Jung et al. Biomedical Dermatology (2017) 1:2
DOI 10.1186/s41702-017-0002-7

Biomedical Dermatology

RESEARCH Open Access

# Facial L*a*b* values and preferred base makeup products among native Korean women: a clinical study

In Jung, Aha Ryoung Jo, Yu Jeong Kwon, Seungbin Kwon and In-Sook An*

## Abstract

**Background:** Bare face L*a*b* values are needed to serve as a standard reference point for the development of base makeup products for Korean women.

**Methods:** A total of 543 Korean women ranging in age from their 20s to 50s underwent spectrophotometer skin analysis under constant temperature (22 ± 2%) and humidity (50 ± 5%) conditions. Eight parts of each subject's face (center of the forehead, right cheekbone, right cheek, under the chin, left cheek, left cheekbone, philtrum, and under the lips) were measured, and average values were calculated. Subjects were then asked to complete questionnaires regarding their use and preferences for base makeup products.

**Results:** Skin tone was classified into three categories (dark, normal, bright) based on L* values. Compared with the contrast value, the dark group L* was 60.66 and the normal group L* was 63.87 (with a difference of 3.21), and the bright group L* was 66.66 (with a difference of 2.79 from the normal group). According to the survey responses regarding preferences and use of base makeup products, the most common answer for all respondents regardless of age was that their skin tone was average or slightly darker than that of their peers. Preferred base makeup products usually were found to be of slightly brighter color than actual skin tone. As in previous studies, the most frequently used base makeup product regardless of age was BB cream.

**Conclusions:** Given that the average L* standard deviation between groups was 3, a difference of one step in skin tone may be considered to be equivalent to this L* value difference. The survey results suggest that target colors for base makeup product development should be brighter than bare face tones.

**Keywords:** Skin color, Skin tone, Native Korean women, L*a*b* values, Base makeup products

## Background

Skin tone provides not only a reflection of individual heritage, but over the course of human history, certain variations in tone have been accepted as standards of beauty (Wagatsuma 1967). In East Asian more than Western cultures, a particular reverence for white skin has unfortunately contributed to the widespread use of lead-containing cosmetics, resulting in lead poisoning becoming a social issue (Dunbabin et al. 1992; Witkowski and Parish 2001). Bleaching agents classified as medicinal ingredients are also illegally added to some cosmetics that target consumers seeking substantially whiter skin (Desmedt et al. 2014).

Skin color is influenced by complicated interactions among a considerable number of factors including skin pigmentation; thickness; water content; relative proportions of melanin, hemoglobin, and bilirubin; seasonal environment; genetic factors; ultraviolet ray exposure; and personal health status (Jablonski 2006; Muehlenbein 2010). Melanin is the black or brown pigment directly responsible for skin color that is present in the skin, hair, and tissues of plants and animals. Melanin undergoes oxidation according to the following process: tyrosine → 3,4-dihydroxyphenylalanine (DOPA) → DOPA quinone → melanin (Kang et al. 2007). Research on melanin inhibition for medicinal, cosmetic, and food applications is being actively pursued. Among

* Correspondence: anis@skinresearch.or.kr
Korea Institute of Dermatological Sciences, 6F, Tower A, 25, Beobwon-ro 11-gil, Songpa-gu, Seoul, Republic of Korea

these, whitening cosmetics and base makeup products are worth looking at more closely.

Attempts to achieve consistent skin tone have led to breakthroughs in base makeup products that can mask skin imperfections and correct skin tone (Couteau et al. 2016). In the cosmetic industry, Korean products are currently leading the global market, with popular items ranging from blemish balm (BB) cream to the cushion compact (Park and Chin 2010; Baek 2015). To permit further advances in skin tone matching and enhancement, it has therefore become necessary to establish L*a*b* value ranges to inform the coloring of base makeup products.

Previous studies measuring skin tone variations among Korean women were conducted mainly for personal color and color research in the fashion industry. The numbers of subjects in these studies were extremely limited, making it somewhat difficult to interpret and generalize these data. Until now, there has been limited utilization of these findings in the field of cosmetic science. In addition, as data from various age groups were not collected, average values could not be calculated. In this study, facial L*a*b* values were measured for 543 Korean women residing in one metropolitan (Seoul, the capital of Republic of Korea) area who ranged in age from their 20s to 50s, and their use of base makeup products was surveyed.

## Methods

### Measurement of facial tone L*a*b* values

Clinical testing of facial tone L*a*b* values was performed for 543 Korean women ranging in age from their 20s to 50s under constant conditions of temperature (22 ± 2%) and humidity (50 ± 5%) (Park et al. 2015). All clinical research was based on the revised Declaration of Helsinki (Shin 2009), and the study protocol was approved by the institutional review board (IRB) of the Korea Institute of Dermatological Sciences (IRB no. KIDS2016W217). All subjects used the same facial cleanser to clean off their makeup and sunscreen to reveal a bare face. After cleansing, subjects rested for 30 min before testing (Binggeli et al. 2003). Then, using a spectrophotometer (CM-2600D, Konica Minolta, Japan), an experienced lab technician measured eight selected parts of the face for each subject: center of the forehead, right cheekbone, right cheek, under the chin, left cheek, left cheek bone, philtrum, and under the lips. Each measurement was taken three times consecutively, and an average was calculated (Weatherall and Coombs 1992; Piérard 1998; Ahn et al. 2002; Latreille et al. 2007).

**Table 1** L*a*b* values by lightness group

| | | ΔL* | Δa* | Δb* |
|---|---|---|---|---|
| Mean ± SD | Dark | 60.66 ± 2.16 | 12.63 ± 1.36 | 17.82 ± 0.65 |
| | Normal | 63.87 ± 2.27 | 11.10 ± 1.67 | 18.12 ± 0.54 |
| | Bright | 66.66 ± 2.34 | 9.84 ± 1.62 | 17.47 ± 0.64 |

The spectrophotometer is a device that measures chromaticity coordinates by measuring the intensity of wavelengths on a sample surface. Measurement modes include Specular Component Inclusion (SCI), which is a total reflection mode that measures both specular reflections (as from a glass-like surface) and diffuse reflections (as from a coarse surface), and Specular Component Exclusion (SCE), which is a mode measuring only diffuse reflections while excluding specular reflections. L*a*b* values indicate the error of color, and one can quickly see the direction of the conversion. This method is therefore widely accepted as a method based on the complementary relationships between yellow, blue, green, and red, whereby humans perceive color. L* (lightness) values are luminosity indices, expressed as

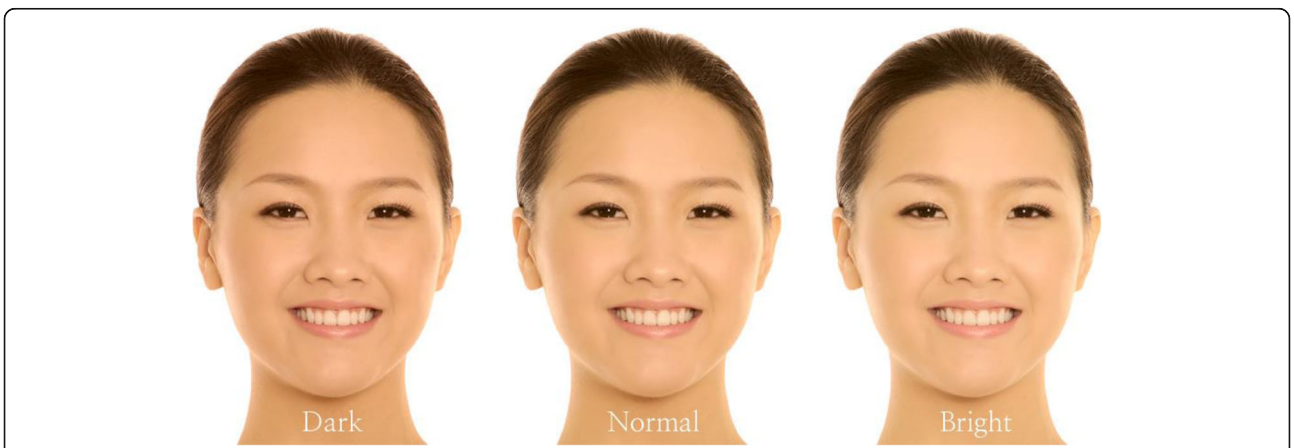


**Fig. 1** Facial color simulation using an Asian model. Using Adobe Photoshop® CS5, average values were applied to the face of an Asian model. The image mode was set to Lab Color, and after loading a picture, a new transparency layer was created and overlaid using the Paint Bucket tool

**Table 2** Differences in preferred products by age (*N* (%))

| | | BB cream | CC cream | Foundation | Cushion compact | Tinted moisturizer | Tinted sunscreen | Powder | $\chi^2$ (*p*) |
|---|---|---|---|---|---|---|---|---|---|
| Age | 20s–30s | 101 (47.6) | 17 (37.8) | 63 (64.3) | 59 (48.4) | 3 (100.0) | 15 (25.9) | 1 (20.0) | 28.51 (0.000) |
| | 40s–50s | 111 (52.4) | 28 (62.2) | 35 (35.7) | 63 (51.6) | 0 (0) | 43 (74.1) | 4 (80.0) | |
| Total | | 212 (39.0) | 45 (8.3) | 98 (18.0) | 122 (22.5) | 3 (0.6) | 58 (10.7) | 5 (0.9) | |

numbers from 0 to 100, with more black colors closer to 0 and more white colors closer to 100. The a* (redness) values and b* (yellowness) values are indices representing saturation. Therefore, high values for a* indicate red, while low values indicate change to green. High values for b* indicate yellow, and low values indicate change to blue (Baulieu et al. 2000; Lee et al. 2002; Armas et al. 2007).

As described in a previous study, L* values sorted in ascending order were used to divide the study subjects into three groups, each including 181 participants (Jung et al. 2013). The group in which the L* values were darkest was designated dark; the middle group, normal; and the brightest group, bright. Face color was not divided by age because there were subjects who were much brighter or darker than their peers within the same age group, and base makeup products on the market are divided by facial color rather than by age.

### Questionnaire responses

In order to investigate use and preferences for base makeup products, following completion of facial color measurements, subjects were asked to complete a questionnaire consisting of nine items. The questionnaire included three items requesting information on demographic characteristics, three on skin color, and three on base makeup product use and preferences. To compare questionnaire responses by age, subjects were divided into two age groups: subjects between 20 and 39 years old (20s–30s) and subjects between 40 and 59 years old (40s–50s) (Shin and Park 2015).

SPSS, version 18.0 (SPSS Inc., Chicago), was used after data coding for data processing, and statistical results were considered significant when $p < 0.05$. Frequency analysis was performed for the demographic analysis of the subjects, and the $\chi^2$ goodness of fit and independence tests were used to compare the actual use and preferences for base makeup products by age.

## Results

### Facial color L*a*b* values among native Korean women

Measured L* values, which is the parameter representing lightness, were 60.66 ± 2.16 for the dark group, 63.87 ± 2.27 for the normal group (with a difference of 3.21 compared with the dark group), and 66.66 ± 2.34 for the bright group (with a difference of 2.79 compared with the normal group). The a* values, which is the parameter representing redness, decreased as skin color became brighter: 12.63 ± 1.36 for the dark group, 11.10 ± 1.67 for the normal group, and 9.84 ± 1.62 for the bright group. The b* values, which is the parameter representing yellowness, were 17.82 ± 0.65 for the dark group, 18.12 ± 0.54 for the normal group, and 17.47 ± 0.64 for the bright group, with no significant differences found among groups (Table 1).

When looking at these results, significant differences in yellowness were not found among subjects of the same race, but differences in redness were observed. In comparison, values measured in a previous study including 110 Korean women were the following: L* was 63.4 ± 2.5 (similar to the normal group in this study), a* was 13.0 ± 1.8 (slightly more red than the dark group in this study), and b* was 15.3 ± 1.9 (more blue than all groups in this study). Only the L* values were similar between studies (Jung et al. 2013).

### Facial color simulation using an Asian model

Using Adobe Photoshop® CS5, average values were applied to the face of an Asian model. The image mode was set to Lab Color, and after loading a picture, a new transparency layer was created and overlaid using the Paint Bucket tool. The overlay was created using the

**Table 3** Notation of products used by age (*N* (%))

| | | Specific code notation by numbering | Notation by Korean | Notation by English | Unique notation depends on the company | No notation for all skin types | $\chi^2$ (*p*) |
|---|---|---|---|---|---|---|---|
| Age | 20s–30s | 183 (44.9) | 18 (39.1) | 28 (65.1) | 20 (90.9) | 10 (41.7) | 24.72 (0.000) |
| | 40s–50s | 225 (55.1) | 28 (60.9) | 15 (34.9) | 2 (9.1) | 14 (58.3) | |
| Total | | 408 (75.1) | 46 (8.5) | 43 (7.9) | 22 (4.1) | 24 (4.4) | |

**Table 4** Differences in skin color perception by age (*N* (%))

| | | Perception of much darker skin color than others | Perception of slightly darker skin color than others | Perception of average skin color | Perception of slightly lighter skin color than others | Perception of much lighter skin color than others | $\chi^2$ (*p*) |
|---|---|---|---|---|---|---|---|
| Age | 20s–30s | 9 (45.0) | 88 (48.9) | 105 (46.4) | 54 (49.5) | 3 (37.5) | 0.781 (0.941) |
| | 40s–50s | 11 (55.0) | 92 (51.1) | 121 (53.5) | 55 (50.5) | 5 (62.5) | |
| Total | | 20 (3.7) | 180 (33.1) | 226 (41.6) | 109 (20.1) | 8 (1.5) | |

layer settings and was able to generate the picture sequence shown in Fig. 1, which presents dark, normal, and bright facial color examples.

### Differences in base makeup product use for skin color correction by age

In order of use, the products applied for skin color correction in the 20s–30s group were BB cream, foundation, and cushion compact, whereas in the 40s–50s group, the order was BB cream, cushion compact, and tinted sunscreen (Table 2). BB cream was reported as the most frequently used product regardless of age. As in previous studies, all ages reported the highest preference for BB cream, which confirms a previous report that BB cream is preferred over other base makeup products.

### Color notation of main base makeup products for skin color correction by age

A specific system for expressing skin color by numbering exists only in Korea. This system uses two digits to indicate differences in color. A first number of 1 refers to pink, 2 refers to beige, and 3 refers to brown. The second number is the lightness value, indicating brightness, with smaller numbers indicating brighter coloration and larger numbers indicating darker shades (Shin 2016). Although there were some differences in the color notation of the most frequently used base makeup products between the two groups, 75.1% of respondents reported using base makeup products no. 13, no. 21, and no. 23, respectively (Table 3). This suggests that additional research is needed in order to determine whether the subjects perceive their skin color brightness as a number.

### Differences in perceived skin color brightness by age

Subjects in both the 20s–30s and 40s–50s groups reported most frequently that they perceive themselves to have average skin color compared to their peers, and the next most common answer was that they perceive themselves to have slightly darker skin than others (Table 4). Among all subjects, 36.8% responded that they had slightly or much darker skin color than others, but 21.6% responded that they perceived themselves to have slightly lighter or much lighter skin color than others.

### Comparing self-perceived skin color with the color of base makeup products currently in use

Both age groups were found to use a slightly brighter product color that would be entirely consistent with their actual skin color (Table 5). There were very few respondents using far darker or brighter colors, but it is meaningful to note that the coloring of the base makeup products was most often chosen to make the skin color lighter than natural skin color.

### Comparing the most important considerations when selecting base makeup products for skin color correction by age

Makeup product measurement items from previous research papers were reviewed (Lee et al. 2014). In order of response frequency, the 20s–30s group answered that they are worried about product adhesion, long-lasting effect, and coverage (Table 6). The 40s–50s group answered that their most important considerations are coverage, product adhesion, and color matching with the skin. There was a limit to the degree of equivalence with the other five view items because the coverage effect surveyed in this item did not ask each subject whether they have their own reference point and prefer if it is weaker or, on the contrary, stronger.

## Discussion

The face, which is always exposed, is continuously tanned by ultraviolet rays, and the lightness or redness of the skin may be further influenced by whitening cosmetics, dermatological procedures, or other variables.

**Table 5** Comparison of color matching between skin color and product by age (*N* (%))

| | | Product color much darker than skin color | Product color slightly darker than skin color | Product color same as skin color | Product color slightly lighter than skin color | Product color much lighter than skin color | $\chi^2$ (*p*) |
|---|---|---|---|---|---|---|---|
| Age | 20s–30s | 0 (0.0) | 15 (30.6) | 75 (42.9) | 165 (52.9) | 4 (66.7) | 12.51 (0.014) |
| | 40s–50s | 1 (100.0) | 34 (69.4) | 100 (57.1) | 147 (47.1) | 2 (33.3) | |
| Total | | 1 (0.2) | 49 (9.0) | 175 (32.2) | 312 (57.5) | 6 (1.1) | |

**Table 6** The most important considerations when selecting products by age (*N* (%))

| | | Color matching with skin | Effect of coverage | Effect of long-lasting | Effect of adhesion | Skin trouble | Nothing here | $\chi^2$ (*p*) |
|---|---|---|---|---|---|---|---|---|
| Age | 20s–30s | 34 (35.1) | 51 (34.7) | 52 (58.4) | 104 (56.2) | 17 (77.3) | 1 (33.3) | 33.63 (0.000) |
| | 40s–50s | 63 (64.9) | 96 (65.3) | 37 (41.6) | 81 (43.8) | 5 (22.7) | 2 (66.7) | |
| Total | | 97 (17.9) | 147 (27.1) | 89 (16.4) | 185 (34.1) | 22 (4.1) | 3 (0.6) | |

Therefore, when measuring facial color, even for the same subject, the season, weather, recently used whitening cosmetics, and any dermatological treatments are among the factors which may affect facial skin L*a*b* values. Therefore, defining a measurement time interval and specifying subject selection criteria are considered among the minimum preparatory steps for starting an experiment. This study only completed a one-time measurement, but in order to generate a more objective skin color chart, further studies will be needed to follow up with subjects and to study deviations by re-measuring the same subjects' skin tones.

One limitation of this study was that only the L* values were used to divide subjects into the three skin color groups. In a previous study on color preference among Korean women, b* values affected certain color preferences among 180 subjects ranging in age from their 30s to 40s (Kang et al. 2014). Although skin color is somewhat difficult to define simply using L* values, there are hundreds of unique skin colors if a* and b* values are included. Therefore, setting a certain reference point appears to be meaningful.

In the questionnaire evaluation, the fact that responses might vary by occupation or living environment within the same age range was not taken into account. Furthermore, it is necessary to separate preferences among subjects in their 20s, 30s, 40s, and 50s to grasp a better understanding. Finally, most respondents used the color notation (for example, no. 21, no. 23) from a numbering system that is used for base makeup products only in Korea. Further research is needed to investigate whether subjects perceive their skin color by the notation created by cosmetic companies, instead of having subjective standards about their skin color, such as perceiving that one's skin color is dark or bright.

## Conclusions

In this study, facial colors among Korean women were classified into three colors: dark, normal, and bright. The color L*a*b* values of the bare face could be used as a reference for coloring base makeup products. When looking at the contrast value that was set as a reference point, the dark group was 60.66 and the normal group was 63.87, with a difference of 3.21. The bright group was 66.66, with a difference of 2.79 compared with the normal group. Considering that the average standard deviation for the L* values among the groups was 3, it can be assumed that a one-step difference in skin tone is equivalent to the addition or subtraction of 3 to the L* value.

Similarities and differences among the age groups were compared using a questionnaire, and in their responses regarding product preference and usage of base makeup products, most subjects gave a common answer that their skin color is average or slightly darker than their peers', regardless of age. It was also found that subjects selected base makeup products that were slightly brighter than their skin color. Therefore, it would be meaningful to aim for a color that is brighter than the bare face when developing base makeup products. As found in previous studies, the most frequently used base makeup product in all age groups was BB cream.

#### Abbreviations

BB: Blemish balm; DOPA: 3,4-Dihydroxyphenylalanine; IRB: Institutional review board; SCE: Specular Component Exclusion; SCI: Specular Component Inclusion

#### Funding

This work was supported by a grant from the Ministry of Trade, Industry & Energy (MOTIE), Korea Institute for Advancement of Technology (KIAT) through the Encouragement Program for The Industries of Economic Cooperation Region (Grant R0003962) and a grant from the Marine Biotechnology Program (20150184) funded by the Ministry of Oceans and Fishers, Republic of Korea.

#### Availability of data and materials

Not applicable.

#### Authors' contributions

IJ, ARJ, and YJK performed the experiments. YJK and SK carried out the experimental design and advising. IJ and ISA analyzed the data and wrote the manuscript. All authors read and approved the final manuscript.

#### Ethics approval and consent to participate

All clinical research presented this work was based on the revised Declaration of Helsinki, and the study protocol was approved by the institutional review board (IRB) of the Korea Institute of Dermatological Sciences (IRB no. KIDS2016W217).

#### Consent for publication

Written informed consent was obtained from the patient for the publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

#### Competing interests

The authors declare that they have no competing interests.

## Publisher's Note

Received: 17 April 2017 Accepted: 10 August 2017
Published online: 03 October 2017

## References

Ahn BT, Moon EB, Song KS. Study of skin colors of Korean women. Proc SPIE. 2002. https://doi.org/10.1117/12.464600.
Armas LA, Dowell S, Akhter M, Duthuluru S, Huerter C, Hollis BW, et al. Ultraviolet-B radiation increases serum 25-hydroxyvitamin D levels: the effect of UVB dose and skin color. J Am Acad Dermatol. 2007;57:588–93.
Baek YR. Going to New York where K-beauty is trendy. Economy Chosun. 2015. http://economychosun.com/special/special_view_past.php?boardName=C11&t_num=8664&img_ho=130. Accessed 27 July 2015.
Baulieu EE, Thomas G, Legrain S, Lahlou N, Roger M, Debuire B, et al. Dehydroepiandrosterone (DHEA), DHEA sulfate, and aging: contribution of the DHEAge study to a sociobiomedical issue. Proc Natl Acad Sci U S A. 2000;97:4279–84.
Binggeli C, Spieker LE, Corti R, Sudano I, Stojanovic V, Hayoz D, et al. Statins enhance postischemic hyperemia in the skin circulation of hypercholesterolemic patients: a monitoring test of endothelial dysfunction for clinical practice? J Am Coll Cardiol. 2003;42:71–7.
Couteau C, Paparis E, Coiffard LJ. BB creams and their photoprotective effect. Pharm Dev Technol. 2016;21:39–42.
Desmedt B, Van Hoeck E, Rogiers V, Courselle P, De Beer JO, De Paepe K, et al. Characterization of suspected illegal skin whitening cosmetics. J Pharm Biomed Anal. 2014;90:85–91.
Dunbabin DW, Tallis GA, Popplewell PY, Lee RA. Lead poisoning from Indian herbal medicine (Ayurveda). Med J Aust. 1992;157:835–6.
Jablonski NG. Skin: a natural history. 1st ed. Berkeley: University of California Press; 2006.
Jung YC, Lee MR, Kim EH, Cho JC, Lee HK. Comparison between face color change and its recognition difference on Asian: Korean, Indonesian and Vietnamian. J Soc Cosmet Sci Korea. 2013;39:323–7.
Kang NG, Kwak TJ, Kim JA, Kim TH, Moon TK, Park SG, et al. A preferred skin color by Korean female in the age between 30s~40s. J Soc Cosmet Sci Korea. 2014;40:373–82.
Kang WK, Hwang SD, Kim HS, Jeung JS, Lee BU. The development of whitening cosmetic ingredient having activity of melanin degradation. KSBB Journal. 2007;22:7–15.
Latreille J, Gardinier S, Ambroisine L, Mauger E, Tenenhaus M, Guéhenneux S, et al. Influence of skin colour on the detection of cutaneous erythema and tanning phenomena using reflectance spectrophotometry. Skin Res Technol. 2007;13:236–41.
Lee SY, Baek JH, Shin MK, Koh JS. The quantitative analysis of spreadability, coverage, and adhesion effect after application of the base make-up product. Skin Res Technol. 2014;20:341–6.
Lee YK, Yoon TH, Lim BS, Kim CW, Powers JM. Effects of colour measuring mode and light source on the colour of shade guides. J Oral Rehabil. 2002;29:1099–107.
Muehlenbein M. Human evolutionary biology. New York: Cambridge University Press; 2010. p. 192–213.
Park HK, Kim NS, Moon TK, Kim B, Jung HY. A comparison study between image analysis and conventional methods in the evaluation of Asian skin color. J Soc Cosmet Sci Korea. 2015;41:97–103.
Park YE, Chin CH. Analysis of B.B cream used condition. AJBC. 2010;8:63–74.
Piérard GE. EEMCO guidance for the assessment of skin colour. J Eur Acad Dermatol Venereol. 1998;10:1–11.
Shin HM. Why do we use cosmetics only No.21? MBC NEWS. 2016. http://imnews.imbc.com. Accessed 13 Oct 2016.
Shin HS, Park YS. A comparative analysis on complexion and skin color in 20s-30s and 40s-50s by frequency of L*a*b values. JKSCS. 2015;29:103–13.
Shin HY. The revised Declaration of Helsinki and clinical research. Transl Clin Pharmacol. 2009;17:152–63.
Wagatsuma H. The social perception of skin color in Japan. Daedalus. 1967;96:407–43.
Weatherall IL, Coombs BD. Skin color measurements in terms of CIELAB color space values. J Invest Dermatol. 1992;99:468–73.
Witkowski JA, Parish LC. You've come a long way baby: a history of cosmetic lead toxicity. Clin Dermatol. 2001;19:367–70.