


Original Investigation

Accuracy of Self-report in Assessing Fitzpatrick Skin Phototypes I Through VI

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IMPORTANCE Determining Fitzpatrick skin phototypes (FST) allows physicians to assess a person's risk of developing sunburn and, by extension, the need for sun protection to prevent the development of skin cancer. Reflectance spectrophotometry objectively measures the melanin index and can assist in determining the accuracy of self-report of FST compared with dermatologist-determined FST.

OBJECTIVES To assess whether self-reported or dermatologist-determined FST is more accurate in identifying a participant's FST for FST I through VI and to assess the relevance of the burning and tanning measures for a range of skin types among ethnically diverse participants.

DESIGN AND SETTING A convenience sample of participants in an observational study from June 2, 2010, through December 15, 2010, at an ambulatory academic dermatologic practice and employee health center in an urban city.

PARTICIPANTS Participants, staff, and students of Northwestern University, who self-identified as being non-Hispanic white, Hispanic or Latino, Asian or Pacific Islander, or black.

MAIN OUTCOMES AND MEASURES Melanin index as measured with reflectance spectrophotometry compared with dermatologist- and participant-determined FST.

RESULTS Forty-two percent (114 of 270) of the participants' responses to the burning and tanning questions could not be classified using standard FST definitions. The spectrophotometry measurements for dermatologist-determined FST were significantly different for FST III and IV ($P < .001$) and FST IV and V ($P < .001$). The spectrophotometry measurements for participant-determined FST were significantly different for FST III and IV ($P < .001$) but not for FST IV and V ($P = .90$). Participant responses to burning and the dermatologist-determined FST were significantly correlated (Spearman ρ , 0.764; $P < .001$). Participant responses to tanning and the dermatologist-determined FST were not significantly correlated (Spearman ρ , 0.089; $P = .15$). Spectrophotometry measurements assessing FST were statistically significantly different for FST III through VI ($P < .001$).

CONCLUSIONS AND RELEVANCE Dermatologist-determined FST is more accurate than self-report for FST III through VI. Rephrasing the questions using specific descriptors that have meaning to people with skin of color, such as skin irritation, tenderness, itching, or skin becoming darker, may allow physicians to more accurately assign a skin phototype and, by inference, assess the risk of these participants developing skin cancer.

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In 1975, sun-reactive skin typing was developed to help determine the best dose of UV-A light for the treatment of psoriasis in non-Hispanic white participants. This skin typing incorporated an implied reciprocal interdependence between the tendency to burn and the ability to tan.¹ The non-Hispanic white participants' responses to questions asked and subjectively interpreted by a trained health care professional were used to classify them as having skin phototypes I through IV.² This classification of skin type into 4 categories—from type I (always burns, never tans) to type IV (burns minimally to rarely)—was widely used clinically, although the precise questions asked and the responses coded varied between studies.³ Eventually, interviews of participants by a health care professional to determine skin type were replaced by 2 separate survey questions with self-report of burning and tanning. Later, brown- and black-skinned persons were included in this classification scheme as having skin types V and VI, respectively.⁴⁻⁶

The manner in which skin types V and VI were added established a precedent for grouping all people of a similar ethnic group into a single category of the Fitzpatrick skin phototype (FST), which introduced potential bias into the assessment of FST by investigators.⁷⁻⁹ Describing skin color as white, brown, or black was not intended to designate the participant's self-identification of cultural or ethnic origin; rather, it denoted the complexion (light, intermediate, or dark) and reflected sunburn sensitivity.¹⁰ However, the heterogeneity of those with multiethnic backgrounds makes it difficult to assess the risk of sunburn, which is determined by melanin protection, on the basis of their skin color or tone, which is ascertained by several pigments such as hemoglobin, melanin, bilirubin, and carotene.¹¹⁻¹³

Melanin density in the epidermis can be estimated accurately with a spectrophotometer.¹⁴ Pershing et al¹⁵ demonstrated that reflectance spectrophotometer assessment of skin phototyping using the area under the intensity curve along the 450- to 615-nm wavelength interval of reflected light was beneficial in helping to determine 6 skin phototypes. The spectrophotometer, a research instrument, objectively assesses a participant's melanin content and can be implemented in evaluating the accuracy of self-reported responses. Flaws in the self-report of participants in determining their own FST are caused by difficulty conceptualizing or labeling their skin's reaction to the sun as tanning or burning.¹⁶ The study by Pichon et al¹⁶ was limited to blacks, but the issues of conceptu-

alizing sunburn and suntan may exist for other people with skin of color. The objective of this study is to determine the accuracy of dermatologist- and participant-determined FST for all 6 skin types. The study also focuses on correlating the melanin index with self-reported responses to the standard survey items about sunburn and suntan and the dermatologist-determined FST.

Methods

Participant Enrollment

From June 2, 2010, through December 15, 2010, we recruited a convenience sample of participants stratified by FST I through VI with a racial and ethnic distribution of skin types among participants aged 18 years or older from general dermatologic clinics at the Northwestern Medical Faculty Foundation and employee health fairs at Northwestern University. Participants were stratified by self-report of ethnicity as non-Hispanic white, Hispanic or Latino, black, or Asian or Pacific Islander. If participants reported a multiethnic background, they were asked to select the 1 group with which they most identified. When the enrollment goal of 79 for a racial or ethnic group was achieved, recruitment for that group ceased. After meeting inclusion criteria, informed consent was obtained from each participant by the research coordinator (S.E.).

Survey and Clinician Determination of FST

Participants completed a written survey of 5 items (eTable in the Supplement). After the completed survey was collected by the research coordinator, 1 dermatologist (J.K.R.), who was masked to the participants' self-report of ease of sunburning and tanning, interviewed each participant by asking the following question: "If after several months of not being in the sun, you stayed outdoors for about 1 hour at noon for the first time in the summer in Chicago without sunscreen, what would happen to your skin?" The participants' responses were interpreted by the dermatologist, with a single best answer selected among the following: always sunburns, sunburns usually, sunburns minimally, rarely sunburns, or never sunburns. Then the dermatologist asked, "Over the next 7 days, would you develop a tan?" The responses were placed into the following categories: never tans, tans minimally, tans moderately, tans deeply, or no noticeable change in color in pigmented skin⁶ (Table 1). The dermatologist-assessed FST was determined by reviewing the definitions of skin phototype and assigning an FST when the responses to sunburning and tanning agreed with those provided in the definition (Table 1). When there was disagreement between the burning and tanning properties, the dermatologist preferentially used the sunburning response to assign the FST. This same solution was used by the dermatologist (J.K.R.) from 1976 through 1978 to assign FST for UV-A light treatment of psoriasis. For example, a participant who reported always burning and developing a light tan would be assigned a FST I to prevent a painful burn that may have an adverse effect on the psoriasis. After the dermatologist completed the interview, the participant had the spectrophotometry measurement performed by the research coordinator. This study was ap-

Table 1. Fitzpatrick Skin Phototype: Erythema and Tanning Reactions to the First Sun Exposure⁶

Fitzpatrick Skin Phototype	Reaction
I	Always burns, never tans (painful burn at 24 h and no tan at 7 d)
II	Burns easily, then develops a light tan (painful burn at 24 h and a light tan at 7 d)
III	Burns moderately, then develops a light tan (slightly tender burn at 24 h, moderate tan at 7 d)
IV	Burns minimally to rarely, then develops a moderate tan (no burn at 24 h and a good tan at 7 d)
V	Never burns, always develops a dark tan
VI	Never burns, no noticeable change in appearance

Table 2. Distribution of the Population

Ethnicity/Race (Self-report)	Fitzpatrick Skin Phototype (as Determined by the Dermatologist)					
	I	II	III	IV	V	VI
Non-Hispanic white (n = 83)	14	32	23	14	0	0
Hispanic or Latino (n = 43)	2	9	7	13	12	0
Asian or Pacific Islander (n = 64)	0	4	6	28	26	0
Black (n = 80)	1	0	0	25	42	12
Total	17	45	36	80	80	12

proved by the Northwestern University Institutional Review Board. Participants did not receive compensation.

Reproducibility of Reflectance Spectrophotometry

To evaluate the consistency of a single person measuring the participant's pigment levels with the spectrophotometer, 1 researcher (S.E.) performed a pilot test that took 10 reflectance measurements on the participant with the portable spectrophotometer (model S2000; Ocean Optics Inc) connected to a laptop computer. This process was completed on 6 different participants with FSTs ranging from I through VI. Before each measurement, white and black color controls were used to calibrate the measurements (Labsphere ISO 9001-certified reflectance standards, model CSS-08-020; Labsphere Inc). The data were presented as the area under the intensity curve along the 450- to 615-nm wavelength interval of reflected light. The data were imported into an Excel (Microsoft) spreadsheet where area under the intensity curve was calculated for each skin site by the trapezoidal rule.¹⁵ For each measurement, the total area under the curve was compared with each other using analysis of variance.

Measurements

The same spectrophotometer and methods reported in the study by Pershing et al¹⁵ were used in this study. Each participant had 1 measurement recorded from the upper volar arm 3 cm inferior to the axilla to obtain the constitutive skin melanin content.

Statistical Analysis

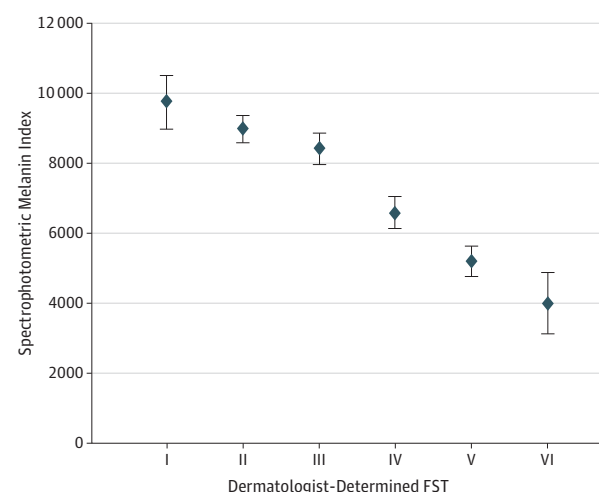
Spectrophotometry measurements of melanin index are presented as means with 95% CIs. Statistical differences between the different spectrophotometry measurements of the melanin index for each differentially determined FST group were analyzed via 1-way analysis of variance followed by the Tukey post hoc test. The correlation between dermatologist-determined FST and participant response to different questions regarding burning and tanning was assessed separately using the Spearman correlation coefficient. Statistical calculations and analyses were performed using SPSS statistical software (version 20; SPSS Inc). $P < .05$ indicated statistical significance.

Results

Population and Skin Phototype

Among 270 participants, the mean age was 47 years (range, 20-89 years). The largest number of participants had FST IV

Figure 1. Dermatologist-Determined Fitzpatrick Skin Phototype (FST) vs Spectrophotometric Melanin Index



Mean values were measured by the spectrophotometer with 95% CIs.

and V as determined by the dermatologist (Table 2). In this ethnically and racially diverse population, 42% (114 of 270) of the participants' responses to the separate burning and tanning questions did not fit the skin type definitions developed in 1975. For example, non-Hispanic whites reported always burning and developing a light tan (10 of 83), which does not meet the definition of FST I of always burns and never tans (Table 1). Black (20 of 80) and Hispanic or Latino (25 of 43) participants reported getting irritated from the sun in Chicago and getting pink in Florida, the Caribbean, and Mexico. Also, blacks did not report tanning; however, they stated that their skin tone got darker (79 of 80).

Dermatologist-Determined FST in Comparison With Spectrophotometer Measurements

The spectrophotometry measurements for FST III vs IV and FST IV vs V are statistically significantly different ($P < .001$). The spectrophotometry measurements for FST I vs II, FST II vs III, and FST V vs VI are not statistically significantly different ($P > .05$) (Figure 1).

Participant Self-reported FST in Comparison With Spectrophotometer Measurements

The spectrophotometry measurements for FST III vs IV are statistically significantly different ($P < .001$). The spectrophotometry measurements for FST I vs II, FST II vs III, FST IV vs

V, and FST V vs VI are not statistically significantly different ($P > .05$) (Figure 2).

Participant Self-report of Burning or Tanning in Comparison With Spectrophotometer Measurements

The spectrophotometry measurements for FST III vs IV as determined by the questions regarding burning are statistically significantly different ($P < .001$), with a negative linear relationship (Figure 3A). The spectrophotometry measurements for FST III vs IV as determined by the questions regarding burning are also statistically significantly different ($P < .05$) (Figure 3B). In addition, the participant responses to burning and the dermatologist-determined FST were compared di-

rectly and were significantly correlated (Spearman ρ , 0.764; $P < .001$). However, the participant responses to tanning and the dermatologist-determined FST were not correlated (Spearman ρ , 0.089; $P = .15$).

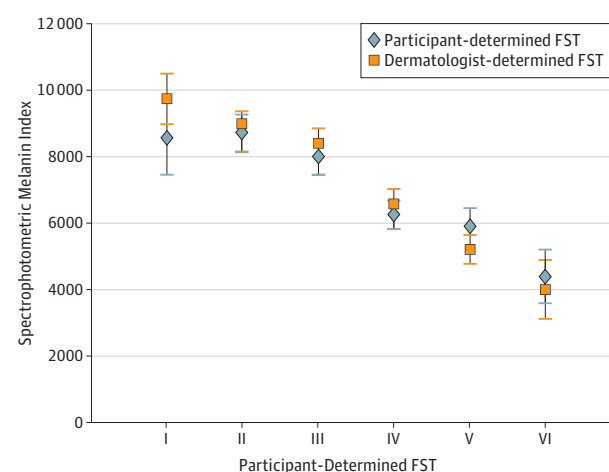
Discussion

This study demonstrated a lack of reliability of self-reported FST among non-Hispanic white participants and participants with skin of color. The FST determined by a dermatologist, with clarification of the responses through directed questioning about the ability to sunburn and tan for ethnicities that do not readily report burning or tanning, allowed for the better differentiation of FST (Figure 1).

Skin reflectance, as measured by spectrophotometry, is determined by the amount and distribution of pigment granules within keratinocytes. Each pigment cell actively transfers its melanosomes to about 40 basal keratinocytes. Thus, reflectance spectrophotometry is an objective, quantitative method of distinguishing darkening caused by increased melanin from erythema as a result of inflammation or increased hemoglobin in the skin.¹⁷ Among Asians or Pacific Islanders, blacks, and whites, an individual's minimal erythema dose is highly correlated with melanin content, as determined by reflectance spectrophotometry.¹⁸ People of mixed heritage (non-Hispanic European and West African) appear to have skin reflectance intermediate between their respective parental groups.¹⁹ In this study, participant self-report responses to the survey item about burning after sunlight exposure and spectrophotometry measurements had a strong correlation (Spearman ρ , 0.764; $P < .001$).

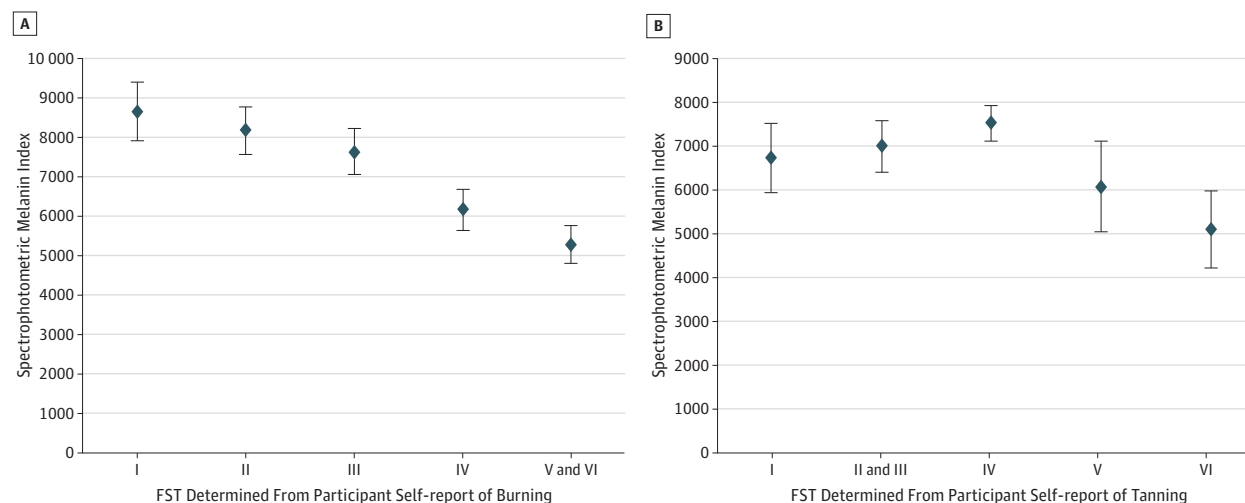
The lack of reliability of self-reported FST among non-Hispanic white participants and those with skin of color appears to be related to the terms *sunburning* and *tanning*, which have

Figure 2. Participant-Determined Fitzpatrick Skin Phototype (FST) vs Spectrophotometric Melanin Index



Mean values were measured by the spectrophotometer with 95% CIs.

Figure 3. Fitzpatrick Skin Phototype (FST) Determined From Participant Self-report of Sunburn vs Spectrophotometric Melanin Index (A) and Tanning vs Spectrophotometric Melanin Index (B)



Mean values were measured by the spectrophotometer with 95% CIs.

various meanings to different persons. Participants with skin of color did not report painful burns or tanning.²⁰ Additional support for participants with skin of color in this study having difficulty providing a response to developing a tan is shown by the lack of correlation between the survey item of self-report of tanning and their determined FST (Spearman ρ , 0.089; $P = .15$). Non-Hispanic whites readily overstated the ability to tan, which contributed to the difficulty discriminating between FST I and II.

The reliability of the dermatologist-determined FST was related to clarification of the participants' ability to sunburn or tan. Hispanic or Latino, Asian or Pacific Islander, and black participants responded to whether they burn often by reciprocally asking, "What is a sunburn?" When sunburn was further defined by the dermatologist as skin irritation, tenderness, or itching in sun-exposed locations, people with skin of color responded as readily as those with FST I or II did to a definition of sunburn as skin blistering or redness in sun-exposed locations. Most participants with skin of color, especially Hispanic or Latino, Asian or Pacific Islander, and black participants, did not understand the meaning of tanning. When tanning was expanded to include skin becoming darker after sunlight exposure, they were able to respond to the question.

In a population-based study of 2691 participants who participated in the 2003 through 2004 National Health and Nutrition Examination Survey, the FST usually correlated with sun sensitivity in non-Hispanic white and Hispanic or Latino participants but not with black participants.²¹ In the United States, the most common skin type is FST III (48%), with FST I or II in 35% of the population.²¹ In our study, participants with FST III were non-Hispanic white, Hispanic or Latino, and Asian or Pacific Islander; however, FST IV was determined by the dermatologist to be among all racial or ethnic groups in this study. The FST system originally excluded blacks and those of mixed heritage from classification. The modifications made in 1988 to the FST to include people with skin of color were neither culturally sensitive nor accurate because participants were unable to respond to the question of sunburn and tanning.²⁰ While the intention in 1988 was to place all blacks into FST VI, in this study, participants who self-identified as black were FST IV, V, or VI. While a universal scale for phototyping the skin of minorities is lacking, scales limited to single ethnic groups have been created²² (eg, Japanese Skin Type by Kawada²³ and a scale for blacks by Willis and Earles²⁴). Expanding the responses for determining FST to more accurately represent people with skin of color would help identify participants' skin type and, by extension, their need for sun protection to avoid the risk of acquiring skin cancer¹⁸ (Table 3).

Skin type, as determined by the ability to sunburn and suntan, was a better predictor of a participant's relative risk of developing nonmelanoma skin cancer than hair and eye color.²⁵ Sunburn and suntan are independently related to melanoma risk.²⁶ In a population-based case-control study of residents of Tasmania, Australia, with 90% tracing their ancestry to the

Table 3. Proposed Skin Type Classification and Questions^a for Non-Hispanic Whites, Hispanics or Latinos, Asians or Pacific Islanders, and Blacks¹⁸

Proposed Skin Type Classification	Reaction
I	Always burns, never develops a tan (painful burn at 24 h and no tan at 7 d)
II	Easily burns, then develops a light tan (painful burn at 24 h and a light tan at 7 d)
III	Mild burning, skin irritation, tenderness, or itching in sun-exposed skin, then develops a medium tan or skin becomes slightly darker in sun-exposed sites (slightly tender, itching at 24 h, moderate tan or slightly darker at 7 d)
IV	Minimal skin irritation, tenderness, or itching in sun-exposed skin, then develops a deep tan or skin becomes darker in sun-exposed sites (no skin irritation, tenderness, or itching at 24 h and a tan or darker skin at 7 d)
V	Occasional skin irritation, tenderness, or itching in sun-exposed skin, then develops darker skin in sun-exposed sites in temperate climates
VI	No skin irritation, tenderness, or itching in sun-exposed skin, no noticeable change in skin in sun-exposed sites in temperate climates

^a Question 1: If after several months of not being in the sun, you stayed outdoors for about 1 hour at noon for the first time in the summer without sunscreen, what would happen to your skin? Would it become pink/red, irritated, tender, or itchy? Question 2: Over the next 7 days, would you develop a tan or notice your skin becoming darker?

British Isles, cutaneous melanin measured by spectrophotometry in the upper inner arm was a strong predictor for all 3 types of skin cancer—melanoma, basal cell carcinoma, and squamous cell carcinoma—in men (odds ratio for melanoma: 6.2; 95% CI, 2.3-16.6; for basal cell carcinoma: 6.3; 95% CI, 2.6-15.1; and for squamous cell carcinoma: 4.2; 95% CI, 1.7-3.7).²⁷

This study limited the choice of race or ethnicity to the one with which the participant most closely identified. Participants of mixed races could not identify all aspects of their heritage. In addition, the self-identification of ethnicity is not a biological indicator but rather a cultural indication of affiliation. Another limitation of this study was the inability to separate FST V and VI because most participants with skin of color could not respond to the written survey item concerning their ability to develop a tan (Table 1).

Spectrophotometry is the most reliable way to assess the photoprotection afforded by melanin, but the personnel and equipment costs of reflectance spectrophotometry may prohibit its routine clinical use. There is a need to classify skin type with reliable questions with responses suitable for all skin types. It seems less difficult to correlate sun sensitivity with FST for most ethnicities or races than to correlate pigment darkening or tanning with FST. The proposed modifications to the definitions of burning and tanning need to be assessed and replicated in other populations (Table 3). Future research will examine the effectiveness of the proposed expanded definitions of burning and tanning in the FST categories.

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