

Facial Skin Color Variability in Korean Women

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ABSTRACT

Color assessment of human skin is an important index in scientific evaluations and has been applied widely in different fields. This study aims to collect the skin colors of Korean women using a spectrophotometer and thereby investigate the color variability across face areas. A total of 157 healthy volunteers were recruited. The seven measured sites were the forehead, nose tip, chin, cheekbone, cheek, jaw, and neck. The results showed that the CIE 1976 $L^*a^*b^*$ values differed significantly between the face areas. The site of lightest skin was on the jaw, whereas the darkest skin was on the forehead. Redness was highest on the chin and lowest on the neck. Yellowness was highest on the nose tip and lowest on the cheek. Next, the skin color categories based on the individual typology angle (ITA°) were reported. The central areas of face—forehead, nose tip, and chin—had a “tan” skin color, whereas the outer areas of face—cheekbone, cheek, jaw, and neck—had an “intermediate” skin color. Human skin color is a very complex subject that warrants much further study, but the research findings should be of value as a basis for future application in dermatology and cosmetology.

KEYWORDS: skin color, facial skin, color difference

INTRODUCTION

Color assessment of human skin is an important index in scientific evaluations and has been applied widely in different fields. For instance, skin color detection is used as a preliminary step in numerous computer vision applications such as face detection, gesture recognition, and person identification (Choi et al., 2017). In the field of dermatology, scientists have investigated the relationships among the numbers of major cutaneous chromophores, such as hemoglobin, and changes in skin colors (Takiwaki et al. 2002). In cosmetology, the development of cosmetic products requires a thorough understanding of facial skin color of women around the world (Caisey et al. 2006). It is clear that skin characteristics vary greatly according to a range of factors, and a better knowledge of these issues are prime factors in the development of skin care and cosmetic products. Several studies have addressed the issue of differences in skin color between different ethnic groups (De Rigal et al. 2010, Caisey et al. 2006). However, the statistical analysis of skin color measurements of different parts of the face is currently not available. Visual observations and subjective assessments lack precision with respect to the communication of color information (Weatherall and Coombs 1992), and therefore, recent scientific investigations have relied on the instrumental measurement of the human skin colors. Hence, the present study was designed to collect standard quantified data on the skin colors of Korean women using a spectrophotometer and thereby investigate facial color variability.

MEASUREMENTS

A total of 157 healthy volunteers living in Daejeon City were recruited. The volunteers were from 17 to 29 years old, including 83 women in their teens and 74 women in their twenties. Exclusion criteria were any disease that may impair or change color of facial skin condition. The seven measured sites were the forehead, nose tip, chin, cheekbone, cheek, jaw, and neck, as shown in Figure 1.

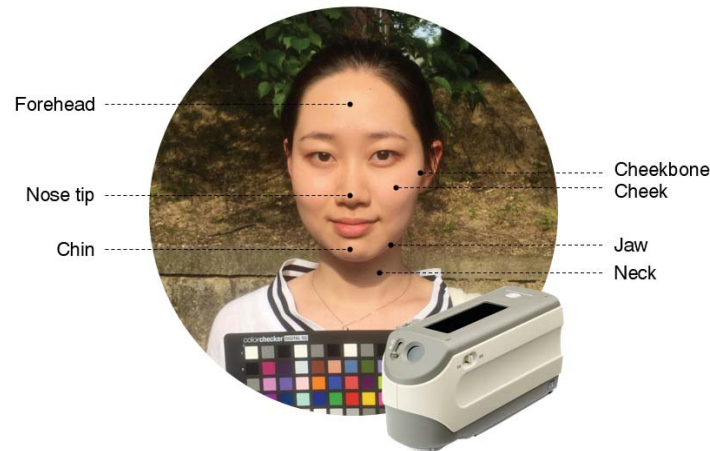


Figure 1: Skin color measurement of seven face areas

The probe of the spectrophotometer (Konica Minolta CM-2600d) was put gently and fully on the tested area to avoid any pressure or light input from outside. During the measuring process, areas of skin with pigmented lesions, moles, erythema or hair were avoided, and other factors affecting the measuring process, such as makeup, were removed. The spectrophotometer provided the spectrum of each area and thus the CIE 1976 L^* a^* b^* values. In the field of dermatology and cosmetology, the degree of erythema, or the amount of haemoglobin in the skin is usually estimated in terms of L^* and a^* values, while assessment of the degree of pigmentation, or the amount of melanin in the skin, usually involves L^* and b^* values (Takiwaki et al. 2002, Wei et al. 2007). The L^* a^* b^* measurements were triplicated on the same skin area and the mean values were adopted.

RESULTS AND DISCUSSION

The means and standard deviations of the L^* , a^* , b^* , C^* , and h° values were reported, as shown in Table 1. A repeated measures ANOVA indicated that all colorimetric values differed significantly between the face areas ($p < .01$). The site of lightest skin was on the jaw ($L^* = 62.84$), whereas the darkest skin was on the forehead ($L^* = 57.01$), $F(6,936) = 173.31$, $p < .01$. Redness was highest on the chin ($a^* = 11.54$) and lowest on the neck ($a^* = 7.12$), $F(6,936) = 225.02$, $p < .01$. Yellowness was highest on the nose tip ($b^* = 19.49$) and lowest on the cheek ($b^* = 14.64$), $F(6,936) = 209.26$, $p < .01$.

Table 1. The means and standard deviations of the L^* , a^* , b^* , C^* , and h° values ($N = 157$)

Face Areas	L^*	a^*	b^*	C^*	h°
Forehead	57.01 \pm 3.29	11.46 \pm 2.07	18.52 \pm 2.45	21.87 \pm 2.47	58.20 \pm 5.42
Nose tip	59.78 \pm 2.70	10.76 \pm 1.87	19.49 \pm 2.41	22.33 \pm 2.54	61.07 \pm 4.38
Chin	59.50 \pm 3.03	11.54 \pm 2.18	18.16 \pm 2.14	21.62 \pm 2.19	57.58 \pm 5.67
Cheekbone	60.66 \pm 2.53	9.11 \pm 1.91	16.06 \pm 2.15	18.56 \pm 2.16	60.40 \pm 5.91
Cheek	60.69 \pm 2.66	10.70 \pm 2.11	14.64 \pm 2.24	18.27 \pm 2.18	53.77 \pm 6.81
Jaw	62.84 \pm 2.60	7.28 \pm 1.70	16.56 \pm 2.06	18.14 \pm 2.28	66.34 \pm 4.39
Neck	62.17 \pm 2.50	7.12 \pm 1.97	17.89 \pm 2.24	19.34 \pm 2.30	68.35 \pm 5.62

Table 2 shows the distribution of the color differences (ΔE_{ab}^*) between each face area. ΔE_{ab}^* values were distributed in a range of 1.50 to 6.44, with a mean ΔE_{ab}^* of 4.18. The jaw and neck were the most similar ($\Delta E_{ab}^* = 1.50$), and the jaw and forehead were the most different in color ($\Delta E_{ab}^* = 7.44$). Comparing the change of skin color with age distribution in the investigated group, the results of independent samples t-test indicated that there

were no significant differences between the teens and the women in their twenties in all colorimetric measurements ($p > .01$, two-tailed).

Table 2. Color differences (ΔE_{ab}^*) between each face area

	Forehead	Nose tip	Chin	Cheekbone	Cheek	Jaw	Neck
Forehead	-	3.02	2.52	4.99	5.40	7.44	6.77
Nose tip	3.02	-	1.57	3.91	4.93	5.49	4.64
Chin	2.52	1.57	-	3.41	3.80	5.64	5.17
Cheekbone	4.99	3.91	3.41	-	2.13	2.89	3.09
Cheek	5.40	4.93	3.80	2.13	-	4.47	5.05
Jaw	7.44	5.49	5.64	2.89	4.47	-	1.50
Neck	6.77	4.64	5.17	3.09	5.05	1.50	-

Although the $L^*a^*b^*$ measurements have long been used to measure skin color, skin color categories may reflect skin color more precisely than a single index (Wei et al. 2007). Skin color categories were first proposed by Chardon et al. (1991) based on the individual typology angle (ITA°), which calculates the skin color volume from plane L^*Ab^* as follows:

$$ITA = [\text{ArcTan}((L^* - 50) / b^*)] \times 180 / 3.14159 \quad (1)$$

The calculation of the ITA° based on spectrophotometric measurements has been used to classify skin types into six physiologically relevant groups—very light, light, intermediate, tan, brown, and dark, as listed in Table 3.

Table 3. Skin color categories based on the individual typology angle (ITA°)

Grading	ITA°	Skin Color Category
I	$> 55^\circ$	Very light
II	> 41 and $\leq 55^\circ$	Light
III	> 28 and $\leq 41^\circ$	Intermediate
IV	> 10 and $\leq 28^\circ$	Tan
V	> -30 and $\leq 10^\circ$	Brown
VI	$\leq -30^\circ$	Black

In terms of the ITA° values, the site of lightest skin was on the jaw ($ITA^\circ = 37.77$), whereas the darkest skin was on the forehead ($ITA^\circ = 20.97$), $F(6,936) = 202.28$, $p < .01$. The central areas of the face—forehead, nose tip, and chin—had a “tan” skin color, whereas the outer areas of the face—cheekbone, cheek, jaw, and neck—had an “intermediate” skin color. It is interesting to note that significant color differences exist in the face, which we may consider as quite a homogeneous area in terms of sun exposure. According to previous studies, similar observations have been made in different ethnic groups: Caucasian, African American, Chinese, Mexicans, and Indians (Barel, Paye, and Maibach 2014, De Rigal et al. 2010). On average, almost half of the subjects had an “intermediate” skin color (55.41%), followed by a “tan” skin color (36.31%). Only 8.28% of those had a “light” skin color. There was no “very light,” “brown,” and “black” skin color in the investigated group. These results are quite in line with the general idea or impression about the skin color of Asian people (Wei et al. 2007). However, it should be noted that the current study took place in the summer, a period with very sunny conditions. As such, more in-depth studies would be worthwhile to investigate the variation in skin colors in different seasons.

Table 4. Skin color categories based on the individual typology angle (ITA°)

Face Areas	ITA°	Skin Color Category
Forehead	20.97 ± 10.27	Tan
Nose tip	26.85 ± 8.13	Tan
Chin	27.55 ± 8.78	Tan
Cheekbone	33.62 ± 8.49	Intermediate
Cheek	36.06 ± 9.08	Intermediate
Jaw	37.77 ± 8.18	Intermediate
Neck	34.31 ± 7.63	Intermediate

CONCLUSION

The purpose of this study was to investigate the facial skin color variability based on collecting objective skin color data of Korean women. A total of 157 healthy volunteers were recruited. The CIE 1976 L*a*b* values of seven face areas—forehead, nose tip, chin, cheekbone, cheek, jaw, and neck—were measured using a spectrophotometer. The results indicated that all colorimetric values differed significantly between the face areas. The site of lightest skin was on the jaw, whereas the darkest skin was on the forehead. Redness was highest on the chin and lowest on the neck. Yellowness was highest on the nose tip and lowest on the cheek. Moreover, the ITA° parameter indicated that significant color differences exist within the face, in which the central areas of the face—forehead, nose tip, and chin—had a “tan” skin color, whereas the outer areas of the face—cheekbone, cheek, jaw, and neck—had an “intermediate” skin color. This indicates that a single color cannot sufficiently represent one’s skin color. Human skin color is a very complex subject that warrants much further study, but the research findings should be of value as a basis for research into skin color and future application in dermatology, cosmetology, and reconstructive plastic surgery.

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