A Study of Skin Color by Melanin Index according to Sex, Age, Site and Skin Phototype in Koreans

Tuk Woo Lim, M.D., Mu Hyoung Lee, M.D.

Department of Dermatology College of Medicine, Kyung Hee University, Seoul, Korea

***Background* : Skin color is determined by many factors including melanin and nonmelanin pigments like hemoglobin and extraneous chemicals. Various factors such as race, sex, and age have been reported to have an influence on skin color.**

***Methods* : Measurement of malanin index (M-index) was made by reflectance spectrophotometer at three different sites including forehead, abdomen and forearm in total 800 healthy subjects consisting of 100 males and 100 females of neonates (three days after birth) and children (male:8.08±0.84, female:8.03±0.80, total :8.06±0.82 years of age), adolescence (male:13.89±0.76, female:13.96±0.79, total:13.93±0.78 years of age), and adults(male:24.26±0.82, female:24.40±0.89, total:24.33±0.86 years of age). We also investigated the change of M-index by each skin phototype of college students determined by Fitzpatrick classification.**

***Results* : From the birth to the puberty, sex difference of melanin index was generally not noted, but adult females showed lower levels of melanin index in all sites measured. M-index increased from birth to adolescence, and decreased after adulthood. Forehead showed highest melanin index compared with other sites. Increase of M-index was noted as skin phototype goes from III to V.**

***Conclusions* : Factors including sex, age, body sites and skin phototype have a significant influence on the changes of skin color in humans. (Ann Dermatol 14(2) 71-76, 2002).**

Key Words : Skin color, Melanin index, Reflectance spectrophotometer

The human skin color depends not only on its constituent elements such as melanin, distribution of blood vessels, hemoglobin and thickness of stratum corneum, but equally on the light source with which it is illuminated and the detector with which it is perceived. Constitutive elements are the absorbing chromophores, scatters, and their constellation and distribution[1]. There are many factors that determine the color of human skin. They include quantity of melanin pigment and its chemical structure and nonmelanin pigments such as oxygenated and reduced hemoglobin which pass through the papillary capillaries, extraneous chemicals like carotene and other chemicals like lycopenic acid or licorice[2]. Various factors including race, sex and age are reported to have an influence on change of human skin color. Human skin color is generally thought to be fairly constant throughout the life. For a long time, variation of human skin color has been of great concern for physical anthropologists. However, visual comparisons of skin color with standardized sets of colored paper were too subjective to obtain reliable results[3]. The first quantitative measurement of skin pigmentation in humans was made by Hardy spectrophotometer which could measure and analyze skin color objectively[4]. Recently, a hand-held microprocessor-controlled reflectance spectrophotometer with digital readout (Derma-Spectrophotometer®, Cortex technology, Hadsund, Denmark) began to be used in

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Reprint request to : Mu Hyoung Lee, M.D., Department of Dermatology, College of Medicine, Kyung Hee University. 1 Hoeki-Dong, Dongdaemun-Ku, Seoul, 130-702 Korea
Tel. (02)958-8512, Fax. (02)969-6538
E-mail: mhlee@khmc.or.kr.

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many dermatological studies. This instrument provides a readout of the erythema and melanin indices as a function of the absorbance characteristic of human skin[5]. Each index increases as the skin becomes more erythematous and more pigmented, respectively, so the M-index can be regarded as a parameter which is mainly influenced by the mela nin content[6].

The purpose of this study is to investigate the patterns of variation of skin color according to sex, age, site and skin phototype in Koreans by using a hand-held microprocessor-controlled reflectance spectrophotometer.(Derma-Spectrophotometer®, Cortex technology, Hadsund, Denmark).

SUBJECTS AND METHODS

Subjects

Total 800 healthy subjects consisting of 100 males and 100 females of neonates (three days after birth) and elementary school (male:8.08± 0.84, female:8.03±0.80, total :8.06±0.82 years of age), middle school (male:13.89±0.76, female:13.96± 0.79, total:13.93±0.78 years of age), and college students (male:24.26± 0.82, female:24.40± 0.89, total:24.33±0.86 years of age) participated in this study in spring to avoid seasonal variations. All of neonates had a known gestational age (37-42 week) calculated from the date of mothers last menstrual period. We also investigated the change of melanin index (M-index) by each skin phototype of college students determined by Fitzpatrick classification.

They were all healthy without any dermatologic problems such as ance, melasma, or nevi and other systemic diseases. Women in their menstrual period were excluded.

Measurement

Measurements of cutaneous pigmentation using M-index by reflectance spectrophotometer(Derma-Spectrophotometer®, Cortex technology, Hadsund, Denmark) at three sites, forehead, abdomen and inner aspect of forearm were performed after calibration to every series of the measurement. For neonates, all measurements were taken between 6:00 AM and 7:00 AM, and for elementary, middle school, and college students, all measurements were taken between 5:00 PM and 6:00 PM.

The reflectance spectrophotometer is a narrow-band spectrophotometer designed for measuring specific colors due to two major chromophores, hemoglobin and melanin. The light sources are two light-emitting diodes with selected narrow bands of emitted wavelengths. The peaks of the two bands are centered at 568nm (green light) and 655nm (red light). They emit light in sequence, and the reflected light from skin is detected with a photodetector. After being converted into digital form with a built-in microcomputer, the reflectance in the two bands are transformed into the erythema index (E-index) and the melanin index (M-index).

On every subject, three readings were taken at each of the three sites after cleansing with cotton swabs. On the forehead, midway between the hairline and the base of nose, on the medial aspect of forearm and in the abdominal area just above the umbilicus. All skin color examinations were made in the same room circumstances. It was a room blocked from sunlight, and the room temperature maintained between 21℃ and 26℃ because readings became unstable above 26℃ possibly due to the temperature increase, change in humidity, or some combination of these variables. For measurement of M-index in newborn infants, exposure to sunlight was almost completely obviated because the newborn infants were born under electric light and, after immediate washing, they were roomed in neonate care center with only the face exposed.

Statistical Analysis

All measurements of M-index were expressed by mean ± SD. For comparison of M-index between male and female, students t-test was used. Analysis of variance (F-test) was used for determination of the change of melanin index according to ages, sites and each skin phototype ($p<0.05$ was considered significant). We also performed Dunkans multiple range test to determine the difference of the values obtained by each age, site, and skin phototype from each other.

RESULTS

1. Difference according to gender

In neonates, no significant sex difference of M-index was observed in all sites measured (Table. 1, Fig

Table 1. Sex and age difference of melanin index (M-index)

Site	Subjects (yrs. of age)	Male	Female	Total
Forehead	Neonates (3 days after birth)	33.14±4.01	32.29±4.29	32.72±3.11
	Elementary school students (8.06±0.82 yrs)	37.36±3.40	37.54±3.26	37.45±2.45
	Middle school students (13.93±0.78 yrs)	40.89±3.13*	39.53±2.90	40.21±1.94[a]
	College students (24.33±0.86 yrs)	38.57±3.06*	34.99±3.20	36.78±2.14
	Total	37.49±4.42	36.09±4.39	36.79±3.63
Forearm	Neonates (3 days after birth)	25.22±3.07	24.67±3.51	24.95±2.52
	Elementary school students (8.06±0.82 yrs)	34.58±3.01	34.35±2.57	34.47±1.95[b]
	Middle school students (13.93±0.78 yrs)	34.73±3.10	34.57±2.66	34.65±1.89[c]
	College students (24.33±0.86 yrs)	31.07±3.10*	29.79±2.87	30.43±2.17
	Total	31.40±4.93	30.85±4.99	31.12±4.49
Abdomen	Neonates (3 days after birth)	25.45±3.82	24.76±3.74	25.10±3.04
	Elementary school students (8.06±0.82 yrs)	31.48±3.11*	29.39±3.08	30.44±2.17
	Middle school students (13.93±0.78 yrs)	32.85±4.23		
	32.40±3.49	32.63±2.52[a]		
	College students (24.33±0.86 yrs)	31.70±3.72*	29.04±3.84	30.37±2.75
	Total	30.37±4.72	28.90±4.47	29.63±3.82

*: $p<0.01$, male vs female

[a]: $p<0.05$, middle school students vs neonates, elementary school students, college students

[b]: $p<0.05$, elementary school students vs neonates, college students

[c]: $p<0.05$, middle school students vs neonates, college students

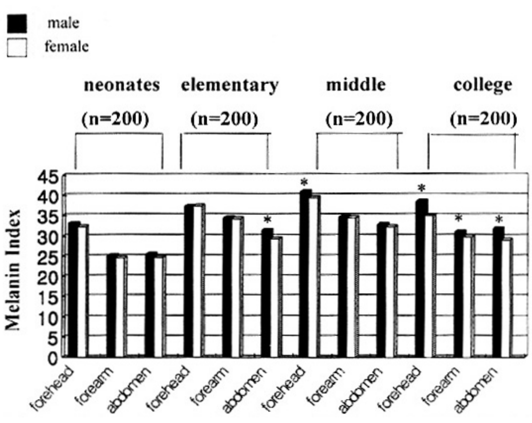

Fig. 1. In abdomen of elementary school students and forehead of middle school students. male showed signifcantly higher level of melanin index (M-index). For college students, male showed higher lenel of M-index in all sites measured (* : $p<0.01$, male vs female).

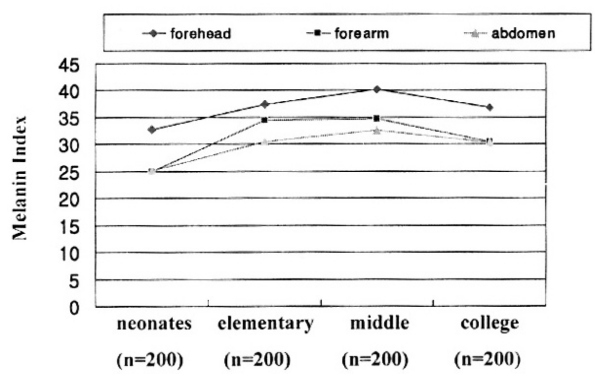

Fig. 2. In all sites measureed, M-index increased from birth to adolescence, and decreased after adulthood.

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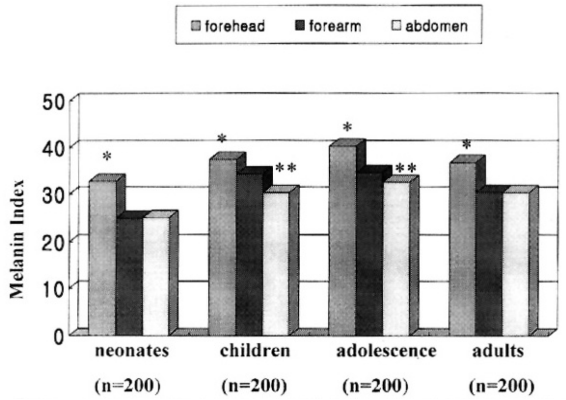

Fig. 3. In all subject, the forehead showed highest M-index comparing other sites. In elementary and middle school students, the M-index significantly decreased as following order. Forehead>forearm>abdomen (* : $p<0.05$, forehead vs forearm, abdomen, ** : $p<0.05$, abdomen vs forehead, forearm).

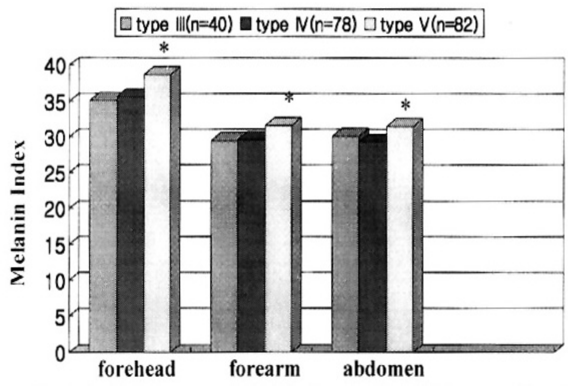

Fig. 4. In all sites measured, M-index increased as skin type gose from III to V However, difference between type III and type IV was not significant (* : $p<0.05$, type V vs type III, tye VI).

1). In elementary school students, no significant sex difference of M-index was noted at the forehead and arm, but males showed significantly higher levels of melanin index in the abdomen ($p<0.01$) (Table 1, Fig. 1). In middle school students, no significant sex difference of M-index at the forearm and abdomen, but males showed significantly higher levels of melanin index at the forehead ($p<0.01$) (Table. 1 Fig. 1). In college students, males showed significantly higher levels of M-index in all sites measured ($p<0.01$) (Table 1, Fig. 1).

2. Changes to the ages

In all sites measured, M-index increased as following orders (neonates<elementary school students<middle school students), and thereafter, M-index decreased(Table 1 and Fig. 2).

3. Difference according to sites

In all sites measured, forehead showed highest

Table 2. Site difference of M-index

Subjects (yrs of age)	Site	Melanin index
Neonate (3 days after birth)	Forehead	32.72±3.11[a]
	Forearm	24.95±2.52
	Abdomen	25.10±3.04
Elementary school students(8.06±0.82 yrs)	Forehead	37.45±2.45[a]
	Forearm	34.47±1.95
	Abdomen	30.44±2.17[b]
Middle school students (13.93±0.78 yrs)	{Forehead	40.21±1.94[a]
	Forearm	34.65±1.89
	Abdomen	32.63±2.52[b]
College students (24.33±0.86 yrs)	Forehead	36.78±2.14[a]
	Forearm	30.43±2.17
	Abdomen	30.37±2.75

[a] : $p<0.05$, forehead vs forearm, abdomen

[b] : $p<0.05$, abdomen vs forehead, forearm

Table 3. M-index according to skin phototype

Site	skin phototype	Number	Melanin index
Forehead	III	40	35.14±3.04
	IV	78	35.60±2.93
	V	82	38.70±3.61*
Forearm	III	40	29.54±2.67
	IV	78	29.68±2.46
	V	82	31.58±3.37*
Abdomen	III	40	30.11±3.12
	IV	78	29.31±3.92
	V	82	31.52±4.19*

* : $p<0.05$, type V vs type III, type VI

M-index regardless of age ($p<0.05$) (Table 3 and Fig. 3). However, forearm and abdomen showed no difference of M-index in neonates and college students (Table 3 and Fig. 3). In elementary sch ool students and middle school students, the M-index significantly decreased as following order, (forehead>forearm>abdomen, $p<0.05$) (Table 3 and Fig. 3).

4. Difference according to skin phototype

In all sites measured, M-index increased as following orders (type III<type IV<type V). Type V showed higher melanin index than type III and type IV ($p<0.05$). However, the difference between type III and type IV was not statistically significant. (Table 3 and Fig. 4)

DISCUSSION

The number of factors intrinsic and extrinsic to the individual that are responsible for variations in skin color is large[7-10]. The skin site, gender, and age differences suggest a number of explanatory hypotheses. However, none of them seems to be mutually exclusive. Since the development of spectrophotometer, the skin colors of many small tribes and isolated groups of people have been studied. According to these studies, it has been observed that females are significantly darker than males just prior to the onset of menarche[7,8,11,12]. Except this time, females are reported to be lighter than males[7,8,11,13-16]. However, sometimes the difference is minimal and does not show statistical significance between males and females. We have not found significant differences of M-index in neonates and in elementary school students except the abdomen in elementary school children. In middle school students, males showed slightly higher level of M-index at all sites measured, but the statistical significance was observed only in the forehead. In college students, the level of M-index was significantly higher in males than in females at all sites. In other words, our data revealed that from the birth to the puberty, sex difference was generally not noted, but in adults, females were indeed significantly lighter than males. This factor confirmed the results which was obtained by other researchers during the developmental period both in Spanish populations and in other populations, which showed no sexual difference in skin color until puberty[17,18]. Our data also showed that sex difference was greater in the forehead than in forearm or abdomen. This finding suggests that women's fairer skin may be due to life-style, and facultative color that develops after exposure to a stimulant like sunlight is more likely to be responsible for sex difference in skin color, rather than constitutive skin color. However, various factors including genetics, environments, and hormones have been suggested to be related to sexual dimorphism[18-21]. According to Mesa[17], from the end of infancy to the onset of puberty, skin color progressively darkens in both sexes without sex difference in color, but during adolescence, both sexes lighten in color, and in male, this lightening occurs later and is less pronounced and during the later stages of adolescence, the skin color also lightens although not as rapidly as at puberty, so sex difference is noted from the adolescence. Our data also showed the same results.

As for the sites, in all subjects, the forehead showed highest M-index comparing other sites in our data. Site difference is probably due to a difference in the density of epidermal melanocytes in the forehead compared with the forearm or abdomen and a difference in the frequency and intensity of exposure to UV light resulted from the more sheltered anat omical position of the forearm or abdomen and in certain instances, from the shielding effects of clothing[22,23].

According to skin phototype by Fitzpatrick[24], in all sites measured, M-index was highest in subjects of type V in our data. The M-index was higher in subjects of type IV than those of type III, however, the difference was not statistically significant in our data. Woo et al[25] also reported that the M-index increased significantly as skin phototype goes from III to V. This result suggests that there is correlation between skin phototype assessed subjectively and M-index assessed objectively.

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