Development of new cosmetic clinical assessment based on skin measurement data according to age of Korean women.

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Abstract

Background: Skin properties are classified several features like wrinkles, texture and hyperpigmentation et al, those are measured and quantified by a variety technique. That is used to evaluating in clinical study. Accumulated skin characteristic data can be used to build skin diagnosis data, which can be used for diagnostic analysis to select cosmetics suitable for one's skin.

Methods: In study 1, In 303 Korean women in their 20s to 40s, skin characteristics data for ages were collected. The data were analyzed for statistically, correlation and regression analysis between the data were conducted to study the new skin index in association with the ages. And cluster analysis was performed to classify the groups into 4 clusters, and the skin characteristics of each cluster were confirmed. In study 2, a clinical study was conducted on 21 Korean women in 2 weeks, the results were compared with the skin cluster results in study 1.

Results: In Study 1, the differences in the skin characteristics of women in age groups were identified. Then performed correlation and regression analysis to create a skin index, and cluster analysis. In study 2, after two weeks than before use products, the skin hydration increased($p<0.001$), the amount of the stratum corneum and skin redness decreased($p<0.001$). Those were compared with the cluster analysis and regression analysis results previously analyzed.

Conclusion: The new skin index can be used in conjunction with other skin indexes like aging index. It is considered that it can be used in big data if the data is continuously expanded.

Keywords: Skin index; Skin characteristic regression analysis; Classification skin; Clinical study; Customized cosmetic

Introduction.

Skin properties can be classified in terms of several specific features such as wrinkles, surface roughness, texture, pores and hyperpigmentation, which have been measured and quantified by a variety of imaging techniques. Such methods are widely used in assessing the efficacy in evaluating the condition of the skin in clinical research. Skin characteristics are not limited to grasping individual skin but can be used for research by classifying people with common skin characteristics. In addition, the accumulated skin characteristic data can be used to build skin diagnosis data, which can be used for diagnostic analysis to select cosmetics suitable for one's skin. The most popular classification criterion for skin classification is the Baumann skin type. [1] The Baumann skin type evaluates the presence or absence of dry/oily, pigmented/non-pigmented, sensitive/resistant, and wrinkle-prone/tight using a questionnaire, and classifies them into 16 types so that the person's skin can be grasped. [1] The Baumann skin type is widely used around the world and there are various studies related to it. [2-3] In addition, the Oilskin Self-Assessment Scale (OSSAS) and the Oilskin self-image questionnaire (OSSIQ) are used as scales for grasping skin types. [4] They are associated with the subject's skin measurement elements based on a questionnaire and provide criteria for people to choose cosmetics. In addition to classifying skin types through questionnaires, research is underway that measures real human skin and correlates it with relevant factors. An active research field is aging-related research. P&G, a representative research case, conducted an 11-year follow-up in Japan for aging research, and studied the difference in skin surface reflectance according to age. In addition, an aging diagnostic index and skin diagnostic device were developed based on the announcement of the research result that the shape of skin wrinkles change in the 30s. [5-8] In addition, collagen, which affects skin elasticity and wrinkles, and skin health In addition to papers on the relationship [9], a study of skin measurement factors and biological factors according to skin area and age of Korean women, [10] The relationship between skin oxidative stress and skin characteristics, [11] Glycosylation products and aging correlations between factors were also studied. [12] Also, it was studied to oily and moisture conditions in skin correlate the skin pigmentation index.

[13] In this study, a new skin index and cluster analysis was performed for Korean women by analyzing the correlation between skin characteristics data and ages as well as comparing skin characteristics. In addition, the results were compared by conducting to clinical study using the prototype product for 2 weeks.

Materials and Methods.

[Clinical study to collect skin characteristics]

A human clinical study was performed to measure skin characteristics on Korean women. A single skin measurement was performed on 303 Korean women. To exclude the influence of homogeneity and the number of samples as much as possible on the basic skin characteristics, the gender of the subjects was unified as one criterion and females were selected. The test site was the face (forehead, both cheeks) and the forearm, and the subjects visited the test site and waited for at least 30 min after washing the test site to stabilize the skin. The device measurement factors are skin hydration, skin melanin index, skin redness index, and skin torsion elasticity. The skin moisture content was measured through the Skin-O-Mat® (Cosmomed, Germany), which measures capacitance. The skin melanin and skin redness values were measured using a dermacatch (Colorix SA, Switzerland), and a derma torque meter (DTM310, Dia-Stron, UK) was used to measure skin elasticity. This study was approved by the Institutional Review Board of CRA Korea. (2020021201-202104-HR-005-01).

[Index development and cluster analysis using skin characteristics]

The correlation between the device measurement results and age of 303 people was analyzed using the spearman correlation test in SPSS 28.0 (IBM SPSS Statistics, USA). After correlation analysis, highly correlated skin characteristic factors were indexed. By examining multi-collinearity between items, VIF (variance inflation factors) indices between items were confirmed. Finally, a model for predicting the skin age of Korean women was finally derived. Based on the data, cluster analysis was performed to classify the 4 clusters and analyze the questionnaire corresponding to each cluster to confirm the characteristics of the cluster.

[Efficacy evaluation of prototype using cluster analysis based on skin characteristic index]

2 prototype products of each containing hyaluronic acid and mandelic acid were used for two weeks, and a clinical study was conducted. To the subjects, 2 types of cosmetics were applied to the face after washing at intervals of 2 times a day for 2 weeks, and no other products were used. Measurements were the device before use, 1 week, and 2 weeks after use. To evaluate the change in skin hydration according to product use, it was measured using Skin-O-Mat®, which is measured based on capacitance. The amount of stratum corneum was measured using black D-squame tape (D-103, Cuderm, USA) after collecting stratum corneum, and using an I-scope 20 (Moritex, Japan) imaging device (manufactured in-house, Korea). Images were taken under normal light source conditions and analyzed using Image J (NIH, USA). Afterwards, Subjects who participated in both studies 1 and 2 were separately selected and the effects according to the cluster of subjects in the product were compared.

[Data Analysis and Statistics]

The normality of the results was tested by the Kolmogorov-Smirnov and Shapiro-Wilk methods. After the normality test, the comparison between before and after uses was done by the Paired t-test. The statistical analysis program used was SPSS 28.0(IBM SPSS Statistics, USA).

Results

[Results of measurement of skin characteristics for Korean women of ages]

The skin characteristics measurement results for 303 Korean women as follows. (Figure 1) Comparing the subjects by age, there were 102 (24.7±0.28) in their 20s, 100 (34.8±0.28) in their 30s, and 101 (44.5±0.28) in their 40s. As a result of comparing skin characteristics by age, there was little difference in skin hydration. Melanin and skin redness were statistically significantly higher in those in their 30s and 40s compared to those in their 20s on both cheeks ($p < 0.01$). In the case of the forearm, the skin hydration of the 30s compared to the 20s was statistically significantly lower ($p < 0.05$), but the skin hydration of the 30s compared to the 40s was statistically significantly higher ($p < 0.05$). In the case of skin melanin index and skin redness index on the forearm, the values were statistically significantly higher as the age

increased ($p < 0.01$). In the case of skin elasticity, the cheek showed a statistically significantly lower value in their 30s and 40s compared to their 20s ($p < 0.001$), and as the age increased, the elasticity value tended to appear lower. In the case of the medial lower extremity, a statistically significantly lower value was found in those in their 40s compared to those in their 20s ($p < 0.001$).

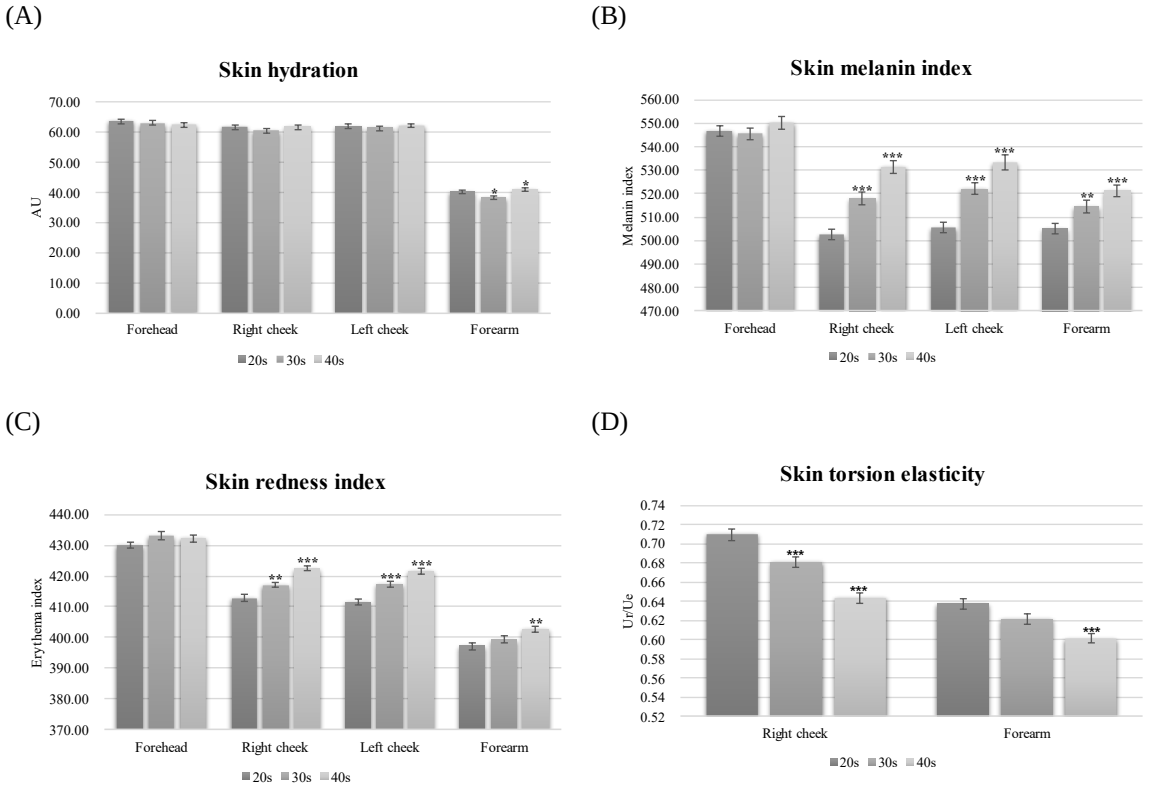


Figure 1. Results of skin characteristics measurement by age group in 20s ~ 40s from data of 303 people(average ± standard error) 20s vs. 30s vs. 40s, Mann-Whitney U analysis. Significant: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$, (A) Skin hydration, (B) Skin melanin index, (C) Skin redness index, (D) Skin torsion elasticity.

[Development of an age prediction model using basic skin characteristics and results of cluster characteristics]

Correlation analysis was performed to obtain the skin index using age and skin characteristics. Age was set as a dependent variable and correlation analysis with skin characteristic data was performed. The list was prepared in the order of the highest simple correlation, and the top

five skin measurement factors were selected and shown in Table 1. The selection factors were facial torsion elasticity, both cheek skin melanin index, redness index. The formula derived from the Index model is Ages = -70.659+0.049(Melanin_Left) + 0.014(Melanin_Right) + 0.166 (Redness_Left) + 0.100 (Redness_Right) + -56.732 (Ur/Ue_Face). The R^2 value of this equation was 0.422 and the corrected R^2 value was 0.412, and the significance of this equation was $p < 0.001$, which was statistically significant. Also, since the VIF is less than 15, it can be judged that there is no problem with multicollinearity, and normality and equal variance of the residuals were also confirmed.

Table 1. Top 5 skin characteristic indicators with simple correlation with age in data of 303 people.

Parameter	Region	Coefficient of correlation
Ur/Ue	Face	-0.493
Melanin	Left cheek	0.453
Melanin	Right cheek	0.435
Redness_Left	Right cheek	0.421
Redness_Right	Left cheek	0.412

Table 2. Results of regression analysis on basic skin characteristics and age of 303 peoples.

Dependent Variable	Independent variable	Unstandardized Coefficients(B)	Std. Error	Standardized Coefficients(β)	t	Sig.	VIF
Ages	(Constant)	-70.659	17.509		-4.036	<.001	
	Melanin _Left	.049	.036	.164	1.354	.177	7.586
	Melanin _Right	.014	.035	.049	.407	.685	7.477
	Redness _Left	.166	.072	.198	2.300	.022	3.806
	Redness _Right	.100	.075	.117	1.334	.183	3.929
	Ur/Ue _Face	-56.732	6.630	-.397	-8.556	<.001	1.106
Ages = -70.659 + 0.049(Melanin_Left) + 0.014(Melanin_Right) + 0.166(Redness_Left) + 0.100(Redness_Right) + -56.732(Ur/Ue_Face) R^2 = 0.422, Adjusted R^2 = 0.412, F = 43.404, p < 0.001, Durbin-Watson = 0.885							

As a result of cluster analysis based on the index model, four types of clusters were found, and each cluster had skin characteristics with different actual and predicted ages (Figure 2). Table 3 shows the characteristics of the cluster.

Figure 2. Result of classification by cluster by comparing the actual age and the age calculated by reflecting the skin index.

Table 3. Skin characteristics according to classification according to cluster analysis and questionnaire by cluster.

Cluster	Number of people	Mainly Affected Skin Characteristics	Representative features through survey answers			
			Skin type	T-zone	U-zone	Skin topic (Top 3)
1	102	Torsion elasticity	Combination skin	Dry skin	Normal to dry skin	-Skin trouble (pimple) -Blemishes (freckles/pigmentation) -Pore (Blackhead)
2	74	Skin melanin	Normal to dry skin	Normal to oily skin	Normal to dry skin	-Dry skin -Blemishes (freckles/pigmentation) -Pore (Blackhead)
3	94	Skin redness	Combination skin	Normal to dry skin	Dry skin	-Dry skin -Blemishes (freckles/pigmentation) -Pore (Blackhead)
4	33	Skin melanin	Normal to dry skin	Oily skin	Dry skin	-Dry skin -Blemishes (freckles/pigmentation) -Skin wrinkles (Deep wrinkles around the eyes or face)

[Clinical study of prototype products using cluster analysis based on skin characteristic index]

Two prototype products were randomly assigned to both sides of the subjects' faces and used for 2 weeks, and then the amount of skin hydration, the amount of stratum corneum, and skin

redness images were measured. The result is shown in Figure 3. As a result of measuring the amount of skin moisture, for prototype products 1, there was a statistically significant increase of 27.4% at 2 weeks after use compared to before use ($p < 0.001$), and for prototype product 2 was increased 32.5% at 2 weeks after use compared to before use ($p < 0.001$). As a result of the analysis of the amount of stratum corneum, in prototype product 1, the amount of stratum corneum decreased by 26.0% statistically significantly 2 weeks after use compared to before use ($p < 0.001$). prototype product 2 was decreased by 23.1% ($p < 0.001$).

In the case of skin redness image analysis, prototype product 1 decreased statistically significantly by 3.8% at 2 weeks after use compared to before use ($p < 0.001$). And prototype product 2 was a decreased statistically significant by 4.0% at 2 weeks after use compared to before use ($p < 0.001$).

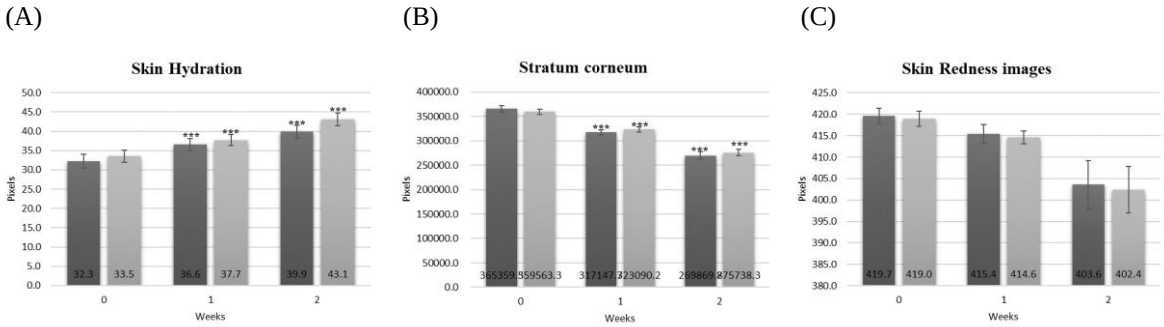


Figure 3. Results of clinical study after 2 weeks of use of two prototype products. 0 week vs. 1 week, 2 weeks, Paired t-test, Significant: ***$p < 0.001$. (A) Skin hydration, (B) Stratum corneum, (C) Skin redness.

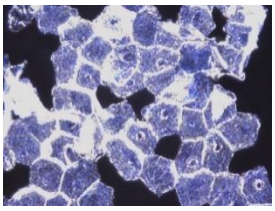
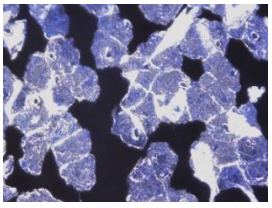
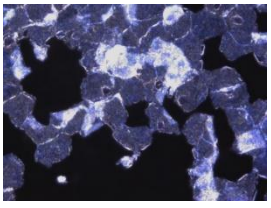
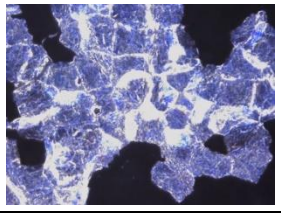
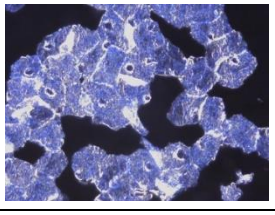
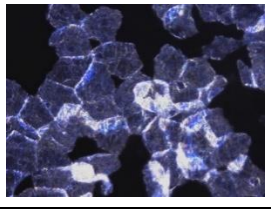
Weeks	0	1	2
CT21-1601-S09			
CT21-1602-S15			

Figure 4. Representative image for stratum corneum using two prototype products

[Prototype products efficacy analysis according to cluster]

Among the test subjects, 18 people with a history of participating in the skin characteristic test were classified according to the cluster and the skin improvement rate was investigated. As a result of subject classification to cluster, there were 9 patients in cluster 1, 8 patients in cluster 3, and 1 patient in cluster 4, and the improvement rates of each measurement factor in clusters 1 and 3 were compared. When comparing the improvement rates, for both prototype products, the improvement in the skin hydration and skin redness image analysis tended to be high in cluster 3. The improvement in the amount of stratum corneum tended to be high in cluster 1. When the clusters suitable for the two test products were analyzed, cluster 1 had a more skin improvement effect in the prototype product 2. But cluster 3 showed a similar skin improvement effect in the two prototype products.

(A) (B)

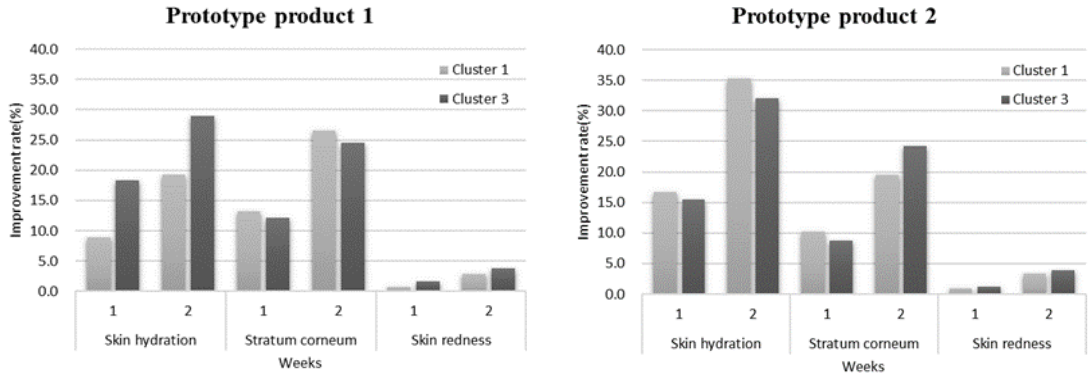


Figure 5. Results of checking the skin improvement of the cluster 1 and cluster 3 subjects in the two types of test products. Cluster 1 vs. Cluster 3, Independent t test or Mann-Whitney U analysis, no significant. Prototype product 1, Prototype product 2.

Discussion.

In this study, new skin index correlation ages and skin characteristics was created, and the possibility of using the new skin index was verified by using it in a clinical study to apply the prototype products. The skin index created by this study has the advantage that it can be widely used by making it evenly reflecting the skin characteristics rather than targeting a

specific target such as aging or whitening. However, since this index is greatly affected by skin elasticity, skin melanin index, and redness index, it is necessary to supplement the index by adding the skin characteristics of subjects like pore, roughness et al rather than limiting to the current results. In addition, to widely utilize the results of cluster analysis, it is necessary to further subdivide the characteristics by additionally measuring subjects from each cluster. If these supplements are made, it will not only expand the current skin index and cluster analysis results, but also contribute to diagnostic technology and cosmetic-related big data that can be used in the cosmetic market in the future.

Conclusion.

This study goes beyond a simple large-scale skin characteristic study to create new indicators and groups through correlation analysis, regression analysis, and cluster analysis. It has the advantage of providing additional data along with the device measurement results by checking the indicators during the human application test. In addition, the new skin index can be used in conjunction with other skin indexes (eg, aging index), and it is considered that additional research is needed in that it can be used in big data if the data is continuously expanded.

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Conflict of Interest Statement. NONE.

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