneous rise of the control curve may also reflect physiological temporal variation or even subtle proximity effects between test sites, which together complicate distinguishing CHMC's effect. Further research, especially in barrier-impaired skin, could clarify whether such stabilization represents a clinically meaningful benefit distinct from short-term hydration peaks.

These results align with prior studies, which have shown that glycerin- and urea-based formulations improve hydration for only a few hours after application.[7,8] Glycerin-based formulations showed escalating dose responses at concentrations of 10%, 18%, 26%, and 35%, with skin hydration measured at 30 minutes, two hours, and four hours. Hydration increased over four hours with all doses, peaking at two hours for the 35% humectant dose.[7] Similarly, a 2014 study comparing "hot process" and "cold process" manufactured glycerin-based moisturizers found significant hydration increases at 1-, 3-, and 5 hours post-application. TDC values for the "hot process" formulation peaked at 50.0 ± 13.9 units at 3 hours, and for the "cold process" formulation at 50.7 ± 13.0 units at 1 hour, with significant differences between the two formulations observed at 3 and 5 hours.[8]

Our study used longitudinal modeling and intersection analysis to extrapolate the timing of moisturizer reapplication. GEE revealed curvilinear hydration patterns, with hydration initially rising before declining, and identified MHBS as the only humectant showing a statistically significant difference in epidermal hydration compared to the control over 24 hours. It is important to interpret the GEE results in the context of the modeling framework. A non-significant coefficient in the 24-hour GEE model does not imply that a moisturizer had no effect; rather, it indicates that the average hydration across the full 24-hour period did not differ significantly from control. This is expected for products that produce transient increases in hydration, which diminish within a few hours, such that short-term benefits are diluted when averaged across the entire day. In this context, the intersection analysis provides complementary insight by identifying when hydration levels return to baseline. Together, the two methods demonstrate that while only MHBS achieved a statistically significant population-average effect over 24 hours, all formulations may have measurable short-term hydration benefits, as inferred from the modeling and intersection analysis rather than directly observed at all intermediate time points.

Clinically, the choice of moisturizer should consider both duration of hydration and practicality of use. While MHBS offered the longest effect, its cost may limit accessibility. The other, more affordable options provide shorter-lived benefits, suggesting these products need more frequent applications to maintain increased hydration effects. Such guidance may help educate patients and improve adherence to treatment regimens.
As this study was conducted in healthy volunteers, these findings may have relevance for conditions characterized by impaired barrier function, such as xerosis or atopic dermatitis. However, hydration dynamics may differ in diseased skin, and these results should be interpreted within the context of healthy skin under controlled conditions.

Limitations include the use of a single application in healthy volunteers, which may not fully represent the performance of moisturizers under real-world conditions or in patients with compromised skin. The study was also limited to a 24-hour observation window, leaving longer-term dynamics and the effects of repeated application unexamined. Additionally, hydration was measured only on the volar forearm, and findings may not generalize to other body sites with different barrier properties. The gradual rise in the control trajectory also complicates interpretation, as it may reflect physiological variation, proximity effects, or minor measurement-related drift. Future studies should evaluate repeated application, performance in disease states (e.g., atopic dermatitis, psoriasis), and across diverse anatomic sites to better define reapplication intervals.

CONCLUSION

This study confirms that humectant-containing moisturizers provide temporary improvements in skin hydration, with effects lasting approximately 3–5 hours depending on the formulation. Longitudinal modeling and intersection analysis revealed that MHBS sustained hydration for the longest duration (~5 hours), while more widely available creams, such as GPMC and USRC, require reapplication every 3–4 hours to maintain above-baseline hydration. These findings provide preliminary, evidence-informed estimates of moisturizer reapplication intervals under the study conditions tested, with potential relevance to conditions involving impaired skin barrier function.

Conflict of Interest Disclosures: None

Funding: None

Acknowledgments: The authors sincerely thank Dr. Radleigh Santos for his guidance and confirmation of the statistical methods used in this study. His expertise provided valuable support throughout the analysis and helped ensure the rigor of the study's findings.

Corresponding Author:
Kawaiola Cael Aoki
3200 S University Dr
Fort Lauderdale, FL 33328

Email: ka1238@mynsu.nova.edu

References:

1. Natsuga K. Epidermal barriers. *Cold Spring Harbor perspectives in medicine*. 2014;4(4):a018218.
2. Del Rosso JQ, Levin J. The clinical relevance of maintaining the functional integrity of the stratum corneum in both healthy and disease-affected skin. *The Journal of clinical and aesthetic dermatology*. 2011;4(9):22.
3. Augustin M, Wilsmann-Theis D, Körber A, et al. Diagnosis and treatment of xerosis cutis–a position paper. *JDDG: Journal der Deutschen Dermatologischen Gesellschaft*. 2019;17:3-33.
4. Riethmuller C, McAleer MA, Koppes SA, et al. Filaggrin breakdown products determine corneocyte conformation in patients with atopic dermatitis. *Journal of Allergy and Clinical Immunology*. 2015;136(6):1573-1580. e2.
5. Purnamawati S, Indrastuti N, Danarti R, Saefudin T. The role of moisturizers in addressing various kinds of dermatitis: a review. *Clinical medicine & research*. 2017;15(3-4):75-87.
6. Mayrovitz HN. Medical Applications of Skin Tissue Dielectric Constant Measurements. *Cureus*. Dec 2023;15(12):e50531. doi:10.7759/cureus.50531
7. Rawlings A, Canestrari DA, Dobkowski B. Moisturizer technology versus clinical performance. *Dermatologic therapy*. 2004;17:49-56.
8. Spada F, Barnes TM, Greive KA. Skin hydration is significantly increased by a cream formulated to mimic the skin's own natural moisturizing systems. *Clinical, cosmetic and investigational dermatology*. 2018:491-497.