J. Cosmet. Sci., **67,** 175–183 (May/June 2016)

Comparison of skin hydration in combination and single use of common moisturizers (cream, toner, and spray water)

LI YUANXI, HUA WEI, XIONG LIDAN, and LI LI, *Department of Dermatovenereology, Sichuan University, Chengdu, Sichuan Province (L.Y., H.W.), Sichuan Cosmetic Engineering Research Center; Center of Cosmetic Safety and Efficacy Evaluation of West China Hospital, Chengdu, Sichuan Province (X.L.), and Department of Dermatovenereology, Sichuan University, and Sichuan Cosmetic Engineering Research Center, Chengdu, Sichuan Province (L.L), China.*

Accepted for publication July 6, 2016.

Synopsis

This study aims to assess the moisturization in combination or single use (including seven general applications) of three common moisturizers: cream, toner, and spray water.

Groups were set as C: cream only; T: toner only; C+T, T+C: cream or toner applied successively within a few minutes; C-T, C-S: cream applied with repeated toner or spray water every 2 h; T-T: toner applied with repeated toner every 2 h; and N: untreated group. Outcomes were the change in skin hydration from baseline at 2, 4, 6, and 8 h after applications.

All treated zones displayed a significantly higher degree of hydration compared with the untreated zone ($p < 0.05$). For normal skin (hydration value at baseline >35 a.u.), C-T led to greatest hydration change rate compared with others, followed by C+T, T+C, and C. Those three applications exhibited analogous hydration at each test point ($p > 0.05$). The hydration rate of C-S differed slightly from T-T, followed by those four mentioned above, with T being the last. For dry skin (hydration value at baseline <35 a.u.), no statistical significance could be detected between C-T zone and C+T, T+C, and C zones ($p > 0.05$), the other results were identical.

When cream and toner were applied successively, the application order has little effect on skin hydration. The application of cream only was an effective and brief way to achieve favorable moisturization especially for dry skin. As a complement, repeated application of toner rather than spray water is efficacious for skin hydration.

INTRODUCTION

As skin moisturization plays a vital role in skin care, receiving a higher skin hydration is essential for major skin types, especially for dry skin and some related skin conditions (1–3). Because moisturizers serve as routine care, the availability of creams and lotions, including toner and sprays, gels, emulsions, oleaginous mixtures, milks, serums, and

Address all correspondence to Prof Li Li at lily2058@126.com.

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other skin moisturizers options, has allowed customers to select optimal treatment regimens that are better for individual management (4).

Development of moisturizers is a scientific and artistic discipline, since the consumers' insights also need to be taken into considerations (5). In the current market, there is a plethora of moisturizer options available for customers, since many skin care products and varieties of applications are promoted to the public (4). Excessive consumption often occurs, and customers may arbitrarily apply moisturizers they have. In our country, many ladies are used to applying spray water or toner when they feel dry, some of them even apply 3–4 times a day in the air-conditioned office. Yet, there is no guarantee that frequent application of spray water or toner can reach the corresponding moisturizing effect.

However, positive effects from the use of moisturizers cannot always be granted, but excessive application or improper use may bring about dermatitis. Moisturizers are usually free from strong irritants, while repeated exposure of sensitive areas to mildly irritating preparations may deteriorate skin barrier function. Although strong irritants are generally easy to identify, weak irritants are less obvious to avoid (6,7).

Most of the moisturizers have humectants, occlusives, and/or emollients as main ingredients. The majority of humectants used in moisturizers are low molecular weight substances with hydrophilic properties. A few high molecular weight substances are also used (e.g., polymers such as hyaluronic acid). Humectants differ in water-binding capacity as well as in their ability to penetrate and influence the degree of skin hydration (8). Occlusives generally minimize water loss to the external environment. The complementary occlusive activity of emollients contributes to stratum corneum hydration as well (9). Apparently, moisturizing efficacy varies due to distinct emulsion formations, and approaching the maximum effect with less concentration can reduce dermatitis caused by overuse.

Current studies have scarcely mentioned whether the use of moisturizers with different applications would result in different moisturizing effects. In the present study, we compared the effects of seven general application ways of using three common moisturizers (cream, toner, and spray water) and provided a way for making a rational choice for a better moisturizing effect.

MATERIALS AND METHODS

This study was reviewed by Biomedical Ethics Committee of local hospital. The process of selecting volunteers and the testing procedure followed the principles of International Ethical Guidelines for Biomedical Research Involving Human Subjects.

Eligible volunteers were healthy young females between 20 and 35 years of age. Exclusion criteria were a history or current disease or condition of skin (e.g., eczema, psoriasis, atopic skin disease); wounds or scars on the forearm and leg test sites, with known allergies or sensitivities to cosmetic products or its components; and currently or has been using external prescription drugs on limbs within the last 1 month. Topical use of body products on limbs was paused for 7 days prior to the study, and the cleansers were avoided on any application area 12 h before and throughout the test. Furthermore, the volunteers must have few body hairs on test zones inherently, averting the influence on corneometer readings caused by body hair and potential effect of shaving test areas. Those volunteers who met the criteria for inclusion completed a study participation questionnaire and signed an informed consent form before participating in our study.

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Eight zones (3 × 3 cm each) were delineated on legs and forearms of each volunteer and were randomized to receive eight different applications (test products or remained nontreated; Table I, Figure 1). The three test products and their ingredients are presented in Tables II and III.

During the study, 18 mg of cream (2 mg/cm^2) or 9 μl of toner (1 μl/cm^2) was applied only once in the designated zone, and the spray water was applied in a same dosage as toner. All the moisturizers were spread evenly by the same technician. Skin hydration was measured by the trained technician using a Corneometer® CM825 (Courage & Khazaka GmbH, Cologne, Germany) before treatment (t_0) and at 2, 4, 6, and 8 h after product applications. All volunteers stayed in a controlled room (temperature 22°C ± 2°C, humidity 50% ± 5%) from 30 minutes before the first measurement (baseline) to the last measurement (8 h). Skin hydration difference rate (%) was calculated as follows:

$$\text{Skin hydration change rate } (\%) = \frac{(H_t - H_0)}{H_0} \times 100$$

Statistical analysis was performed using the SPSS statistical software, version 19.0 (SPSS Inc, Chicago, IL) and $p < 0.05$ was considered statistically significant. The skin hydration change rate between test products and the nontreated group was analyzed using repeated measures analysis. The skin hydration change among various test products was analyzed using repeated measures analysis or Student–Newman–Keuls test or Dunnett's T3 test.

RESULTS

A total of 20 female volunteers with a mean age of 26.6 ± 2.24 years completed the study. The average hydration value at baseline was 35.92 a.u. The baseline values of each application group had no significant differences ($p > 0.05$; Figure 2). The skin types of test legs and arms were divided into dry and normal skin according to their moisture status (average hydration value at baseline for dry skin is <35 a.u. and for normal skin is >35 a.u.; Table IV) (10,11).

Table I
Eight Applications on Each Zone of Forearm or Leg

Application	t_0	2 h	4 h	6 h	8 h
C	Cream (2 mg/cm^2)	—	—	—	—
T	Toner (1 μl/cm^2)	—	—	—	—
T+C	Toner (1 μl/cm^2) + cream (2 mg/cm^2)	—	—	—	—
C+T	Cream (2 mg/cm^2) + toner (1 μl/cm^2)	—	—	—	—
C-T	Cream (2 mg/cm^2)	Toner (1 μl/cm^2)	Toner (1 μl/cm^2)	Toner (1 μl/cm^2)	—
C-S	Cream (2 mg/cm^2)	Spray water (1 μl/cm^2)	Spray water (1 μl/cm^2)	Spray water (1 μl/cm^2)	
T-T	Toner (1 μl/cm^2)	Toner (1 μl/cm^2)	Toner (1 μl/cm^2)	Toner (1 μl/cm^2)	—
Untreated	—	—	—	—	—

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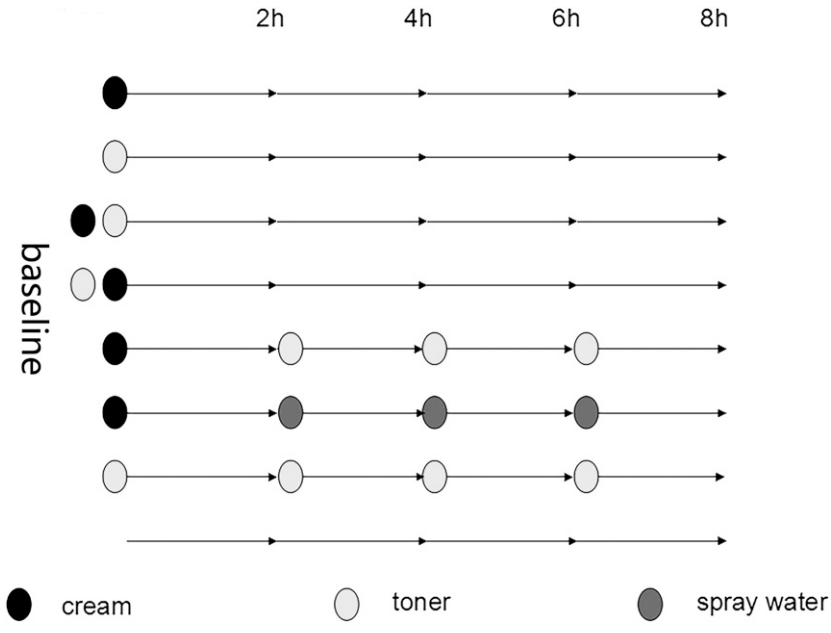

Figure 1. Eight applications (test products or remained untreated).

For normal skin, the effect of each application on hydration change from baseline is illustrated in Table V and Figure 3. All treated zones represented a significantly higher hydration change compared to the untreated zone ($p < 0.05$). Cream (including C, C+T, T+C, C-T, and C-S zones) induced a high degree of hydration change for 2 h after application. Three zones (C, C+T, T+C zones) treated with cream at the beginning but without any continuous moisturizing had a significantly high hydration change 2 h later, which reduced gradually, but still remained elevated for 8 h. These three zones exhibited analogous hydration change at each test point ($p > 0.05$). C+T and T+C zones might have instant higher hydration change than C zone for the first 2 h; however, the differences could not be detected even 8 h after application. The order of cream or toner application had little or no effect on the skin hydration. The hydration change of C-T zone reduced slowly and even maintained a high level for 8 h due to repeated toner treatment. However, three times repeated applications of spray water led to a rapid decline of hydration change of stratum corneum.

Although compared with the cream-treated zone, toner only provided a mild moisturizing effect, and repeated applications of toner induced sustained increase in hydration change rate that exceeded cream-treated zone 8 h later. In addition, cream applied with

Table II
Information on the Three Cosmetics Used in This Study

Moisturizer	Product name	Manufacturers
Cream, C	Natural skin care moisturizing and softening cream	Winona®, Kunming, China
Toner, T	Natural skin care anti-sensitive moisturizing toner	Winona®, Kunming, China
Spray water, S	Thermal water	Avene®, Pierre Fabre, France

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Table III
Information on the Ingredients of the Three Cosmetics Used in This Study

Ingredients of cream
Aqua, glycerol, butyrospermum parkii oil, dimethicone, glycereth-26, tridecyl trimellitate, pentylene glycol, hexyldecanol, sucrose polystearate, diethylhexyl cyclohexane, petroleum jelly, tocopheryl acetate, prinsepia utilis rogle oil, portulaca oleracea extract, β-glucans, sodium hyaluronate, cetylhydroxyproline palmitamide, α-bisabolol, a, cetearyl alcohol, hydrogenated polyisobutene, acrylamide, acrylamide/ammonium acrylate copolymer, acrylates/C10-30 alkyl acrylate crosspolymer, tween 20, xantham gum, EDTA-2Na, polybutene, polyisobutene, butyl stearate, stearic acid, phenoxyethanol, ethylhexylglycerin
Ingredients of toner
Aqua, pentylene glycol, glycerol, glycereth-26, trimethylpentanediol/adipic acid/glycerin crosspolymer, portulaca oleracea extract, β-glucans, sodium hyaluronate, hydroxyethyl cellulose
Ingredients of spray water
Avene Thermal Spring Water 100%

supplement of toner every 2 h displayed the highest efficacy on hydration change than the other methods at 6- and 8-h test point ($p < 0.05$), followed by cream and toner successively applied and only cream applied. Then hydration change of cream applied first with repeated three times spray water and that of repeated four times toner applications differed slightly for 8 h, for the better moisturization of former and later half period, respectively. A very mild moisturizing effect was observed with merely one application of toner for 8 h.

For dry skin (hydration value at baseline <35 a.u.), no significant differences could be detected when C-T zone was compared with C+T, T+C, and C zones ($p > 0.05$); the other results were identical (Table VI, Figure 4).

DISCUSSION

In this study, we assessed the short-term effects of seven different moisturizing approaches with different combination of three products on skin hydration and proved the utility of

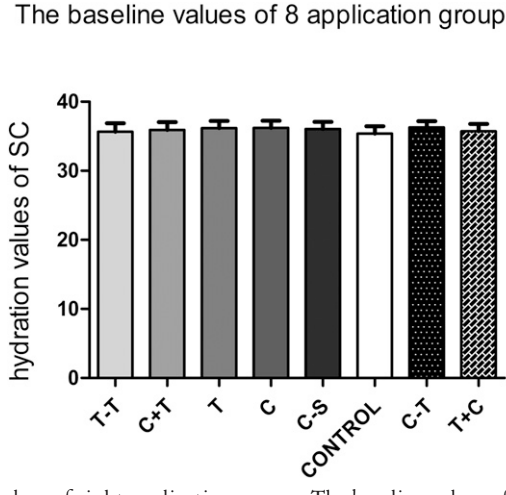

Figure 2. The base line values of eight application groups. The baseline values of each application group had no significant differences ($p < 0.05$).

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Table IV
Distribution of Test Subjects with Mean Corneometer Values at Baseline

	Values (a.u.)		
Skin type	Maximum	Minimum	Average
Dry skin ($n = 18$)	34.90	26.21	30.54 ± 2.57
Normal skin ($n = 22$)	49.22	35.18	40.33 ± 4.25

every approach by comparing the significant difference to the control. Among the seven applications, cream applied with toner as replenishment for three times led to greatest hydration change rate compared with other zones on normal skin. The integrated emulsion formulation within cream demonstrated superior moisturization among the occlusive formulation such as petroleum jelly, which forms a layer on skin surface and retards the evaporation of water and diffuses into the intercellular lipid domains, simultaneously. Anhydrous, natural petroleum jelly reduces water loss by more than 98%, while other oils only manage a 20–30% reduction (9,12). In addition, repeated applications of toner containing potent humectants, for instance, sodium hyaluronate, also contributed to water retention. Although the consequence of repeated applications of toner for dry skin was not clear, the effect of water evaporation was greater on dry skin.

On the other hand, cream applied with spray water (almost pure aqua) repeated for three times as supplement represented a quicker descent rate of hydration, which confirmed that the spray water without any humectants or occlusives had instant smoothing, comforting, and refreshing actions, but promoted a heavier water evaporation instead of reducing water loss, and its cleansing action that might wash off the cream (lipids) previously applied weakened the moisturizing effect further. Therefore, repeated applications of spray water (almost pure aqua) reduced original moisturization of cream.

C+T and T+C zones expressed similar hydration rates since two products were applied 2 h later. It suggested that no matter whether the application order was either cream before toner or toner before cream (the interval was a few minutes), hydration was similar when the same quantity of the mixture of cream and toner was applied. No significant difference could be detected when compared with cream only, implying that the moisturizing effect of mixture of cream and toner is mainly determined by cream, and toner merely plays a supporting role. The skin hydration might reach saturation after "evaporation phase" (13) for these two products. It is speculated that for each zone of skin in a different environment, hydration reaches a peak (due to the property of moisturizer), then gradually declines (14) owing to water flux and retention that exist on the skin and maintain homeostasis.

Humectants promote water retention within stratum corneum. Emollients increase the water content in the stratum corneum not only by delivering their water to the skin, but also by forming an occlusive layer, resulting in an increase in skin hydration (15). While shortly after skin application, emulsions break and (related to their water concentration) most of the incorporated water evaporates (16), thereby providing a dynamic balance between water retention and evaporation physically, extremely influenced by inside and outside circumstances. Hence, toner provides immediate hydration through its water content, and as water evaporates, skin hydration reduces. Even predominant humectants barely retain water within stratum corneum. Some ingredients, such as trimethyl

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Table V
Eight Application Groups of Mean HCRs of Normal Skin at Every Test Point

	The mean HCRs of normal skin (%), N=22							
Groups	T-T	C+T	T	C	C-S	CONTROL	C-T	T+C
2 h	27.24 ± 10.06	62.17 ± 17.52	25.55 ± 11.28	58.74 ± 15.54	56.95 ± 17.00	0.57 ± 5.88	56.9 ± 14.24	61.09 ± 30.50
4 h	35.19 ± 12.09	49.83 ± 18.76	20.66 ± 12.35	51.38 ± 14.80	43.02 ± 18.40	0.35 ± 4.50	54.75 ± 19.84	50.7 ± 21.87
6 h	41.08 ± 11.24	40.86 ± 19.16	16.65 ± 10.46	43.02 ± 16.29	33.77 ± 19.68	−0.38 ± 5.66	55.9 ± 17.98	42.44 ± 23.10
8 h	43.24 ± 12.64	35.35 ± 18.62	12.98 ± 12.15	35.87 ± 16.32	24.63 ± 17.42	−1.44 ± 5.46	53.84 ± 13.25	34.21 ± 17.70

Table VI
Eight Application Groups of Mean Hydration Change Rates, HCRs of Normal Skin at Every Test Point

	Mean HCR (%), N = 18							
Groups	T-T	C+T	T	C	C-S	CONTROL	C-T	T+C
2 h	25.68 ± 21.05	74.37 ± 24.98	27.25 ± 17.51	68.71 ± 21.43	67.84 ± 28.95	1.81 ± 6.40	62.06 ± 24.26	79.24 ±30.80
4 h	34.86 ± 19.68	60.02 ± 22.90	21.81 ± 13.91	55.45 ± 15.03	37.77 ± 21.27	1.30 ± 4.70	51.28 ± 22.60	60.9 ± 22.48
6 h	36.29 ± 20.00	47.52 ± 18.67	17.77 ± 11.75	44.33 ± 14.31	23.03 ± 17.95	1.54 ± 5.90	50.2 ± 20.61	51.81 ± 24.11
8 h	44.04 ± 23.86	40.88 ± 18.63	11.35 ± 13.86	37.39 ± 13.57	18.96 ± 16.86	1.63 ± 5.35	48.28 ± 20.58	43.53 ± 18.13

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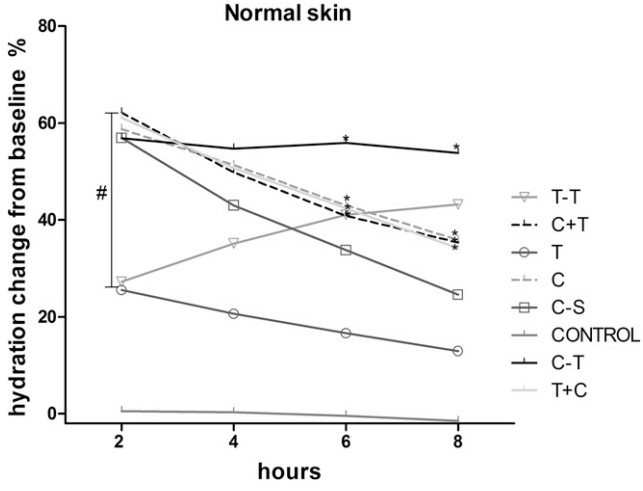

Figure 3. For normal skin (hydration value at baseline >35 a.u.). *Significant differences could be detected at 6 and 8 h test points when compared C-T zone to C+T, T+C, and C zones ($p < 0.05$); #Significantly higher hydration compared to the control zone ($p < 0.05$).

pentanediol, adipic acid, glycerin cross-polymer that serve as emollient (17), may also form a moisturizing layer at a certain concentration, thus four times applications of toner is distinguished from just one time application.

CONCLUSION

The combination of cream and toner and their application order had little or no effect on the skin hydration. Single use of cream was efficacious and was an easy way to achieve favorable moisturization especially for dry skin. It was convenient and effective to apply toner repeatedly as a complement for normal skin, but not necessary for

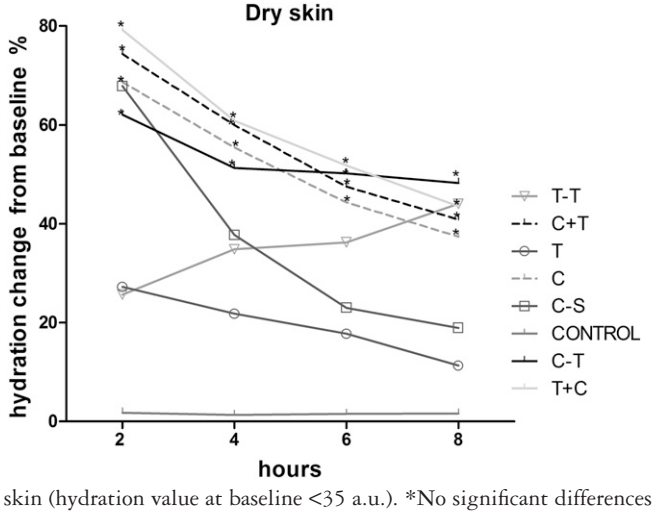

Figure 4. For dry skin (hydration value at baseline <35 a.u.). *No significant differences could be detected when compared C+ T, T+C, C zones with C-T zone ($p > 0.05$).

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dry skin. Spray water (almost pure aqua) might not be appropriate for repeated use as a moisturizer.

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