Effects of age, hydration level, and cosmetic treatment on skin mechanical properties of Thai

Dusadee Charnvanich, Vipaporn Panapisal, Waraporn Suwakul, Anyarporn Tansirikongkol*

Department of Pharmaceutics and Industrial Pharmacy, Faculty of Pharmaceutical Sciences, Chulalongkorn University, Bangkok, Thailand

Corresponding Author:
Anyarporn Tansirikongkol, Department of Pharmaceutics and Industrial Pharmacy, Faculty of Pharmaceutical Sciences, Chulalongkorn University, 254 Phayathai Road, Pathumwan, Bangkok 10330, Thailand.
Tel: +662 218 8399.
Fax +662 218 8401.
E-mail anyarporn.t@chula.ac.th

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ABSTRACT

Purpose: Age and skin hydration influence skin mechanical properties. However, correlation between hydration improved by cosmetic and mechanical properties is uncertain. This study aimed to investigate the relationship between age, intrinsic skin hydrations, skin hydration after topical treatment, and skin mechanical parameters of different age ranges. **Patients and Methods:** A total of 123 healthy volunteers, aged 18–55, were divided into three age groups. Skin hydration and biomechanical properties were evaluated using Corneometer® and Cutometer®, respectively. Subsequently, 61 healthy women aged 30–55 were measured for skin hydration and biomechanical parameters after 8 weeks application of microemulsion or nanoemulsion. The changes in each parameter and their correlation were evaluated. **Results:** Skin capacitance correlated to some mechanical parameters only in young volunteers. Only gloss elasticity (R2) presented strong negative correlation with age in 30–40-year-old volunteers while all elasticity parameters (R2, R5, and R7) showed significant negative correlations with age in 41–55 years old volunteers. Microemulsion or nanoemulsion significantly improved skin hydration; however, it did not always affect elasticity parameters. **Conclusion:** Skin elasticity decreased with age and changes in R2 were firstly observed. Decrease in R2 parameter could, then, be the first sign of skin aging. Skin hydration and elasticity were not related in any age. Improvement in skin hydration and elasticity by topical treatment was independent and based on individual formulation.

Keywords: Age, bioengineering, correlation, efficacy, elasticity, hydration

INTRODUCTION

Skin is the largest organ in the body mainly functioned to protect the inner organism against external harmful environment. Skin aging is a complex biological process. The gradual changes of skin could be attributed to the age-related process or to the exposure of external harmful factors such as ultraviolet (UV) radiation, trauma, and smoke. The aging process results in the alteration of skin appearance, structure, and mechanical properties which include the signs of skin dryness and roughness, an increase in skin wrinkle, and loss in skin elasticity. The influences of age, skin hydration, anatomical sites, and ethnic groups on biomechanical properties and skin wrinkle have been investigated.[1-4] Several studies revealed that the loss of skin elasticity and an increase of skin wrinkle was predominant in aged population.[5] In addition, biophysical parameters are varied on body locations and racial groups. Previous reports, however, have been conducted mostly based on the population with constricted age range or might have been focused on particular skin property.

The use of topical cosmetic product has drawn more attention with objective to alleviate the sign of aged skin. Anti-aging products are based on the principle to increase hydration, elasticity, and smoothness of skin. Bioengineering application has been utilized to monitor and measure these properties objectively. Several products have been reported to improve skin roughness, scaliness, smoothness, or wrinkles; however, the degrees of effectiveness were different based on their combinations of materials. Improvement in skin hydration was another factor to improve skin condition. Increase in skin hydration is believed to fulfill both the epidermis and dermis portions which would supply skin pliability and alleviate the fine wrinkle expression. However, the effect of skin hydration increased by topical application on skin elasticity parameters has not yet been fully discovered.

Correlation between changes in skin parameters after topical treatment as well as relationship between age, skin hydration, and mechanical properties of different age groups in Thai shall be clarified for a better understanding in basic skin condition and effect of cosmetic treatment. The purpose of this study, therefore, was to investigate the influences of age and skin hydration on skin mechanical properties. Correlations between each parameter were performed on different age groups. The correlation among changes in skin hydration and skin mechanical parameters after topical treatment was also evaluated.

MATERIALS AND METHODS

Participants and Study Protocol

A total of 123 Thai female participants with the age range of 18–55 years were enrolled in the study and was distributed into three age groups; Group 1: 62 participants, aged 18–30 years; Group 2: 30 participants, aged 31–40 years; and Group 3: 31 participants, aged 41–55 years. In the first study, skin hydration and mechanical parameters were measured on all participants' cheek areas to assess the skin properties of normal condition (baseline condition). Subsequently, 61 healthy women aged 31–55 were involved in the second study. Each participant was randomly supplied with either nanoemulsion or microemulsion serum with totally of 32 and 29 participants each group, respectively. Approximately, 10 drops of serum were applied on the designated cheek area twice daily for consecutive 8 weeks. The treated areas were reevaluated for skin hydration and skin mechanical properties at the end of treatment period. Each measurement was performed after the volunteers were acclimatized in a controlled room maintained at 25 ± 2°C and 50 ± 5% relative humidity for 15–20 min. This study was reviewed and approved by the ethical committee of Faculty of Pharmaceutical Science, Chulalongkorn University, Bangkok, Thailand.

Products

Products included in the study were nanoemulsion- and microemulsion-based serums. Nanoemulsion was oil in water type containing caprylic/capric triglyceride (Croda, UK) and Tween® 20 (Croda, UK) in citrate buffer pH 5.5. Microemulsion contained isopropyl myristate (S.Tong Chemical Co.Ltd, Thailand), Tween® 80 (Croda, UK), ethanol and citrate buffer pH 5.5. Nanoemulsion and microemulsion were thickened with Carbopol® 940 (Lubrizol, USA) and Aristoflex® HMB (Clariant, USA), respectively.

Measurement of Skin Hydration

Skin hydration was evaluated using Corneometer® CM825 (Courage Khazaka, Germany) mounted on a Multiprobe Adaptor MPA 580. The capacitance measurement of the Corneometer® detects the water content of the superficial epidermis layer and expresses in the instrumental unit, arbitrary capacitance unit. The arbitrary capacitance unit was expressed in the unit range of 0–120 demonstrating a low to high water content. Four skin measurements were performed on each treated cheek area and average value was obtained.

Measurement of Skin Mechanical Properties

The skin mechanical properties were determined by the use of non-invasive suction skin elasticity meter (Cutometer® MPA 580, Courage Khazaka, Germany) equipped with a 2 mm diameter measuring probe. A constant negative pressure standardized to 450 mbar was applied for 3 s followed by a relaxation period of 3 s with five repetitions. Each measuring cycle generated a skin deformation profile [Figure 1] which demonstrated the final distension (Uf), the total skin recovery (Ua), the immediate distension (Ue), delayed distension (Uv), the immediate retraction (Ur), and residual deformation (R). The device-produced mechanical parameters of interest which were the skin firmness (R0; Uf), the gross elasticity (R2; Ua/Uf), the net elasticity (R5; Ur/Ue), and the biological elasticity (R7; Ur/Uf). In addition, the other parameters were also provided. All the measuring parameters were calculated by Win-Cutometer® MPA Version 1.1.0.5 software (Courage Khazaka, Germany). Four skin measurements were performed on each treated cheek area and average value was obtained.

Statistical Analysis

Changes in skin parameter after 8 weeks of topical treatment were calculated as the percent change:

Percent change = [(A-B)/B] × 100

Where A is individual value of any measured parameter after 8-week treatment and B is the same measured parameter before the treatment. The Pearson's correlation coefficient was determined to evaluate the relationship between interested parameters. The linear correlation equation was analyzed and value of $P < 0.05$ was considered statistically significant correlation.

RESULTS

Intra-individual Variation in Skin Parameters

Correlations in skin parameters between the right and left cheeks were investigated. Figure 2 demonstrated significantly positive correlation between the left and right cheeks on skin hydration and selected elasticity parameters. Pearson's correlation coefficients for each parameter were calculated and presented herein. Since insignificant variation between treated sites was observed, left cheek was, therefore, chosen as a measuring site for the following investigations.

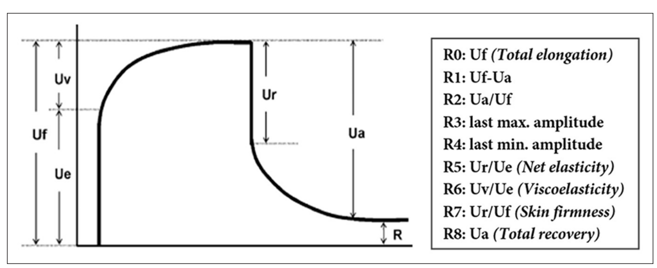

Figure 1: Skin deformation profile and R-parameters provided by the Cutometer®

The Relationship among Age and Skin Hydration or Mechanical Properties

Pearson's correlation coefficients between age and skin hydration or age and skin mechanical properties were calculated for individual age groups [Table 1]. No correlation was found in the young population (aged 18–30 years). Elasticity parameters became negatively correlated with age in the population above 30 years. Only gross elasticity parameter (R2) showed significant negative correlation with age in the 31–40 years' participants. As the age increases, the result showed a significantly negative correlation between all elasticity parameters (R2, R5, and R7) and age.

The Relationship among Skin Hydration and Skin Mechanical Properties

Skin hydration measured through Corneometer® shows significant correlation to some mechanical parameters in young participants [Table 2]. Even though skin hydration was found to be correlated with R0, R1, R3, R4, R6, and R8 in a group of participants aged 18-30 years, these correlations were not observed in the participants aged above 30 years. Furthermore, parameters representing skin elasticity (R2, R5, and R7) had no relationship to skin hydration in all age.

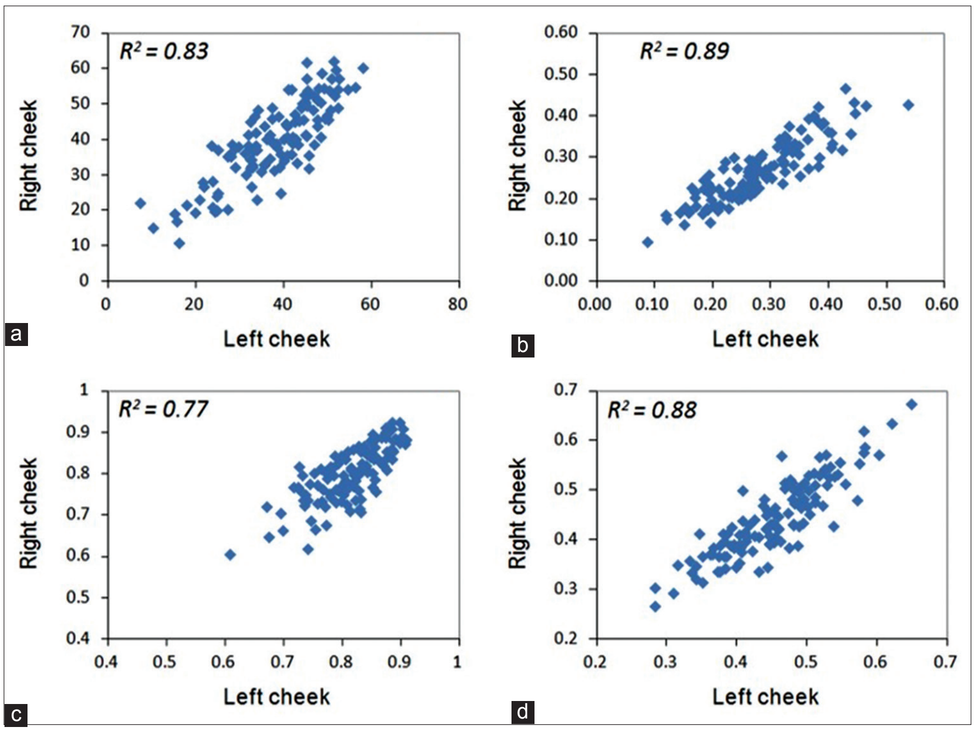

Figure 2: Scatterplots and regression lines showing significantly positive correlation between the left and right cheeks for skin properties of (a) skin hydration, (b) final distension (R0), (c) gross elasticity (R2), and (d) biological elasticity (R7). All presented statistically significant correlation ($P < 0.05$).

Table 1: The correlation coefficient between age and skin hydration or age and skin mechanical parameters

Age (years)	Hydration	R0	R1	R2	R3	R4	R5	R6	R7	R8
18–30	−0.076	−0.154	−0.046	−0.078	−0.155	0.011	0.168	0.325	0.019	−0.153
31–40	0.143	−0.086	0.225	−0.421*	−0.072	0.225	−0.184	0.082	−0.302	−0.151
41–55	0.223	0.135	0.479*	−0.476*	0.136	0.531*	−0.634*	−0.248	−0.601*	−0.024

* indicates statistically significant correlation (P<0.05)

Table 2: The correlation coefficient between skin hydration and mechanical parameters

Skin hydration									
Age (years)	**R0**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
18–30	0.320*	0.334*	−0.142	0.350*	0.303*	−0.117	−0.401*	0.100	0.258*
31–40	0.281	0.230	−0.009	0.278	0.226	0.064	0.270	0.272	0.271
41–55	0.291	0.340	−0.317	0.295	0.343	−0.194	−0.064	−0.172	0.212

*indicates statistically significant correlation (P<0.05)

Table 3: The correlation coefficient between increases in skin hydration and changes in mechanical parameters after 8 weeks of microemulsion serum application

	R0	R1	R2	R3	R4	R5	R6	R7	R8
Hydration	0.329**	−0.068	0.002	0.345**	−0.029	0.046	0.051	0.017	0.320**
R0		0.407*	−0.128	0.985*	0.440*	−0.346**	−0.403*	−0.189	0.900*

*indicates statistically significant correlation ($P<0.05$) or **$P<0.1$

Table 4: The correlation coefficient between increases in skin hydration and changes in mechanical parameters after 8 weeks of nanoemulsion serum application

	R0	R1	R2	R3	R4	R5	R6	R7	R8
Hydration	0.188	0.115	−0.035	0.179	0.105	0.047	−0.096	0.100	0.175
R0		0.798*	−0.122	0.995*	0.834*	−0.726*	−0.803*	−0.563*	0.935*

*indicates statistically significant correlation ($P<0.05$)

The Influence of Cosmetic Treatment on Skin Parameters

Changes in skin parameters after 8 weeks of cosmetic treatment were calculated as percent change. Correlations between percent changes in skin hydration and mechanical properties and between changes in R0 and other mechanical parameters were evaluated. The results are presented in Table 3 for microemulsion serum treatment and in Table 4 for nanoemulsion serum treatment. Eight weeks application of microemulsion or nanoemulsion serum significantly improved skin hydration measured by the use of Corneometer® [Figure 3]. Skin hydration increased by microemulsion serum showed more positive correlation to an increase in R0. Changing in R0 was inversely correlated to the changes in elasticity parameter (R5). Contrarily, no correlation was observed between changes in skin hydration and skin mechanical properties in nanoemulsion treatment group. R0 increased after such application was negatively correlated to both skin elasticity parameters of R5 and R7 with higher intensity than in microemulsion treatment.

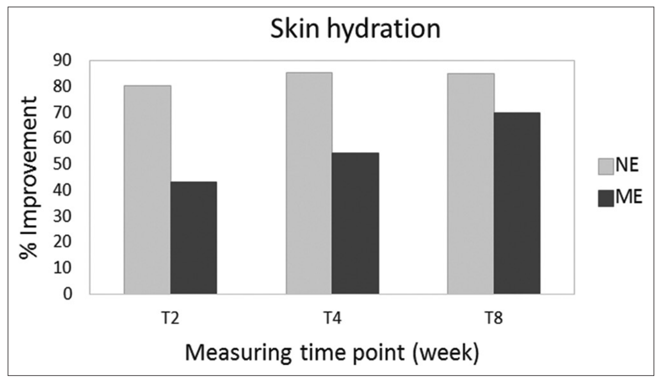

Figure 3: Clustered column demonstrating an increase in skin hydration after treatment with nanoemulsion (NE) or microemulsion (ME) serum compared to the initial condition

DISCUSSION

Skin is the largest and outermost organ of the body providing one of the people physical appearances. Changes in skin condition could be resulted from intrinsic and extrinsic factors such as time passage and UV radiation, respectively. Significant changes of skin condition include skin dryness, scaliness, roughness, and losses in skin firmness and elasticity and they are more obvious with age increased. Strong negative correlations between age and skin hydration or age and mechanical properties have been demonstrated.[6,7] However, at which age duration that significant changing in skin condition could be detected, has not been reported. In addition, effect of intrinsic skin hydration or skin hydration increased by cosmetic application on each skin mechanical parameters has not been fully characterized. Thus, in this study, we analyzed the left-to-right side difference and relationship between several skin parameters and skin mechanical properties.

Regional and gender variations in skin physiological parameters such as stratum corneum hydration, skin surface pH, and transepidermal water loss (TEWL) have been widely established.[8-12] Left-to-right side differences of several skin parameters except for TEWL have also been reported.[13,14] In contrast to previous data, strong correlation between left and right facial sides on skin parameters including skin hydration, R0, R2, R7 [Figure 2], melanin index, typological angle, and L* (data not shown) was revealed in the present study. This contrast result could be suspected to be due to the differences in routine skin care regimen, in anatomical test sites or in ethnic groups being measured.

In accordance with Mayes *et al.*,[4] an insignificant relationship between age and skin hydration was detected in the present study [Table 1]. Average scores of skin hydration were roughly stable for the age ranges evaluated (18–55 years). Wendling and Dell'Acqua also revealed comparable forehead skin hydration of volunteers among age of 20–73 years.[15] However, several reports demonstrated a significant relation between skin hydration and age.[3,15,16] Their data revealed a lower stratum corneum hydration of the older individuals, especially volunteers with age of above 70 years. Skin hydration of volunteers in the young and middle age groups; however, was relatively stable which is in agreement with our findings. Stratum corneum hydration, therefore, seems to significantly decrease after age of 70 which could be due to the lower in sebum content and natural moisturizers.[16]

Although skin hydration is independent from age of individuals below 70 years old, skin mechanical properties are strongly related with age. The results of the present study are in strong agreement with previous findings,[5,6,15,17] where all elasticity parameters of R2, R5, and R7 were negatively correlated with age. According to dermal structure, collagen forms a network essentially for the skin strength while elastic fiber provides elasticity which allows the skin to return to its initial stage after stretching. The decrease in both dermal fibers by proteinase activity and by repetitive effect of UV radiation, thus, leads to the lower in stretching parameters (Uf, Ue) by up to 50% and in parameters corresponding to skin recovery (Ur, Ua) by up to 75% over lifespan.[5] Degeneration of elastin accounting for only 2–4% of skin dry weight results in the more obvious changes in skin elasticity compared to firmness. Interestingly, the present finding demonstrated that, among elasticity parameters, decreases in R2 could be firstly observed during the age of 30–40 years while the changes in R5 and R7 could be detected only after the age of 40s. Therefore, the changes in R2 was identified as a first sign of intial skin aging condition.

While positive correlation between age and mechanical properties has been in strong agreement by various research groups, relationship between skin hydration and mechanical properties is still in discrepancy. Dobrev[18] demonstrated that viscoelasticity (R6) was the most sensitive Cutometer® parameters to the changes in epidermal hydration level. This fluidity was positively correlated to the skin hydration. They suggested that skin hydration decreased the viscosity of interstitial fluid, lowered the friction between fibers and, hence, facilitated the movement of skin tissue. In addition, positive correlations between gross (R2) or net (R5) elasticity and hydration level were also revealed.[6] In contrary, the present data demonstrated that the skin hydration influenced only on some mechanical parameters in the young population. It, however, had no effect on skin elasticity in all age groups [Table 2]. Our results are in accordance with the previous reports showing no significant correlation between the capacitance measured by Corneometer® and elasticity parameters (R2, R5, and R7) of untreated skin.[18-21] We agreed with the previous suggestion[19,22] demonstrating that Corneometer® measures the skin hydration of the superficial epidermis while Cutometer® monitors the deformation of tissue as deep as dermal layer. It is difficult to compare or correlate the data obtained from measurements of different skin levels. Thus, capacitance is not a proper predictor for the mechanical properties of untreated skin.

Intrinsic skin moisturization was independent from age and mechanical properties. However, epidermal hydration influenced by external sources, such as application of water or cosmetic usage, might offer some effect on mechanical properties of skin depending on type of material applied. Yilmaz and Borchert[23] demonstrated an increase in skin hydration and skin elasticity following topical application of cream containing stratum corneum lipid and ceramide 3B. Bettinger *et al*.[24] confirmed the result by showing positive correlation between skin capacitance and skin elasticity after treatment with glycerol emulsion. However, no correlation was detected by the treatment of urea and propylene glycol. Lacks of relationship between skin moisturization and elasticity following application of moisturizers were also reported by Murray and Wickett[19] and Dobrev.[18] An independent effect was supported by the present study. Eight weeks of microemulsion or nanoemulsion treatment significantly improved skin hydration. However, increases in skin hydration as detected by the changes in Corneometer® unit were not directly correlated to elasticity parameters. It might, however, affect some other mechanical parameters such as R0 which represents the total elongation of skin fiber. Skin hydration increased by microemulsion showed more positive correlation to R0. Increase in R0 after microemulsion treatment could be resulted partly from skin hydration which enhances the stretchability of skin fiber. Therefore, the changes in this parameter (R0) by microemulsion treatment were not obviously correlated to the changes in elasticity parameters (R2, R5, and R7). In contrast, increase in R0 after nanoemulsion application was independent from skin hydration. It might solely enhance by losses in skin firmness, thus, it showed obvious negative correlation to skin elasticity parameters (R5, R7). The present result would confirm the lack of relationship between moisturization and elasticity parameters. In addition, although both formulations enhanced skin hydration, correlations between skin hydration and mechanical properties were different. Since age distributin of participants in both treatment groups were comparable, hence, improvement in skin elasticity following cosmetic treatment would probably depend on type of ingredient applied. Relationship between moisturization and skin elasticity would be dependent on cosmetic ingredients. One which directly affects only on skin hydration would be dominant on the change of line and wrinkle than skin elasticity which is related to the quality of skin fiber.

CONCLUSION

The skin elasticity decreased with age and changes in gloss elasticity (R2) was firstly observed. As the age increases, R5 and R7 showed stronger negative relationship to the age. Intrinsic skin hydration was independent from age and elasticity. However, increase in skin hydration by topical treatment might affect skin elasticity depending on the type of material applied. Topical product which only enhances skin hydration might not affect skin elasticity which is related to the quality of elastin fiber.

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Disclosure

The author reports no conflicts of interest in this work.

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