Received: 1 April 2022 | Accepted: 14 September 2022
DOI: 10.1111/srt.13207

ORIGINAL ARTICLE

WILEY

Validity of self-reported skin color by using skin color evaluation scale

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Funding information
The Ministry of Education, Culture, Sports, Science and Technology of Japan

Abstract

Introduction: Although skin color has been suggested to be associated with the risk of some chronic disease, there has been no validated visual skin-color scale, with which subjects can self-report their skin color. Our objective was to develop a visual skin color evaluation scale for self-reporting that would be useful in large-scale epidemiological studies.

Materials and methods: Study participants were 99 university Japanese students aged 19–29. We developed a skin color evaluation scale consisting of six colors from light to dark. Participants were asked to choose one color that was the closest to their skin color. Their skin color was measured on the back of the hand and the inner upper arm by an examiner using a narrowband reflective spectrophotometer. Self-reported skin color was compared with the melanin and erythema indices.

Results: Spearman's rank correlation coefficients of self-reported color with the melanin index after adjusted for age, temperature, and humidity were moderate but significant at both sites for both men and women. The correlation coefficients with the erythema index were significant only on the back of the hand for men. The higher melanin index was significantly associated with the darker skin color in both sexes for both sites. The erythema index showed such a significant trend only in men and not in women.

Conclusions: The validity of the skin color chart was moderate of melanin among Japanese people. It may be useful for large population studies examining the relationships between skin color and health outcomes.

KEYWORDS
epidemiology, self-report, skin color evaluation scale, spectrophotometer, validity

1 | INTRODUCTION

Exposure to ultraviolet radiation has been established as a risk factor for skin cancer. Previous studies have also reported that skin pigmentation is associated with several other chronic diseases such as blood pressure, obesity, diabetes, and cardiovascular metabolic abnormalities[1–5] and mortality.[6]

Skin color has been evaluated by measurement instruments such as the narrowband spectrophotomete[2,7–9] and the tristimulus colorimeter.[10] Although measurements by instruments can noninvasively and reliably measure skin color, it is expensive and impractical for population-based studies with a large number of samples. Skin color charts[1,6,7,10–12] and questionnaires[3,9,12] have also been used to evaluate skin color. For example, Fitzpatrick skin typing, which is used to predict the risk of sun damage and skin cancer,[13] may not be understood by people of different ethnicities because it not only classifies skin color in words but also includes responses to sun exposure and tanning habits.[8,14] A skin type classification for Japanese people called Japanese skin type[15] also classifies skin types into three categories based on questions about sensitivity to ultraviolet rays, sunburn, and tanning. Visual color charts such as the Munsell Soil Color Book[7,11] and the Felix von Luschan skin color chart[10] are validated among limited populations. There are no validated skin color charts for Japanese. Moreover, the Munsell Soil Color Book requires practical training for examiners because the color chart consists of a huge number of color variations according to three-dimensional representations based on the three attributes of hue, value, and chroma. The Felix von Luschan skin color chart, which consists of 36 colors, also requires adequate training for examiners to use correctly. In order to investigate the associations between skin color and a variety of health outcomes in large-scale epidemiological studies, it would be useful to develop a validated skin color chart that allows subjects to visually self-report their skin color.

Therefore, the main objective of this study was to develop a visual skin color scale for self-reporting. The melanin content of skin is known to be the main determining factor of skin color. Erythema referring to skin redness is also another factor of skin color. The validity of self-reported skin color was evaluated by comparing measurements of melanin and erythema among the Japanese.

2 | MATERIALS AND METHODS

2.1 | Development of the skin color chart

First, a skin color scale “Skin Color 75” developed by the Japan Color Enterprize Co. Ltd. was applied to 10 volunteers to measure colors at two skin sites, that is, the back of the hand and the inner upper arm. The back of the hand is likely to get a tan, and so its color is considered to be influenced both by the constitutive skin color and sun exposure. The inner upper arm is unlikely to be exposed to sunlight, and its color reflects the constitutive skin color. The “Skin Color 75” included 75 colors, covering five hues, three saturations, and five lightnesses. The volunteers were asked to choose one color that was the closest to their skin color at each site. For each person, the color at the inner upper arm appeared to be much lighter than those included into the color scale book. This color scale may have been more suitable for measuring facial skin color. To include lighter colors into our scale, we sought skin color charts that have been applied to Asians. In a previous study that used the Felix von Luschan skin color chart, only 18 of 36 colors were chosen for four skin sites among 53 volunteers in Thailand.[9] Besides these colors and those chosen by our volunteers, we also referred to the color samples of several cosmetics, including creams, lotions, and foundations that were commonly used in Japan. As we proposed to develop a simpler color chart for self-reporting, we finally chose six colors from light to dark (numbers: 1–6) for our original color chart (Figure 1).

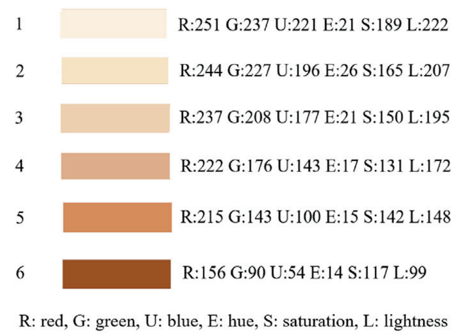

FIGURE 1 The original skin color chart and the composition of each color

3 | APPLICATION OF COLOR CHART

3.1 | Subjects

Subjects were graduate and undergraduate students of Gifu University. They were recruited by a notice posted on a bulletin board on campus from April to September of 2019. A total of 99 students from 19 to 29 years of age participated with informed written consent. The study was approved by the ethical committee of the Gifu University Graduate School of Medicine.

3.2 | Measurement of skin color

Skin color was assessed at the skin sites, the back of the right hand and the inner upper right arm. Skin color was measured in a room during the day. None of the subjects had any obvious skin blemishes or eczema on the skin sites assessed. First, using the original color chart, subjects were asked to choose one color that was the closest to their skin color at each site. Next, one trained examiner measured skin colors using a narrow-band reflectance Mexameter MX 18 skin colorimeter (C + K Electronic GmbH, Cologne, Germany). The device is designed to quantify melanin content and hemoglobin (erythema) content, which is expressed as the melanin index and hemoglobin index, by placing a probe on the skin.[16] This device measures and quantifies melanin and hemoglobin, which constitute skin color, by irradiating light of three specific wavelengths (568, 660, and 880 nm) with different absorption rates for melanin and hemoglobin, and measuring the ratio of reflected light. Melanin is measured at two wavelengths (660 and 880 nm) and hemoglobin at two wavelengths (568 and 660 nm), yielding results on a wide scale from 0 to 999.[17] [Correction added on [4 Nov 2022], after first online publication: One of the wavelengths has been changed from from 780nm to 880nm in the preceding sentence.] The surface of a participant's skin and the instrument were cleaned with alcohol wipes before the measurement. Participants rested for about 15 min in the room before the skin measurements were taken.

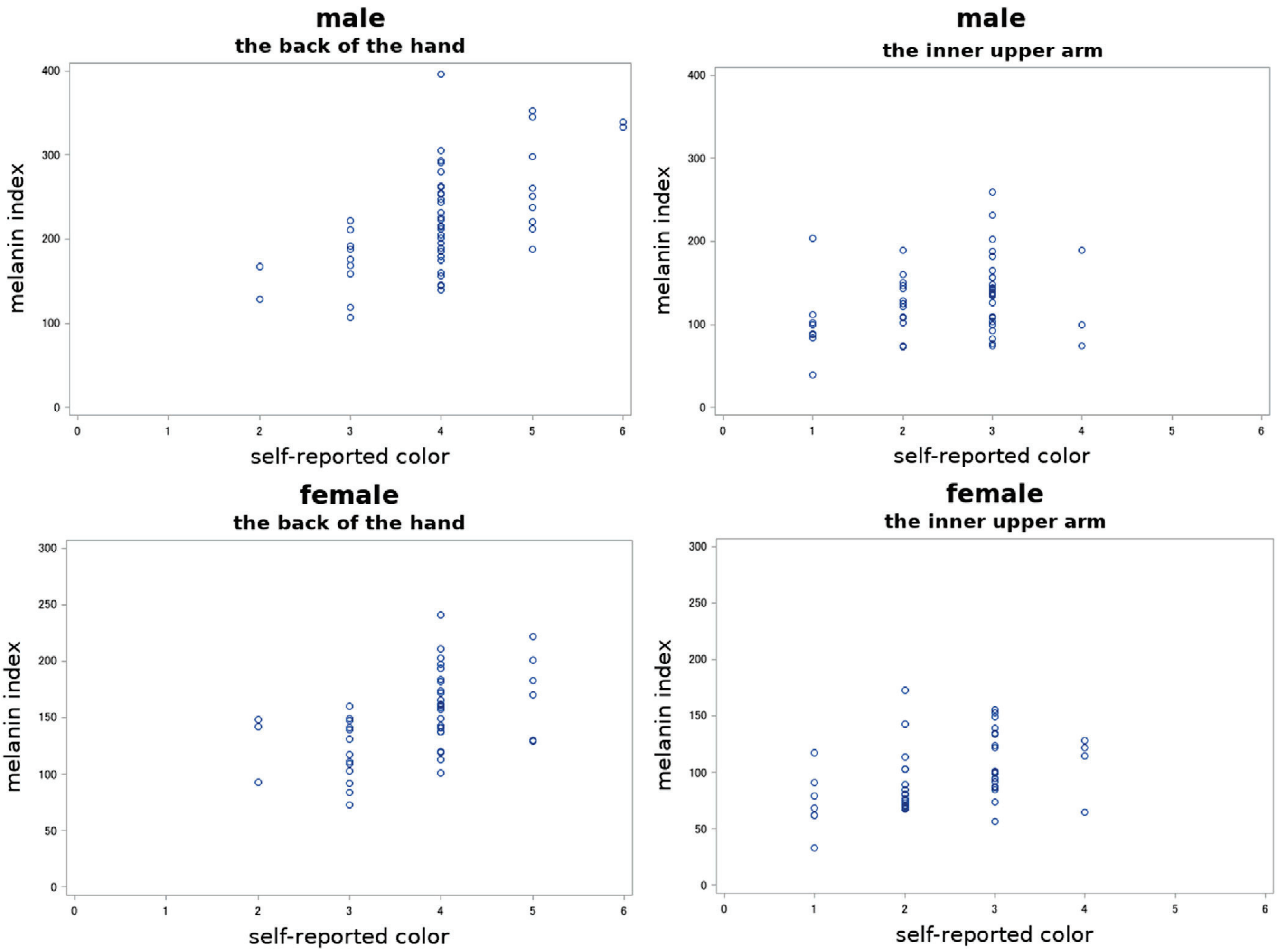

FIGURE 2 The scatter plot of self-reported color and melanin index by MX18

3.3 | Statistical analysis

All statistical analyses were performed by gender. Spearman's rank correlation coefficients between self-reported color and the melanin and erythema indices were assessed after adjusting for age, room temperature, and humidity. In addition, the mean values of the melanin index and erythema index according to the self-reported color were computed by an analysis of covariance with age, room temperature and humidity as covariates. [Correction added on [4 Nov 2022], after first online publication: 'age' has been inserted in the preceding sentence.]

All analyses were conducted using SAS programs (SAS Institute Inc., Cary, NC, USA). A *p* value of less than 0.05 was considered to be statistically significant.

4 | RESULTS

The study subjects were 52 (52.5%) men and 47 (47.5%) women, with a mean age of 22.5 years (range: 19–29 years). The room temperature averaged 25.5 degrees, and the humidity averaged 46.5%.

The percentages of men who reported color numbers 1 to 6 were 3.9%, 3.9%, 13.5%, 57.7%, 17.3%, and 3.9%, for the back of the hand, respectively, and 13.5%, 26.9%, 53.9%, 5.8%, 0%, and 0%, for the inner upper arm, respectively. For women, the corresponding values were 0%, 6.4%, 27.7%, 53.2%, 12.8%, and 0%, respectively, for the back of the hand and 14.9%, 36.2%, 40.4%, 8.6%, 0%, and 0%, respectively, for the inner upper arm. The scatter plots of self-reported color and the melanin index are shown in Figure 2. Spearman's rank correlation coefficients between self-reported color and the melanin index after adjusting for age, temperature, and humidity were 0.59 ($p < 0.001$) in men and 0.51 ($p < 0.001$) in women for the back of the hand, and 0.30 ($p = 0.037$) in men and 0.45 ($p = 0.002$) in women for the inner upper arm. The scatter plots of self-reported color and the erythema index are shown in Figure 3. Spearman's rank correlation coefficients between self-reported color and the erythema index after adjusting for covariates were 0.49 ($p < 0.001$) in men and 0.27 ($p = 0.075$) in women for the back of the hand, and 0.27 ($p = 0.058$) in men and 0.24 ($p = 0.123$) in women for the inner upper arm.

The higher melanin index was associated with the darker self-reported color on the back of the hand ($p < 0.001$) and on the inner upper arm ($p = 0.037$) for men, and on the back of the hand ($p < 0.001$) and on the inner upper arm ($p = 0.008$) for women (Table 1). The higher erythema index was associated with the darker self-reported color on

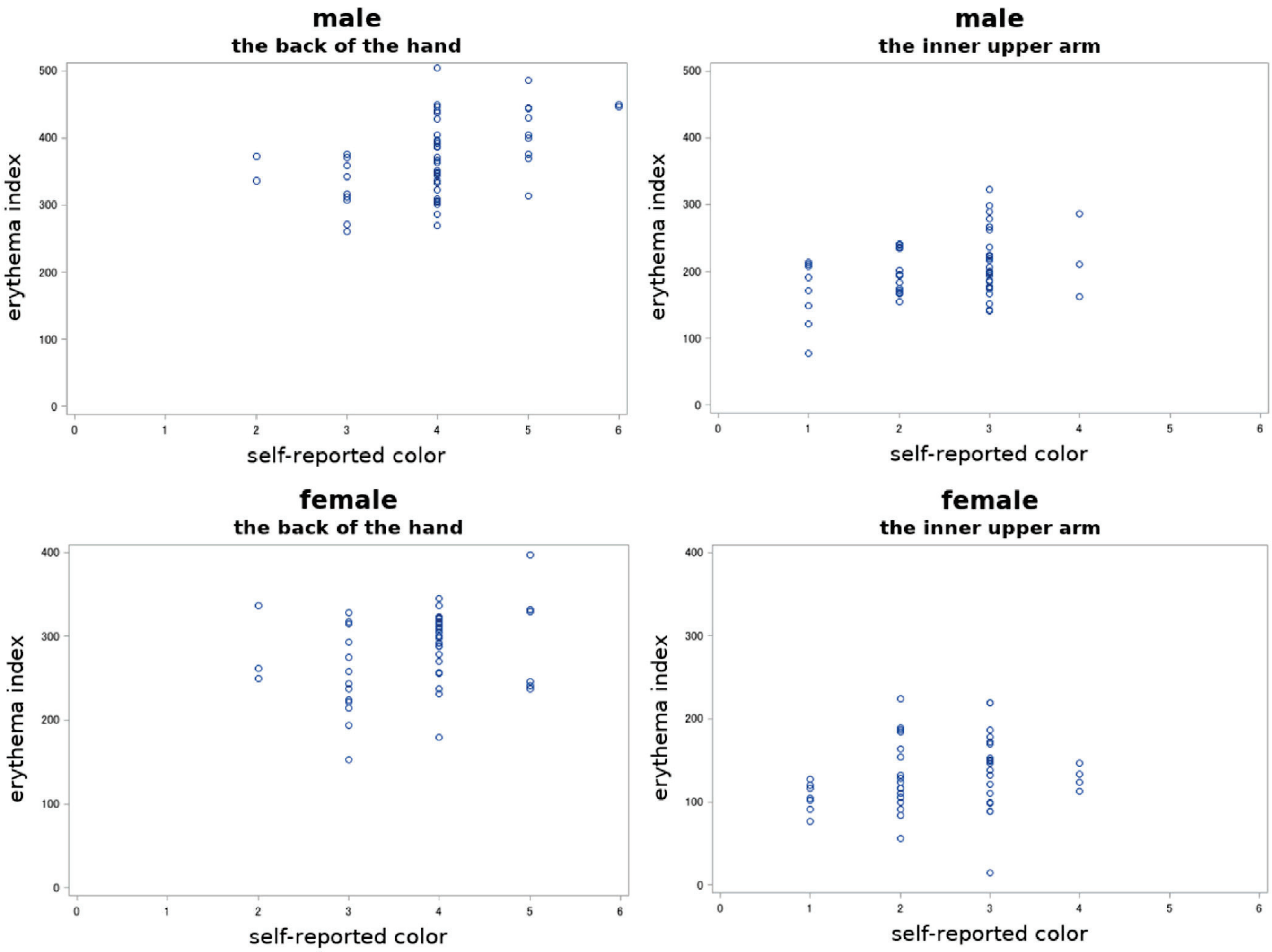

FIGURE 3 The scatter plot of self-reported color and erythema index by MX18

the back of the hand ($p < 0.001$) and on the inner upper arm ($p = 0.010$) for men, but such significant trends were not observed for women.

5 | DISCUSSION

This is the first study to assess the validity of the skin color scale for self-reporting. We observed a moderate correlation between the self-reported color using this scale and the melanin index as measured by the spectrophotometer. Higher melanin indices were observed as participants reported darker skin colors.

Two previous studies have reported the validity of a skin color chart as compared with melanin indices measured by spectrophotometer.[7,9] In both studies, trained examiners—not participants themselves—chose the colors from the charts. The correlation coefficient between self-reported color using the Felix von Luschan color chart and the melanin index was 0.90 among the medical workers from Thailand.[9] Although this result showed an excellent correlation, the correlation was assessed with the combined data of four different skin sites (midpoint between the elbow and the wrist on the medial aspect of the volar regions and the medial aspect of the dorsal regions of both forearms), instead of assessing at each site. When the data from the two skin sites in our study were combined similarly to their methods, Spearman's correlation coefficients were 0.72 for males and 0.67 for females. In another study of New Zealand college students, the weighted Kappa coefficient between the skin color by the Munsell Soil Color Book and the skin color category by the individual typology angle score, another index of melanin content, was 0.61 on the inner upper arm, which seemed a little higher agreement than that in this study.[7] This might be partly due to the fact that the New Zealand population is composed of a greater range of ethnicities ranging from European to Asian, resulting in a wider range of skin colors than that of the Japanese population. The validity of skin color questionnaires has been demonstrated to be lower among population with similar skin colors than in those with more diverse skin colors.[10]

We observed no significant correlation or trend for the erythema index with self-reported skin color in women. This may suggest that our color scale would not be suitable for measuring the extent of erythema in women. Actually, none of our subjects had any obvious skin blemishes or eczema. We should state that this technique is not

TABLE 1 Adjusted least-square means of melanin index and erythema index according to the self-reported color on the back of the hand and the inner upper arm adjusted for age, temperature, and humidity

			Self-reported color							
			1	2	3	4	5	6	*p*-Value	P for trend
Back of the hand	Male	*n*	0	2	9	30	9	2		
		MI[†]	–	147.5	172.2	228.3	269.0	332.1	0.002	<0.001
		SE	–	43.9	20.8	11.3	21.3	43.9		
		EI[‡]	–	360.7	322.7	365.0	411.9	445.4	0.006	<0.001
		SE	–	38.3	18.2	9.9	18.6	38.3		
	Female	*n*	0	3	13	25	6	0		
		MI[†]	–	121.1	117.7	164.3	166.3	–	<0.001	<0.001
		SE	–	18.7	9.0	6.6	13.5	–		
		EI[‡]	–	278.2	248.0	295.2	292.6	–	0.051	0.061
		SE	–	27.5	13.3	9.7	19.8	–		
The inner upper arm	Male	*N*	8	14	27	3	0	0		
		MI[†]	111.3	116.7	137.1	149.3	–	–	0.205	0.037
		SE	14.3	10.9	7.6	24.2	–	–		
		EI[‡]	172.7	195.4	215.0	233.8	–	–	0.087	0.010
		SE	16.5	12.7	8.9	28.1	–	–		
	Female	*N*	7	17	19	4	0	0		
		MI[†]	72.2	91.5	110.6	100.1	–	–	0.025	0.008
		SE	10.8	7.0	6.5	14.8	–	–		
		EI[‡]	104.1	134.2	139.1	125.2	–	–	0.338	0.224
		SE	16.4	10.6	10.0	22.5	–	–		

[†]MI: melanin index.
[‡]EI: erythema index.

appropriate for erythematous skin (rosacea eczema, psoriasis etc.). Nonetheless, previous studies on skin color and diseases have rather implicated a role of melanin in the underlying mechanism. Our skin color scale would be still useful to conduct epidemiological survey for the diseases whose risk factor is melanin pigmentation. However, we should keep in mind that our skin color scale cannot be used for people with Fitzpatrick 5–6 skin type (in people of African descent).

The validity of self-reports was higher at the back of the hand than at the inner upper arm. The reason was unclear, but it might be because participants had more difficulty holding the color scale against their skin on the inner upper arm than on the back of the hand. The validity of the results for the melanin index on the inner upper arm was somewhat low among men, while the validity for the erythema index on the both two skin sites was low among women. Since no previous studies have reported differences in the validity of self-reported color by skin site and gender, it needs to be examined in further studies.

The strength of this study includes the fact that the color scale was based on visual categorization rather than on verbal color categories. By using this color scale consisting of six different colors, participants were able to directly compare the scale color and their skin colors visually. However, there are several limitations in this study. The selection of colors was subjective. Collection of photos of the corresponding skin sites from a much larger sample in advance could have provided information on skin color distributions among Japanese and aided to determine colors for a scale. Second, we assumed that skin color scale could reflect skin pigmentation, but the melanin indices for the each color of the scale were uncertain. Therefore, we could not evaluate accuracy of self-reports in terms of the misclassification of skin color. Third, although this questionnaire was printed by a single printer and the skin color assessment was conducted in the same room, environmental conditions such as the printer used and lightning may vary in surveys that require the distribution of questionnaires. However, it is likely that the ranking of lightness of skin color would not be affected within the study. Fourth, sample size was small. Some of the colors have been selected by two or three participants only, and thus the results may have been by chance. Finally, the participants of this study were mostly in their 20s. It has been reported that skin color darkens with age.[17] It is not clear whether this skin color scale is applicable to people in different age groups. Further research is needed among different age groups.

6 | CONCLUSION

We developed a skin color evaluation scale for self-reporting. Self-reported skin color by using the color scale was moderately correlated with the melanin index measured by the spectrophotometer in the Japanese population. This skin color chart may be a useful measurement tool for assessing skin color in large-scale studies of skin color and health outcomes. This scale is not meant for people with erythematous skin or those with Fitzpatrick 5–6 skin type.

ACKNOWLEDGMENTS

This study was supported by grants from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

CONFLICT OF INTEREST

The authors have no conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

The data used to support the findings of this study have not been made available due to confidentiality.

ETHICS STATEMENT

Ethical approval for this study was provided by the ethical committee of the Gifu University Graduate School of Medicine. All procedures involving participants were conducted after obtaining agreement.

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How to cite this article: Nakashima Y, Wada K, Yamakawa M, Nagata C. Validity of self-reported skin color by using skin color evaluation scale. *Skin Res Technol*. 2022;1-6. https://doi.org/10.1111/srt.13207