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Developing an Aging Facial Skin Quality Scoring System for Taiwanese Females: A Comparative Study

Tzu-Miao Lin[1]
[*]Hsi-Chieh Lee[2]
Kuang-Hung Hsu[3]

[1]Dept. of Nursing, Hsin Sheng College of Medical Care and Management, Taiwan
[2] Dept. of Computer Science and Information Engineering, Quemoy University, Taiwan
[3]Dept. and Graduate Institute of Health Care Management, Chang Gung University, Taiwan

This study aims to develop a standardized skin testing procedure to identify facial skin biophysical properties and impact factors of females in Taiwan by using the epidemiology investigation method of a cross-sectional study for facial skin quality. A total of 389 female volunteers aged 18-70 years from across Taiwan and with apparent healthy facial skin took part in the study. Seven facial skin biophysical properties were taken in a controlled environment and using a standardized protocol to ensure consistency of survey. The relationship between facial skin biophysical properties and chronological age were found to follow a linear model; as expected the properties were found to decline with age. Certain lifestyle habits known to have significant effects on facial skin aging were identified. They include body mass index, menstrual cycle, menopausal status, onset of menopause, lifetime sun exposure, hair dye usage, routine of facial cleansing, methods of daily skin care, skin color, skin type and geographical location. A Facial Skin Quality Aging Score System was developed, and it was discovered that the calculated scores significantly ($p<0.0001$) increased with chronological age. The facial skin surface sebum casual level exhibited a distinguishably biphasic decrease ($p<0.0018$), with a sharp drop between the chronological age groups of 35-39 and 40-44. In conclusion, our study demonstrated that a standardized Facial Skin Quality Aging Score System could be used for producing a global systematic reference for human skin quality aging. A standardized facial skin testing center, testing procedure and prediction index of skin quality aging for the Taiwanese population are important concerns. The results of this study could be helpful to the consideration of proper measures for dermatology and cosmetic products.

Keywords: Skin aging, skin biophysical properties, photo images of facial skin, facial skin quality aging score system, courage+khazaka cutometer MPA580

Skin aging is a complex process reflecting changes in tissue structure and function. These changes appear as biophysical properties: viscoelasticity, melanin, erythema, trans-epidermal water loss, skin surface hydration, skin temperature, skin surface sebum casual level, and pH value [1, 2 and 3]. The exact

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*Corresponding author: imhlee@gmail.com

relationship of these biophysical properties and chronological age to skin aging is not fully understood. It appears that intrinsic as well as extrinsic factors both contribute to skin aging [4] and these contributive factors have been used as an informative tool for quantifying skin aging. Thus, it is possible to delineate complex skin aging processes by further extensive investigation of these biophysical properties using information technology.

To determine the contributions of biophysical properties to skin aging, it is necessary to generate objective measures of skin in a given individual for comparison with others of the same chronological age. Over the past 25 years, Courage+Khazaka electronic GmbH has offered scientific skin testing systems and instruments to determine skin type, contributing to skin investigation academically and clinically.

People are very aware of and very sensitive to the appearance of their skin. Skin appearance has stimulated extensive research in the fields of medicine, cosmetology, computer graphics and computer vision. Image processing techniques have been used extensively for defining aged skin, measuring skin color, analyzing skin texture, assessing sensitive skin, treating burn injuries to skin, diagnosing skin cancer, and classifying skin tumors [5, 6, 7 and 8]. Popular approaches include non-invasive and real-time evaluation of aging skin quality, molecular structures and skin cellular elements.

In our study, we compared biophysical properties with photo images of facial skin for analyzing the skin aging process among adult women in Taiwan. We developed a Facial Skin Quality Aging Score System and demonstrated that the biophysical properties of Taiwanese women have the uniqueness of race, ethnic cultural background, geography, and the social economic differences as compared to European women. This information would be valuable to the cosmetic industry and the Facial Skin Quality Aging Score System could produce scientific standardized information for future application.

MATERIALS AND METHODS

-Study Subjects

The facial skin characteristics of 389 Taiwanese female volunteers were analyzed for skin quality and entered into a database from February 2004 to April 2005 [10]. The study was approved by the human study IRB committee of Chang Gung Memorial Hospital (Chang Gung Medical Foundation), Taiwan (Approval No.

93 6126). Subjects was selected from five distinguished regions in Taiwan. The number of subjects in each region was normalized in according to the ratio of female population to total in that region. A total of 207 were from the North, 60 from the Middle, 71 from the South, 27 from the Northeast, and 24 from the East. All participants were recruited across sections on a voluntary basis, and informed consent was obtained from each one.

-Study Methods

Seven facial skin biophysical properties were measured: viscoelasticity, melanin, erythema, trans-epidermal water loss, skin surface hydration, pH measurement, and skin surface sebum casual level. Measurements were made using the Courage+Khazaka Cutomer MPA580 [3]. The manufacturer' s instructions were followed and measurements were taken in an air-conditioned testing room with 20-24℃constant temperature and 50-60% relative humidity.

-Statistical Analysis

Statistical analysis software (SAS, Release 8.12; SAS Institute, Inc., 1999, Cary, NC.USA) was used to assess the captured facial skin biophysical properties and photo-image features to establish the facial skin quality aging score (FSQAS). Univariate analysis of variance was examined using T-test, multiple regression, analysis of variation (ANOVA) and Correlation [11]. This was followed by multivariate statistical analysis examined by using correlation and factor analysis [12]. The analyzed data was assembled into databases for the biophysical properties and photo-image features analysis of facial skin quality.

-Correlation of Facial Skin Biophysical Properties to Chronological Age

The 389 study subjects were divided into seven age groups: 18-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-70; the face of each subject was divided into four areas: forehead, right cheek, left cheek, chin. A confirmatory factor was used to analyze the measurements of the 27 skin bio-physiological properties, which were split into 6 dimensions: pigmentation, viscoelasticity, epidermal hydration, trans-epidermal water loss, skin surface pH value, and sebum casual level. To modeling of the 6 dimensions' scores with chronological age was constructed by calculating the correlation matrix contains coefficients. The obtained values of assessments and calculations were correlation into corresponding to each of chronological age groups and facial skin biophysical properties interrelationships (Figure 1). The facial skin biophysical properties measurements as well as the potential interactions were analyzed using mean standard deviation, analysis of variation (ANOVA) and calculated by correlation analysis.

-Correlation of Facial Skin Photo-Image Features to Chronological Age

Three facial images (one frontal and two side views) were taken by a digital camera (Nikon Cool Pix 5000 and Sanyo Digital Movie C1 3.2 Megapixel), which were standardized by positioning fixation and color correction to ensure consistent processing of images from each of the 389 study subjects. These images were stored in a computer memory bank for future analysis.

The photos of the faces of 16 randomly sampled women were blindly evaluated by three clinical dermatologists for skin texture, spots, comedos and wrinkles. An assignment score was used: 1 for zero defects, 2 for a few defects, and 3 for large obvious defects. Based on this pilot study, a panel of 25 facial skin image features (Figure 2) was developed and used to collect by examining the photo-graphics of all 389 participants. We used a confirmatory factor to analyze the 25 facial skin image features and split them into 4 dimensions: skin texture, spots, comedos, and wrinkles. A model of the 4 dimensions' scores with chronological age was constructed by calculating the correlation matrix contains coefficients. These obtained assessment and calculation values were correlation into corresponding to each of chronological age groups and facial skin image features interrelationships (Figure 2). The facial skin image features measurements as well as potential interactions were analyzed using mean standard deviation, analysis of variation (ANOVA) and calculated by correlation analysis.

All of the above correlations of facial skin biophysical properties and photo-image features to chronological age values were tested in a multiple regression model, and then used to obtain the Facial Skin Quality Aging Scoring System (Figure 3).

RESULTS

Facial skin's biophysical properties were found to correlate with chronological age. The calculated skin quality aging scores of the six biophysical properties dimensions, i.e., pigmentation, viscoelasticity, epidermal hydration, trans-epidermal water loss, skin surface pH value and sebum casual level, were paired with the corresponding chronological age groups in Table 1-1 and Table 1-2 and further depicted in Figure 4. Correlation analysis showed facial skin pigmentation significantly increased with skin quality aging at

$p<0.0001$, whereas viscoelasticity significantly decreased with skin quality aging at $p<0.001$. Facial skin surface sebum casual level significantly decreased with skin quality aging at $p<0.0018$. The analysis also showed a biphasic decrease with a sharp drop between chronological age-groups 35-39 and 40-44, as shown in Table 1-1 and Figure 4-F. Facial skin surface pH value and trans-epidermal water loss did not significantly correlate with facial skin aging quality.

Facial skin image features were shown to correlate with chronological age. The calculated scores of the four facial skin image features dimensions, i.e. skin texture, spots, comedos and wrinkles, and the paired chronological age groups are shown in Table 2 and depicted in Figure 5. Skin texture, spots, and wrinkles appeared significantly increased with skin quality aging at $p<0.0001$, whereas comedos significantly decreased with increased skin quality aging at $p<0.0001$.

The construction of the Facial Skin Quality Aging Score System is illustrated in Table 3 and depicted in Figure 6. Calculated age scores of biophysical properties and photo-image features are shown in Table 3 column 1 and 2, respectively. The calculated aging scores were highly significantly increased in comparison with the increase of chronological age at $p<0.0001$. By our definition, the Facial Skin Quality Aging Score (FSQAS) is the sum of the addition of biophysical properties age score and photo-image features age score. FSQAS is presented in Table 3 column 3 and depicted in Figure 5-C. The calculated FSQAS were shown to significantly increase as the chronological age increased. This correlation was highly significantly at $p<0.0001$, as showed by the multiple variance analysis.

DISCUSSION

Skin is the outermost tissue in the human body. It is mainly composed of skin layer, fine wrinkles, hair and skin surface lipids. Recently, age-related changes in female [9] and male [13] skin have been reported. It is greatly interesting to compare the aforementioned study to our results.1 The study examined 150 females and 150 male subjects (age 20-70 years, all healthy) and we studied 389 females (age 18-70 years). Our study participants were selected from the five regions of Taiwan' s main island, with great attention to enrolment in accordance with the ratio of the female population in the regions. Our study attempts to achieve that the female participants could represent the entire female population on the island [2]. They used globally acknowledged biophysical measuring methods and instruments, i.e. the Courage+Khazaka Cutometer; we used the Cutometer MPA580 [3]. They found that trans-epidermal water loss and skin sebum production did not correlate with increasing age. Our results show that facial skin surface sebum level was biphasic decreased as age increases with $p<0.0018$. The biphasic curve’ s breaking point is at age group 35-39 to 40-44, as shown in Table 1 and Figure 1. The sebum levels were 33.01±23.31 $\mu g/cm^2$ to 31.14±19.13 $\mu g/cm^2$ for age groups 18-24, 25-29, 30-34, and 35-39, then sharply dropped to 21.40±12.73 $\mu g/cm^2$, 20.27± 9.74 $\mu g/cm^2$, and 22.68±15.31$\mu g/cm^2$, for age groups 40-44, 45-49, and 50-70 respectively. This biphasic decrease in facial skin surface sebum could be due to physiological menopause, as reported by Luebberding et.al. [9] and they reported the decrease of forehead sebum level profoundly occurred at age groups 50-59 and 60-80, but without biphasic pattern. The difference in facial skin sebum changes between German women and Taiwanese women could be due to race or lifestyle differences. Nonetheless, based on the results of two studies, it could be clear that post-menopausal women need to tend their skin sebum level using exogenous products. In the same reports, they found that stratum corneum (SC) hydration decreased significantly at the face and neck. The greatest decrease was assessed at the forehead. Our data (in Table 1 and Figure 4-C) showed that facial skin epidermal hydration decreased significantly with age at $p<0.0074$. They found facial skin surface pH significantly increased with age. On the contrary, our results showed the facial skin surface pH stayed constantly around 5.5 for all the whole age groups. Further comparing our results with those of other studies [9, 13], it could be concluded that skin biophysical properties differences between Germany and Taiwanese could be due to differences in race, gender, geography, social economics and lifestyle. Furthermore, recently published reports [14-24] suggest that a standardized biophysical measuring of facial skin surface quality might be necessary for producing a global systematic reference for human skin quality aging.

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Group	Skin Pigmentation	Skin Viscoelasticity	Epidermal Hydration
18~24	286.54±37.22	0.5906±0.0580	95.20±11.28
25~29	274.52±30.98	0.5664±0.0653	93.74±11.46
30~34	291.38±35.63	0.5647±0.0529	100.74±12.52
35~39	301.88±45.37	0.5257±0.0429	91.56±11.07
40~44	298.02±39.61	0.5096±0.0489	94.51±10.96
45~49	302.92±55.18	0.4904±0.0638	92.80±13.34
50~70	320.10±45.49	0.4668±0.0558	96.55±10.53
P Value	<0.0001	<0.0001	0.0074

Table 1-1. Chronological Age vs. Bio-physiological Parameters

Group	Skin Surface pH Value	Trans-Epidermal Water Loss	Skin Surface Sebum Level
18~24	5.56±0.36	16.26±4.57	33.01±23.31
25~29	5.56±0.36	17.13±4.43	30.84±19.65
30~34	5.50±0.30	16.28±4.20	29.39±17.55
35~39	5.48±0.34	17.01±7.19	31.14±19.13
40~44	5.51±0.35	16.04±4.20	21.40±12.73
45~49	5.60±0.33	15.57±4.44	20.27±9.74
50~70	5.49±0.34	14.89±4.77	22.68±15.31
P Value	0.7275	0.4289	0.0018

*Mean±SD

The physiological measurements were obtained using the Courage+Khazaka Cutometer MPA580.

Table 1-2. Chronological Age vs. Bio-physiological Parameters

Age Group (yrs.)	**Photo-image Characteristic Values (Score)***			
	Texture	**Spots**	**Comedos**	**Wrinkles**
18~24	2.66±0.55	2.77±0.50	2.31±0.64	2.12±0.60
25~29	2.94±0.62	2.90±0.39	2.37±0.61	2.48±0.50
30~34	3.18±0.58	3.11±0.49	2.24±0.63	2.71±0.34
35~39	3.46±0.63	3.26±0.61	2.23±0.68	2.77±0.25
40~44	3.66±0.53	3.46±0.52	1.87±0.66	2.84±0.00
45~49	3.80±0.50	3.51±0.52	1.87±0.59	2.79±0.21
50~70	4.08±0.14	3.83±0.49	1.76±0.66	2.84±0.00
P Value	<0.0001	<0.0001	<0.0001	<0.0001

*Mean±SD

Table 2. Chronological Age vs. Photo-Image Characteristic Values

Age Group (yrs.)	**Skin Quality Aging Scores***		
	Bio-physiological Scoring	**Photo-image Characteristic Scoring**	**Skin Quality Aging Scoring**
18~24	35.67±5.08	2.05±0.34	37.75±5.18
25~29	35.05±4.37	2.25±0.33	37.34±4.45
30~34	37.22±4.91	2.46±0.32	39.68±4.99
35~39	38.77±6.39	2.63±0.32	41.67±6.44
40~44	38.42±5.56	2.81±0.30	41.23±5.61
45~49	39.19±7.69	2.87±0.31	42.06±7.79
50~70	40.91±6.37	3.10±0.20	44.01±6.43
P Value	<0.0001	<0.0001	<0.0001

*Mean±SD

Table 3. Chronological Age vs. Skin Quality Aging Scores

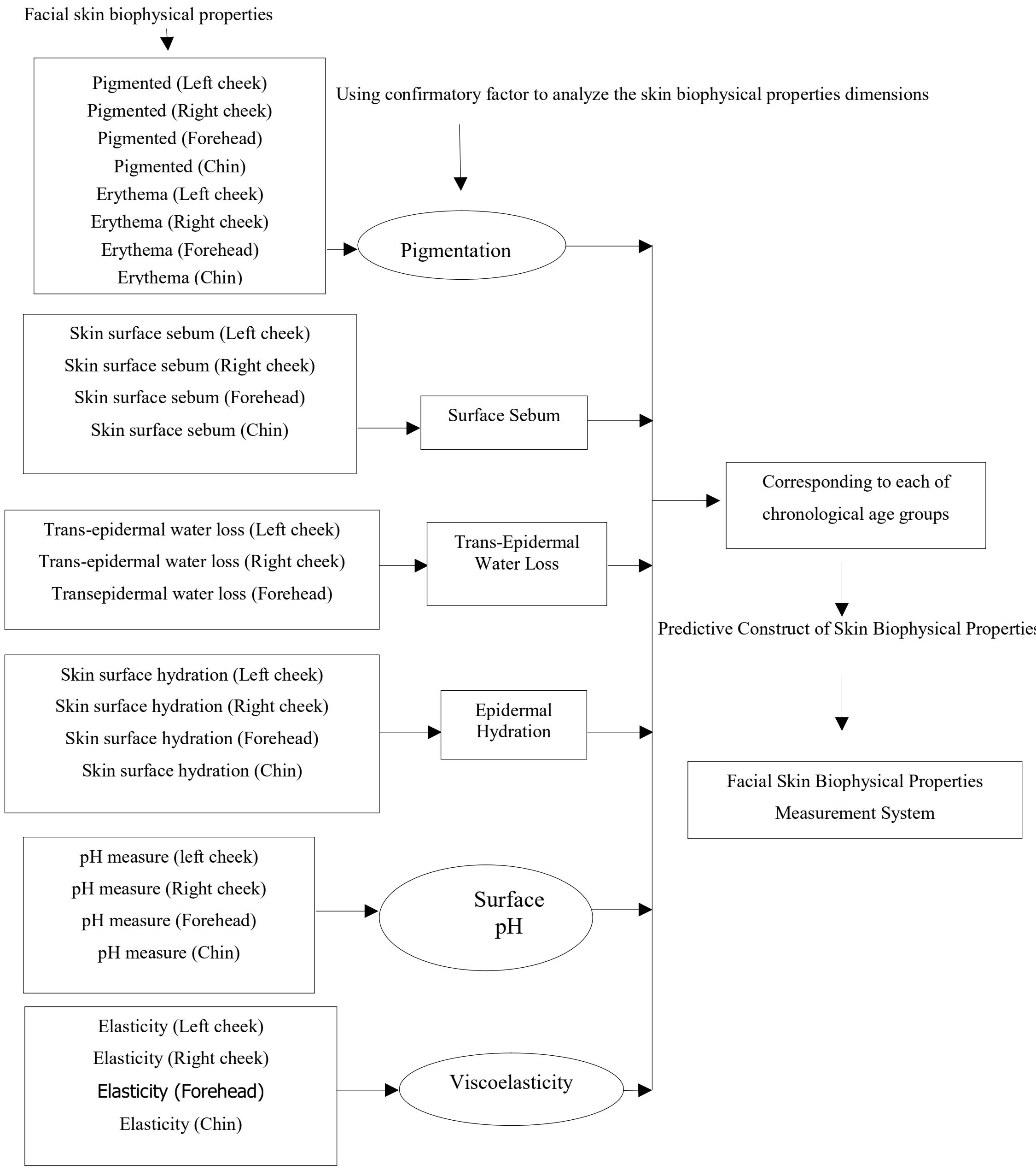

Figure 1. Facial Skin Biophysical Properties' Measurement System

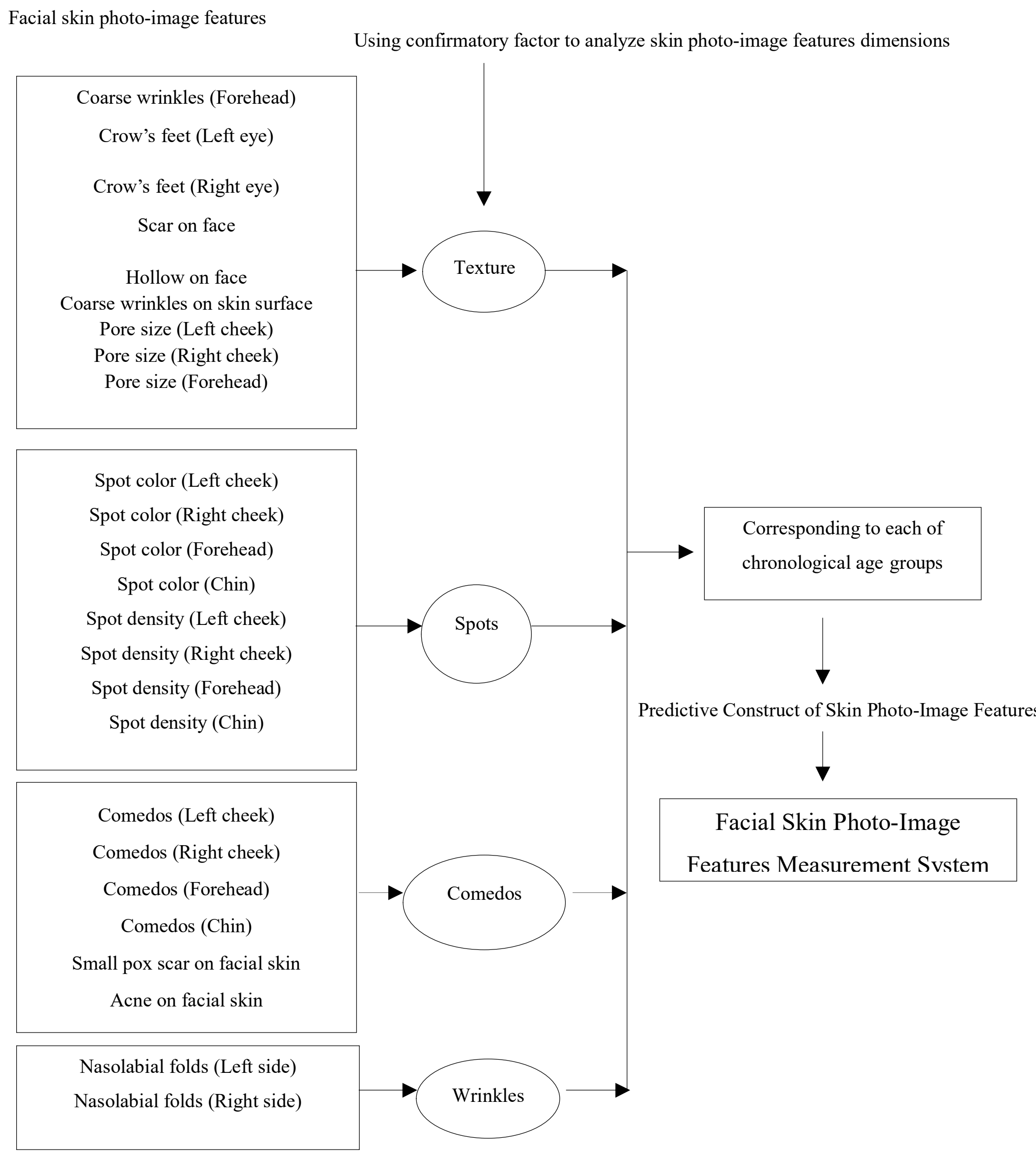

Figure 2. Facial Skin Photo-Image Features Measurement System

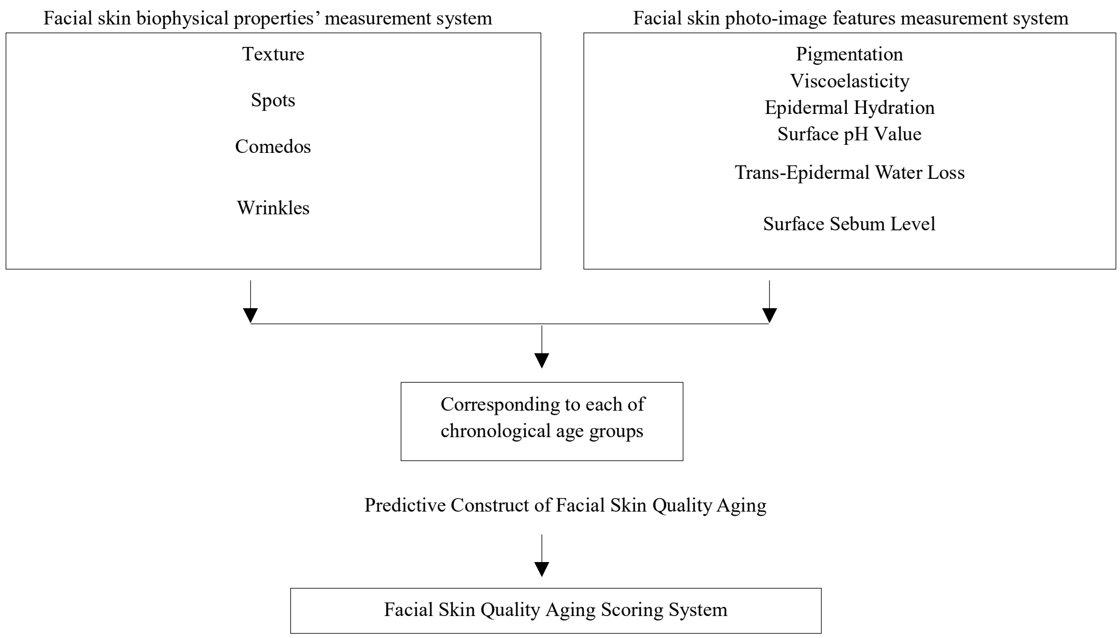

Figure 3. Development of Facial Skin Quality Aging Scoring System

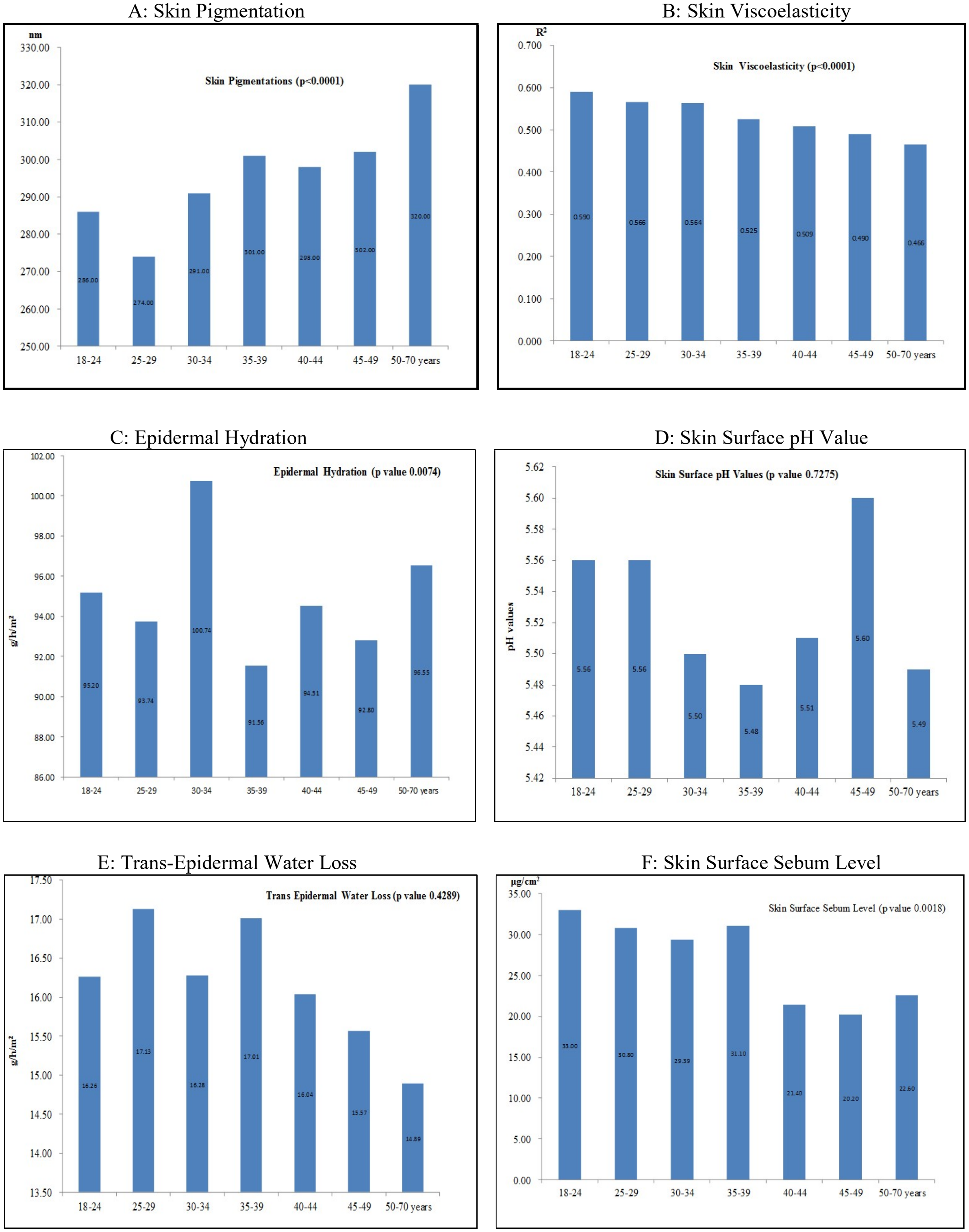

Figure 4. Correlation of Bio-physical Characteristics with Chronological Age
A: Skin Pigmentation; B: Skin Viscoelasticity; C: Epidermal Hydration;
D: Skin Surface pH Value; E: Trans-Epidermal Water Loss; F: Skin Surface Sebum Level

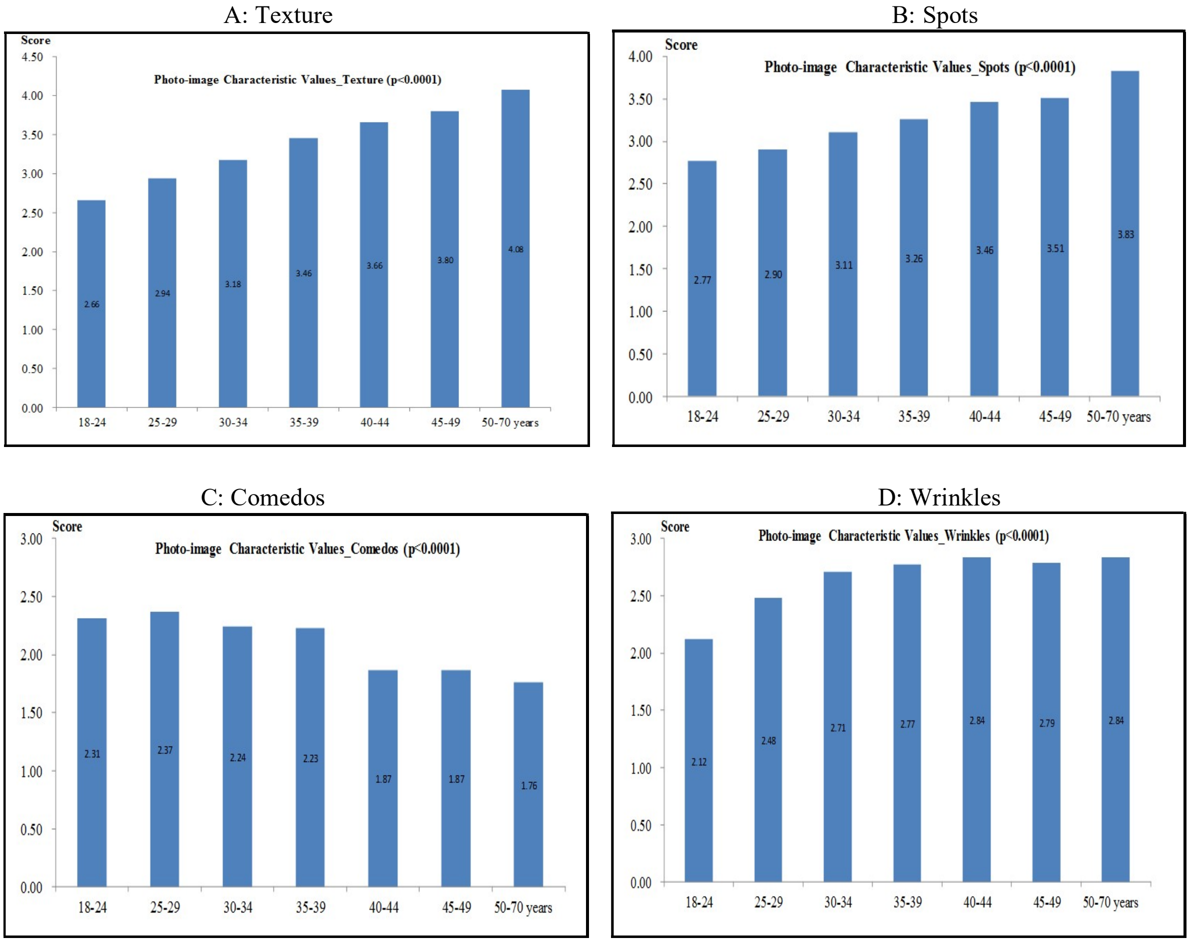

Figure 5. Correlation of Photo-Image Characteristic Values with Chronological Age
A: Texture; B: Spots; C: Comedos; D: Wrinkles

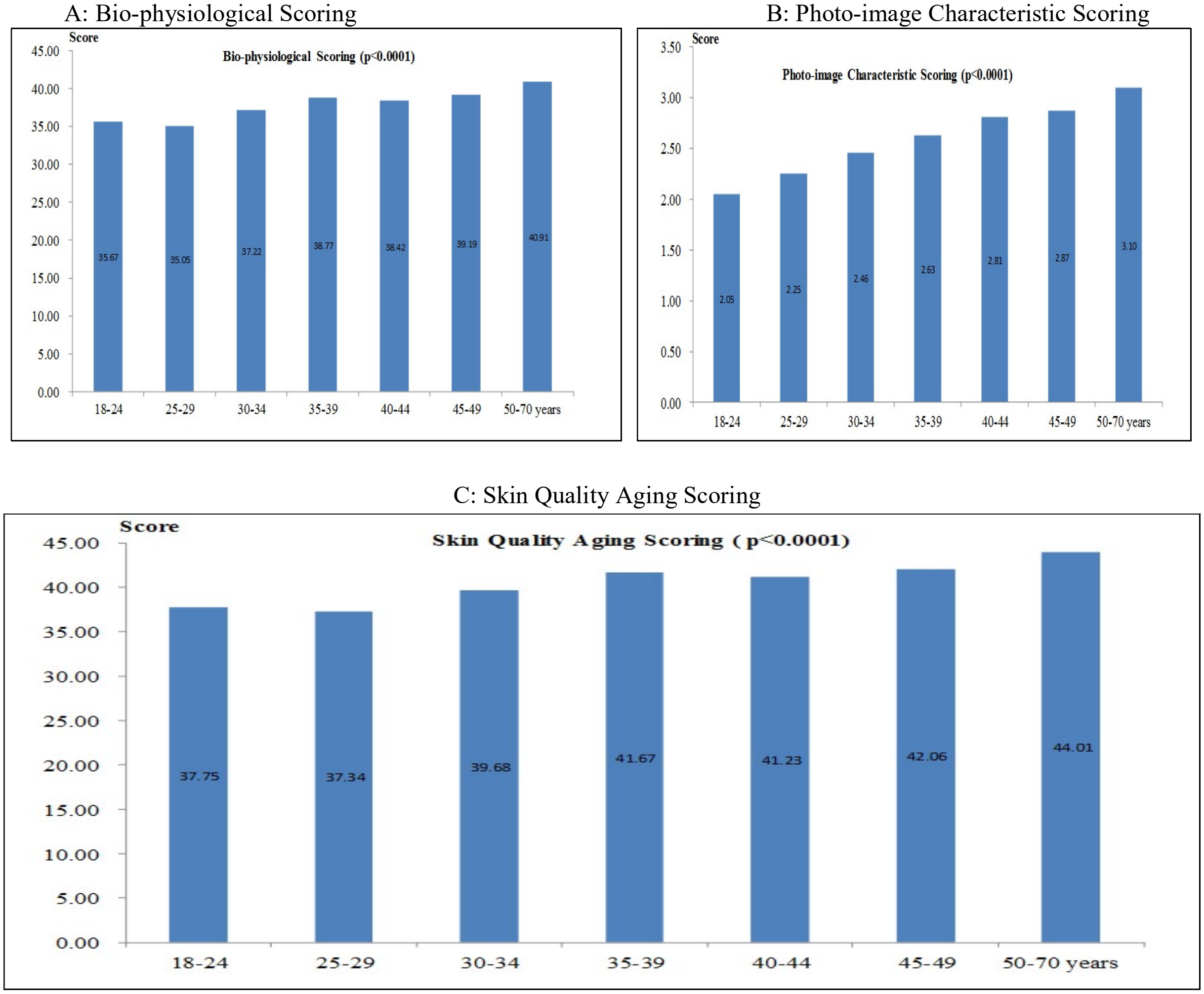

Figure 6. Correlation of Skin Quality Aging Scores with chronological age
A: Bio-Physiological Scoring; B: Photo-Image Characteristic Scoring; C: Skin Quality Aging Scoring