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Comparing Alternative Methods of Measuring Skin Color and Damage

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Abstract

Objective: The current study investigated the reliability and validity of several skin color and damage measurement strategies and explored their applicability among participants of different races, skin types, and sexes.

Methods: One hundred college-aged participants completed an online survey about their perceived skin damage and skin protection. They also attended an in-person session in which an observer rated their skin color; additionally, UV photos and spectrophotometry readings were taken.

Results: Trained research assistants rated the damage depicted in the UV photos reliably. Moderate to high correlations emerged between skin color self-report and spectrophotometry readings. Observer rating correlated with spectrophotometry rating of current but not natural skin color. Lighter-skinned individuals reported more cumulative skin damage, which was supported by UV photography. Although women's current skin color was lighter and their UV photos showed similar damage to men's, women reported significantly more damaged skin than men did.

Conclusions: These findings suggest that self-report continues to be a valuable measurement strategy when skin reflectance measurement is not feasible or appropriate and that UV photos and observer ratings may be useful but need to be tested further. The results also suggest that young women and men may benefit from different types of skin cancer prevention interventions.

Keywords

Reproducibility of Results; Spectrophotometry

Introduction

Skin cancer is the most common form of cancer, with over a million new cases diagnosed in the United States each year (ACS, 2007). On average, one in six Americans will develop skin cancer during their lifetime (CDC, 1996). Most forms of skin cancer are preventable by limiting ultraviolet (UV) radiation exposure and enhancing UV protection behaviors. Finding accurate and feasible strategies for measuring UV exposure, protective behaviors, and related skin damage is important for skin cancer prevention and intervention efforts. Choosing a measure is determined in part by the purpose of the assessment. Clinicians and researchers need to understand how various measurement strategies compare with one another. The current study compared four methods of assessing skin color, UV exposure, and damage: verbal self-report,

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observation, ultraviolet-filtered photographs, and spectrophotometry readings. We examined their reliability, convergent validity, and compared measurements across participant groups.

Current research regarding skin cancer interventions uses primarily (93.8%) self-report and, to a lesser extent, direct observation and objective measures to assess outcomes such as UV exposure and protective behaviors (Glanz and Mayer, 2005). Self-report remains an easy and inexpensive measure of skin color, skin damage, and related behaviors. As is inherent in any form of self-report, however, there may be inaccuracies in reports of protective behaviors, perceived skin damage, or natural skin color. Most research on UV exposure and protective behaviors has been conducted with adolescents and young adults, who exhibit the highest levels of related risky behaviors (Coups *et al.*, 2008; Jackson *et al.*, 1999). Previous research indicates an optimistic bias in that most adolescents perceive their own risk from tanning as significantly lower than the perceived risks to others (Sjöberg *et al.*, 2004). A review of UV exposure measurement strategies determined that good evidence exists for the inter/intrarater reliability of self-report data but that further research is needed to establish its validity and test-retest reliability (Glanz and Mayer, 2005). On the other hand, most objective measures of skin color and UV damage can only assess the time period of measurement, and therefore, often do not take long-term behaviors into account as self-report can.

Visual inspection typically involves using trained raters to assess the participant's current level of tanness, sunburn, or other skin damage (e.g., freckling or moles) as rated on an ordinal scale (Creech and Mayer, 1997). Visual inspection can provide a more objective rating than self-report but can be time intensive and may not generalize to the individual's routine behaviors (Glanz and Mayer, 2005). Although it is assumed that observer ratings are standardized, tanness may vary by individual and natural skin color (Creech and Mayer, 1997).

UV photographs reveal the chronic damage that has occurred to an individual's skin as a result of UV exposure. UV light is selectively absorbed by the melanotic or damaged areas of the epidermis, thus dramatically enhancing the contrast between these areas and surrounding normal skin in the photos (Fulton, 1997). Current skin damage appears as irregular spots, freckling, and areas of darkness and uneven coloring (Fulton, 1997). UV photos have been used successfully as a motivational tool in some skin cancer intervention studies (Gibbons *et al.*, 2005; Mahler *et al.*, 2007; Mahler *et al.*, 2003; Mahler *et al.*, 2005; Pagoto *et al.*, 2003), though not as an outcome measure to date. UV photography allows for the assessment of chronic damage and may serve as a proxy for previous UV exposure and protective behaviors, though this method of measurement is relatively expensive, requires an in-person assessment, and requires trained raters to assess the photos.

Skin reflectance measurement devices such as spectrophotometers and colorimeters utilize technology that allows for objective, reliable, in vivo quantification of human skin color (Afromowitz *et al.*, 1987; Bjerring and Andersen, 1987). Similar to UV photography, spectrophotometry allows for the assessment of current skin damage or the opportunity to track changes in skin pigmentation over time (Glanz and Mayer, 2005). Spectrophotometry ratings of sunburn ($r = .99$) and melanin pigmentation ($r = .99$) are highly correlated with amount of laboratory-induced UV exposure (Andersen and Bjerring, 1990). Reflectance techniques offer objective measurement and high inter/intra-rater reliability, though these devices are expensive, require training for users, and are difficult to use with dark-skinned or highly freckled individuals (Glanz and Mayer, 2005). Because of the high cost of skin reflectance measurement techniques, comparisons to less costly methods of measurement can help future research best utilize resources when measuring UV exposure and also begin to establish the validity of self-report as compared to objective measures such as skin reflectance measurement.

Since skin cancer is associated with UV exposure and damage, we sought to explore several modalities of measuring skin color and damage. The current study compared self-report with visual inspection, UV photography, and spectrophotometry readings of skin color and damage in a sample of young adults. This project is the first to report the use of visual inspection of skin color and UV photography as a measure of skin damage. Only one study has compared spectrophotometry readings and observer report and found small but significant correlations ($r = .17$) between parental reports of their children's UV exposure and spectrophotometry readings, suggesting a positive correlation between tanning and reported exposure (Milne et al., 2001). Since one-time spectrophotometry measures current skin color, it is affected by both genetics and behavior, thus accounting for the small but significant correlation between spectrophotometry readings and observer report of exposure. The exact nature of the relationship between demographic variables such as race/ethnicity or gender and measures of skin color and UV damage is unknown as is the ability of measures to distinguish between different groups of individuals.

The purpose of the current study, therefore, was to compare these measures of skin color and damage and to explore their relationship to relevant demographic variables such as race/ethnicity and gender in order to enable researchers and clinicians to more validly assess the effectiveness of their skin cancer prevention interventions. Specifically, by comparing measures of skin color and damage, the current study was able to assess 1) reliability, both inter-rater reliability and the association between findings from the same measures of different constructs, 2) convergent validity or the association between different measures of the same construct, and 3) the ability of the measures to distinguish between groups based on time of year, ethnicity, and skin color (sometimes referred to as discriminant validity). Our hypotheses were that 1) UV photographs could be rated reliably and that the same measures of different constructs would be associated with one another, 2) the association between different measures of the same construct would demonstrate convergent validity, and 3) lighter-skinned individuals would rate their skin as more damaged than those with darker skin, and women would rate their skin as more damaged than men.

Materials and Methods

Participants

Participants were young adults enrolled in a pilot behavioral skin cancer prevention intervention study testing the impact of education, motivational interviewing counseling, and UV photos on UV exposure and skin protection behaviors. College-age participants were selected because teens and young adults are known to be frequent tanners and protect their skin minimally, putting them at risk for skin cancer and photo-aging (Coups *et al.*, 2008; Godar *et al.*, 2003; Jackson *et al.*, 1999; Knight *et al.*, 2002). One hundred participants were recruited from three universities in the Philadelphia area during the 2007 spring semester. Participants were recruited from a psychology department subject pool as well as other academic departments and the campuses at large.

The study was initially contacted by 229 potential participants. Of these, eighty-two individuals did not follow through with eligibility screening. Twenty-two individuals screened eligible for the study but did not follow through with the baseline session. Sixteen individuals screened ineligible for the study: 12 because they would be moving out of the area during the study timeframe, three for being older than 24 years, and one for an unknown reason. Nine were told about the study and decided they were not interested in participating.

One hundred participants completed all measures included in the baseline session. The baseline participants were 82% female and were on average 20.41 years of age ($SD = 1.51$). Participants described their ethnicity as 78% Caucasian, 11% Asian American/Pacific Islander, 5% African

American, 4% other ethnicity, and 2% Hispanic/Latino. The students were primarily sophomores (29%) and juniors (34%), with a range of college freshmen to graduate students.

Measures

Demographic variables: Participants reported their sex, age, year in school, and race/ethnicity.

Measures of Skin Color

Self-report of skin color and tanning ability: Participants rated the color of their untanned skin on a 7-point Likert-type scale from very fair/light (scored as a 1) to very dark (scored as a 7). Ratings of 1-2 indicate light skin, 3-5 indicate medium skin, and 6-7 indicate dark skin. Participants reported their likelihood of burning and tanning according to Fitzpatrick skin type (Fitzpatrick, 1988). There are six skin types ranging from Type I being the fairest, most likely to burn, and least likely to tan to Type VI being the darkest, least likely to burn, and most likely to tan.

Observer rating of skin color: A research assistant rated each participant's presumed natural skin color from 1 = fair to 6 = very dark and level of tanness from 1 = no tan to 6 = extremely tan. No prior published study has reported on the use of such a method.

Spectrophotometry: Melanin skin content was estimated using skin reflectance spectrophotometry. Skin reflectance measurement is a relatively new method of observing UV exposure in the context of intervention studies, with few studies using it as an outcome measure to date (for review see (Glanz and Mayer, 2005; Mahler *et al.*, 2007). Measures of skin color via spectrophotometry have been demonstrated to be reproducible, not affected by ambient lighting, and independent of skin pigmentation (Konica_Minolta_Camera_Corporation, 1998; Levine *et al.*, 1991). Spectrophotometers are lightweight, handheld devices that measure hue or red versus green (a^* scale), lightness or black versus white (L^* scale), and saturation or yellow versus blue (b^* scale). The a^* scale measures skin erythema or redness (i.e., sunburn). Skin reddening (sunburn) typically subsides within 48-72 hours following UV exposure (Muizzuddin *et al.*, 1990). Previous work has demonstrated that increases in b^* and decreases in L^* scale components better indicate skin darkening caused by cumulative UV exposure (Seitz and Whitmore, 1988). The L^* scale was used in the current study. For this measure, 0 indicates pure black and 100 indicates pure white, thus, as the L^* scale increases, skin pigment is lighter. In order to obtain a reading, the spectrophotometer (Konica Minolta CM-2600, Ramsey, NJ) was placed on each participant's skin (with minimal pressure). Two readings of a relatively lesser exposed area of the skin (underside of the upper arm) and two readings of two frequently exposed areas of the skin (outside of the same forearm and facial cheek) were taken. An average of the two readings from each site was used for analysis.

Measures of Skin Damage

Ultraviolet-filtered Photographs: Two black-and-white photos were taken of participants, one regular and one UV photo, using a Canfield instant Polaroid UV Reflect camera (Fairfield, NJ). UV photos were coded by two trained raters as to how much damage was visible on the photos on a scale from 1 (no damage) to 5 (considerable damage). Damage could be seen as dark, freckled, spotted, wrinkled, uneven, or pitted areas.

Self Report of Skin Damage: Participants also rated perceived long-term skin damage due to sun/tanning, from 1 = none to 7 = a lot.

Procedures

The study took place in Philadelphia, Pennsylvania from March through June 2007. Participants were recruited via a university psychology student participant pool, as well as announcements, flyers, emails, and advertisements in academic departments and around three university campuses. Participants were eligible if they were between 18 and 24 years of age, would be available for in-person follow ups (e.g., not graduating seniors), and had at least one of several possible behavioral or family skin cancer risk factors. Students who screened eligible for the study were provided with a website URL to complete a self-report survey on-line. Students then attended an in-person session in which photographs, spectrophotometry readings, observer skin color ratings, and preventive interventions were completed. Some students could earn extra credit for their classes for their research participation. All participants received \$5 for completion of the baseline survey and in-person intervention session. The current measurement study was part of a larger intervention study; all participants who attended the in-person intervention session were included in the current analyses. This study was approved by the appropriate institutional review boards and followed Declaration of Helsinki protocols including written informed consent.

Data Analysis

To assess the reliability of measures, we first calculated kappas comparing ratings of damage depicted in the UV photos made by two raters. Additionally, we calculated Pearson correlations to compare findings from the same measure of different constructs. In order to examine convergent validity (the relationship between different measures of similar theoretical constructs), Pearson correlations were calculated among measures of natural skin color (L^* scale of upper arm and observer rating), current skin color (L^* scale of cheek and lower arm and observer rating), and measures of UV damage (self-rating and UV photo). One form of discriminant validity (the ability of measures to classify respondents into groups) was assessed using ANOVAs to assess differences by time of year, race/ethnicity, and skin color (as measured by self rating, L^* scale of the upper arm). In order to examine the impact of gender on the variables of interest, moderation models of regression based on the procedure described by Baron and Kenny (Baron and Kenny, 1986) were conducted.

Results

Measures of Reliability

Interrater Reliability of UV Photos—An inter-rater reliability analysis was conducted for the two ratings of the UV photographs of skin damage, $Kappa = .86$. Because of the high reliability between raters, an average of the two ratings was used for the analyses. The average UV photo damage rating was 2.6 ($SD = 1.1$) on a scale of 1 (no damage) to 5 (considerable damage). Mean values for photos, self, observer, and spectrophotometry ratings are presented in Table 1. Thirteen of the 100 UV photos were noted as defective due to film or camera problems (e.g., abnormally light or dark, lines down the middle, etc.). Kappa for these photos was 0.67. Twelve photos appeared to be of darker-skinned, non-Caucasian individuals. The kappa for these photos was 1.0. Eleven of these twelve photos were rated as having no damage, and one was rated as a two out of five. Anecdotally, the raters found photos of darker-skinned individuals difficult to rate due to the difficulty of visually discerning contrasting shades within the photos.

Comparing Findings from the Same Measures of Different Constructs

Spectrophotometry: The skin colors of the body sites used for spectrophotometry measurement were highly related. The L^* scale from the upper arm and cheek ($r = .82, p < .01$), upper arm and lower arm ($r = .79, p < .01$), and cheek and lower arm ($r = .88, p < .01$)

were all significantly correlated. Because the spectrophotometry L* scale on the lower arm was highly correlated with the L* scale of the cheek, accordingly, only the L* scale of the cheek was used in subsequent analyses. Correlations are reported in Table 2

Observer report: Observer ratings of natural and current skin color were not related, $r = .16$, $p = \text{n.s.}$

Self-report: Self-report of natural skin color and of Fitzpatrick (Fitzpatrick, 1988) skin type were significantly correlated, $r = .63$, $p < .001$. Self-report of natural skin color was more highly correlated with the other variables of interest than was the Fitzpatrick skin type, thus self-report of natural color was used instead of Fitzpatrick skin type in the remaining analyses. Self-report of natural skin color and self-report of cumulative UV damage were inversely related ($r = -.41$, $p < .01$), indicating that as self-reported skin color became darker, participants reported less UV damage.

Measures of Validity

Comparing Different Measures of the Same Construct

Natural Skin Color: Self-rating of natural skin color was highly correlated with L* scale ratings of the upper inner arm, $r = -.70$, $p < .001$. The inverse relationship indicates that as L* scale ratings increase, indicating less pigment, natural skin color ratings also became lighter. Conversely, observer rating of natural skin color was not significantly correlated with the L* scale of the upper inner arm, $r = -.16$, $p = \text{n.s.}$

Current Skin Color: Observer rating of current skin color was highly correlated with the L* scale ratings from the cheek ($r = -.77$, $p < .01$) and the lower arm ($r = .74$, $p < .01$).

Cumulative UV Damage: Self-reported cumulative UV damage was minimally correlated with UV photo rating of cumulative UV damage, $r = .25$, $p < .05$.

Comparing Measurements of Constructs by Participant Group

Month: Participants completed the study between the months of March and June. March and April sessions ($n = 53$) were combined and compared to May and June sessions ($n = 47$). There was a significant main effect for month of survey completion for observer-rated natural skin color ($F(1,98) = 16.7$, $p < .001$, mean difference = $-.64$, 95% CI, $-.95, -.33$), observer rated current skin color ($F(1,98) = 14.2$, $p < .001$, mean difference = $-.93$, 95% CI, $1.4, .44$), and the L* scale of the cheek ($F(1,98) = 9.9$, $p = .002$, mean difference = 4.5 , 95% CI, $1.7, 7.4$). Not surprisingly, the L* scale ratings indicated darker skin pigment in May and June (average $L^* = 65.4$) as compared to March and April (average $L^* = 60.05$). Likewise, the observer rated participants' natural skin color and current skin color as darker in May and June.

Race/Ethnicity: Participants were separated into three groups based on self-reported race/ethnicity: African American ($n = 5$), Caucasian ($n = 78$), and other ($n = 17$). There were significant group differences for all variables except natural skin color as rated by an observer. Caucasians had more cumulative skin damage than African-Americans ($p < .05$) as measured by both self-report and UV photos (Table 3).

Self-Rated Natural Skin Color: A one-way ANOVA was conducted to examine differences between those rating their natural skin color as lighter (ratings of 1-2, $n = 51$), and those who rated their natural skin color as darker (ratings of 3-7, $n = 49$). Participants who rated their natural skin color as darker had significantly lower (indicating darker) spectrophotometry scores (L* scale upper-inner arm: $F(1,98) = 22.9$, $p < .01$, mean difference = 6.42 , 95% CI,

3.8, 9.1; L* scale cheek: $F(1,98) = 18.9, p < .01$, mean difference = 6.2, 95% CI, 3.5, 9.0) and higher observer ratings of current skin color ($F(1,98) = 38.7, p < .01$, mean difference = -1.4, 95% CI, -1.9, -.98). Participants with self-reported lighter natural skin color were rated to have significantly more long-term damage according to both self-report and UV photography (Table 3).

Inner-Upper Arm L* Scale Spectrophotometry: Two groups were formed based on a median split L* cheek scale ratings, lighter (67.95 and higher, $n = 51$) and darker (67.95 and lower, $n = 49$). There were significant group differences for all variables, with participants having lighter upper arm skin also having lighter cheek L* scale ratings ($F(1,98) = 24.7, p < .01$, mean difference = -6.7, 95% CI, -9.4, -4.0), lighter self-ratings of natural skin color ($F(1,98) = 30.6, p < .01$, mean difference = 1.2, 95% CI, .78, 1.6), and lighter observer ratings of skin color (natural: $F(1,98) = 22.1, p < .01$, mean difference = 1.3, 95% CI, .82, 1.7; current: $F(1,98) = 31.1, p < .01$, mean difference = .72, 95% CI, .41, 1.0). Again, participant rating and UV photos indicated that participants with darker skin had less long-term UV damage (Table 3).

Gender: Because UV exposure and protective behaviors vary by gender, as do skin cancer rates, we evaluated the impact of gender on the variables of interest. We examined gender differences on all measures using a one-way ANOVA. Significant gender differences emerged for the L* scale of the cheek ($F(1, 98) = 4.5, p < .05$, mean difference = 4.1, 95% CI, .28, 7.9), current skin color as rated by an observer ($F(1, 98) = 4.1, p < .05$, mean difference = -.68, 95% CI, -1.3, -.01), and participant rating of cumulative UV skin damage ($F(1, 98) = 8.8, p < .01$, mean difference = 1.0, 95% CI, .33, 1.7). Women were rated as lighter in skin color by spectrophotometry compared to men (Women L* cheek = 64.0, Men L* cheek = 60.0), however, women self-rated more cumulative skin damage. Interestingly, no gender differences emerged for cumulative skin damage as rated by UV photo ($F(1, 98) = .54, p = .46$, mean difference .22, 95% CI, -.37, .81).

The correlations between measures were also examined by gender. Significant gender differences were revealed when comparing self-rated cumulative UV damage, except for the correlation between observer rated natural skin color and self-rated long-term damage. Correlation coefficients were slightly stronger for women compared to men, except for the correlations between long-term damage and average L* scale lower arm. Interestingly, as women's skin was rated higher (indicating lighter skin) by spectrophotometry, self-rated long-term damage was also higher. The relationships were inverse for men: as spectrophotometry ratings were higher (lighter), self-reported damage was lower.

A multiple regression was conducted to further examine whether gender functions as a moderator between self-reported UV damage and L* scale spectrophotometry ratings of the cheek. The interaction between gender and the L* scale of the cheek was a significant predictor of self-rated UV damage ($b_3 = -.106, SE_b = .05, p < .05$). L* scale from the cheek, gender, and the interaction between the two accounted for 19.1% of the variance in self-ratings of long-term damage. Women with lighter skin as rated by spectrophotometry reported the most long-term damage as compared to women with darker skin and men (See Figure 1). The distribution of each variable was examined and the assumptions of regression were tested; there were not violations of homoskedasticity, multicollinearity, or uneven distribution of error variances.

Discussion

Psychometrically sound measurement of skin color and damage is important for surveillance in skin cancer prevention and intervention efforts. While the current study did not include an assessment of skin cancer, the study is unique in its use of observer ratings of skin color, UV

photographs to assess cumulative skin damage, and its comparison of four different skin color and damage measurement strategies. Reliable ratings of UV photo damage were obtained. Moderate to high correlations emerged between self-report of skin color and the gold standard, skin reflectance spectrophotometry, indicating that these measures have convergent validity. Observer rating correlated with spectrophotometry rating of current but not natural skin color, suggesting that observer rating of current skin color converges with the gold standard skin reflectance spectrophotometry, although observer rating of natural skin color does not. Overall, lighter-skinned individuals reported more cumulative skin damage, which was supported by UV photography. Although women's current skin color was lighter and their UV photos showed similar damage to men's, women reported their skin to be significantly more damaged than men did.

Previous studies have used viewing UV photos as an intervention to promote skin cancer prevention behaviors (Gibbons *et al.*, 2005; Mahler *et al.*, 2007; Mahler *et al.*, 2003; Mahler *et al.*, 2005; Pagoto *et al.*, 2003), but none have assessed their utility as an outcome measure of intervention effect. As expected, the UV photos were able to be rated reliably in the current study; however, the ratings were only minimally correlated with self-report ratings of cumulative skin damage. The small correlation between UV photos and self-report of damage suggests that these measures have low convergent validity; however, the small correlation may represent self-report bias or misjudgment of damage. Because the photos were only compared with self-report of cumulative damage, this does not allow us to draw conclusions about the validity of the UV photos. In future studies, the validity of the photo ratings could be assessed by monitoring exposure and protective behaviors longitudinally or by creating a more comprehensive self-report scale measuring cumulative UV damage including items inquiring about UV exposure and protection behaviors over time. Additionally, the use of UV photos with darker-skinned individuals needs to be evaluated further. Finally, digital UV photography is now available, which allows even greater accuracy and versatility.

The use of a simple 1-7 Likert scale for self-report of natural skin color was found to correlate better with the other measures of interest than the more sophisticated and commonly-used Fitzpatrick (Fitzpatrick, 1988) scale measuring skin sensitivity. Clinically, our group has noted that individuals typically underestimate their skin sensitivity. Self-report of natural skin color was moderately to highly correlated with spectrophotometry readings for each body area that was measured, again supporting convergent validity. The strength of this correlation is impressive given that self-report was compared to a "gold standard." Interestingly, the correlation was similar regardless of which body area was measured. Spectrophotometry measurements of the upper inner arm were highly correlated with both the facial cheek and the lower outer arm. The similarity of the spectrophotometry ratings indicates that measuring the upper inner arm may not accurately reflect a body area that does not receive UV exposure as suggested previously (Mahler *et al.*, 2007). We could have analyzed our data using lower arm minus upper arm spectrophotometry readings to indicate tanness. However, prior research has found that spectrophotometry measurements of the upper inner arm change over time with UV exposure (Mahler, personal communication, 2006). Likewise, we found very few people whose lower arm was significantly darker than their upper arm. Assessment of lower exposure body areas, however, may be more successful in high exposure settings (i.e., warm climates) or times of the year (i.e., summer).

Observer rating of tanness was moderately to highly correlated with spectrophotometry scores from the facial cheek and lower arm, but observer rating of untanned skin color was not correlated with spectrophotometry measurement of the upper arm. Thus, spectrophotometry readings converge with observer rating of tanness but not observer rating of untanned skin color. In other words, the rater was relatively successful at rating what she actually saw in person, but was also given the difficult task of rating what she would have seen if participants

had no tan. Additionally, the rater generally only saw the face, arms, and hands of the participants in an individual session with no opportunity to compare their skin color to others, thus the failure to find a significant association is not surprising. A more accurate way to gather observer ratings would be to have the observer rate current skin color, perceived race/ethnicity, examine areas of the body that might receive more or less UV exposure, or to compare individuals to others or to standard images. Ideally, more than one observer or an expert observer such as a dermatologist would be utilized, but this was not feasible in the current study. Likewise, we took only black and white photos, but obtaining color photos might have allowed for more comprehensive observer ratings.

Lighter-skinned individuals, as determined by spectrophotometry, self-rating, or race/ethnicity, reported more cumulative skin damage than darker-skinned individuals. This is not surprising given that light-skinned individuals are at higher risk of skin damage such as sunburns and skin cancer, particularly when not well protected (Bajdik *et al.*, 1998; Böni *et al.*, 2002; Davis *et al.*, 2002; Hall *et al.*, 2003). These results support one form of discriminant validity of spectrophotometry and self-rating. Although the differences in self-rated skin damage between dark and light-skinned individuals were statistically significant, they were not large in absolute terms. Given the low report of damage, it is possible that some participants under-reported their amount of skin damage because even the light-skinned individuals did not rate their damage as above four out of seven on average, and participants were selected for having at least one skin cancer risk factor (Fitzpatrick, 1988).

Interestingly, although women's current skin color was lighter and their UV photos showed similar damage to men's, women reported their skin to be significantly more damaged than men did. Which sex was a more accurate judge of skin damage is unclear without further assessment of skin color and damage. For example, darker skinned men may have reported more damage based on recent tanning behavior. However, lighter skinned women may have reported more damage based on prior burning experiences. Prior studies have found that women both tan more and protect their skin more (e.g., use sunscreen) than men (Steffen *et al.*, 2007; Thieden *et al.*, 2005; Weinstock *et al.*, 2000). This gender difference is likely due to greater appearance concern and cultural pressure to be attractive for females (Boldeman *et al.*, 2003; Boldeman *et al.*, 1997; Demko *et al.*, 2003; O'Riordan *et al.*, 2006). Although American men are at higher risk for melanoma than American women (Ries *et al.*, 2006), men in the current sample self-reported significantly less skin damage than did women. Therefore, different skin cancer prevention interventions may be appropriate for men and women, or at least subgroups of individuals with high UV exposure and low protective behaviors or other skin cancer risk factors such as a family history of skin cancer. However, more research is needed in this area because the current study sample included only 18 men and 82 women.

Limitations of the study are that it utilized a cross-sectional convenience sample, and only a small number of items were rated by the participants and the observer. A convenience sample of individuals responding to advertisements may differ in a variety of ways from individuals selected randomly. Study findings suggest that self-report continues to be a valuable measurement strategy when measuring skin reflectance is not feasible or appropriate and that UV photos may also be useful but need to be tested further. Observer rating of skin color were satisfactory but may be improved through the use of additional measures or with more comprehensive protocols or training. Future research should continue to test these measurement strategies with larger and more diverse populations and compare them with other types of measures over time such as behavioral observation or objective measurement of UV exposure and protective behaviors such as dosimeters measuring real-time UV exposure and skin swabbing for evidence of adequate sunscreen application (for a review, see (Glanz and Mayer, 2005). Longitudinal studies could also evaluate the predictive validity of some of these measures. Skin cancer rates and exposure behaviors such as indoor tanning are rising, while

protective behaviors such as sunscreen use remain steady (Feldman *et al.*, 2004; Lamberg, 2002; NCI, 2007; Robinson *et al.*, 1997). Adequate measurement of skin color and damage is important for surveillance in prevention and intervention efforts. To this end, we must determine which measures are most reliable, valid, convenient, and cost-effective for specific situations.

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Abbreviation

UV, ultraviolet.

References

- ACS. Cancer facts and figures 2004. American Cancer Society; Atlanta, GA: 2007.
- Afromowitz MA, Van Liew GS, Heimbach DM. Clinical evaluation of burn injuries using an optical reflectance technique. *IEEE Trans Biomed Eng* 1987;34:114–127. [PubMed: 3557491]
- Andersen PH, Bjerring P. Spectral reflectance of human skin in vivo. *Photodermatol Photoimmunol Photomed* 1990;7:5–12. [PubMed: 2196543]
- Bajdik CD, Gallagher RP, Hill GB. Sunlight exposure, hat use, and squamous cell skin cancer on the head and neck. *J Cutan Med Surg* 1998;3:68–73. [PubMed: 9822778]S. F
- Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* 1986;51:1173–1182. [PubMed: 3806354]
- Bjerring P, Andersen PH. Skin reflectance spectrophotometry. *Photodermatol* 1987;4:167–171. [PubMed: 3684742]
- Boldeman C, Jansson B, Dal H, Ullen H. Sunbed use among Swedish adolescents in the 1990s: a decline with an unchanged relationship to health risk behaviors. *Scand J Public Health* 2003;31:233–237. [PubMed: 12850979]
- Boldeman C, Jansson B, Nilsson B, Ullen H. Sunbed use in Swedish urban adolescents related to behavioral characteristics. *Prev Med* 1997;26:114–119. [PubMed: 9010906]
- Böni R, Schuster C, Nehrhoff B, Burg G. Epidemiology of skin cancer. *Neuro Endocrinol Lett* 2002;23:48–51. [PubMed: 12163848]
- CDC. National skin cancer prevention education program at a glance 1996. Centers for Disease Control; Atlanta, GA: 1996.
- Coups EJ, Manne SL, Heckman C. Multiple skin cancer risk behaviors in the U.S. population. *American journal of preventive medicine* 2008;34:87–93. [PubMed: 18201637]
- Creech L, Mayer J. Ultraviolet radiation exposure in children: a review of measurement strategies. *Ann Behav Med* 1997;19:399–401. [PubMed: 9706367]
- Davis KJ, Cokkinides VE, Weinstock MA, O'Connell MC, Wingo PA. Summer sunburn and sun exposure among US youths ages 11 to 18: national prevalence and associated factors. *Pediatrics* 2002;110:27–35. [PubMed: 12093943]
- Demko CA, Borawski EA, Debanne SM, Cooper KD, Stange KC. Use of indoor tanning facilities by white adolescents in the United States. *Arch Pediatr Adolesc Med* 2003;157:854–860. [PubMed: 12963589]
- Feldman SR, Liguori A, Kucenic M, Rapp SR, Fleischer AB Jr, Lang W, et al. Ultraviolet exposure is a reinforcing stimulus in frequent indoor tanners. *J Am Acad Dermatol* 2004;51:45–51. [PubMed: 15243523]
- Fitzpatrick TB. The validity and practicality of sun-reactive skin types I through VI. *Arch Dermatol* 1988;124:869–871. [PubMed: 3377516]

- Fulton JE Jr. Utilizing the ultraviolet (UV detect) camera to enhance the appearance of photodamage and other skin conditions. *Dermatol Surg* 1997;23:163–169. [PubMed: 9145957]
- Gibbons FX, Gerrard M, Lane DJ, Mahler HI, Kulik JA. Using UV photography to reduce use of tanning booths: a test of cognitive mediation. *Health Psychology* 2005;24:358–363. [PubMed: 16045371]
- Glanz K, Mayer JA. Reducing ultraviolet radiation exposure to prevent skin cancer methodology and measurement. *American journal of preventive medicine* 2005;29:131–142. [PubMed: 16005810]
- Godar D, Urbach F, Gasparro F, van der Leun J. UV doses of young adults. *Photochem Photobiol* 2003;77:453–457. [PubMed: 12733658]
- Hall HI, Saraiya M, Thompson T, Hartman A, Glanz K, Rimer B. Correlates of sunburn experiences among U.S. adults: results of the 2000 National Health Interview Survey. *Public Health Rep* 2003;118:540–549. [PubMed: 14563911]
- Jackson A, Wilkinson C, Pill R. Moles and melanomas--who's at risk, who knows, and who cares? A strategy to inform those at high risk. *Br J Gen Pract* 1999;49:199–203. [PubMed: 10343423]
- Knight JM, Kirinich AN, Farmer ER, Hood AF. Awareness of the risks of tanning lamps does not influence behavior among college students. *Archives of Dermatology* 2002;138:1311–1315. [PubMed: 12374536]
- Konica_Minolta_Camera_Corporation. Precise color communication. Osaka, Japan: 1998.
- Lamberg L. "Epidemic" of malignant melanoma: true increase or better detection? *JAMA* 2002;287:2201. [PubMed: 11980506]
- Levine N, Sheftel SN, Eytan T, Dorr RT, Hadley ME, Weinrach JC, et al. Induction of skin tanning by subcutaneous administration of a potent synthetic melanotropin. *Journal of the American Medical Association* 1991;266:2730–2760. [PubMed: 1658407]
- Mahler HI, Kulik JA, Gerrard M, Gibbons FX. Long-term effects of appearance-based interventions on sun protection behaviors. *Health Psychology* 2007;26(3):350–360. [PubMed: 17500622]
- Mahler HI, Kulik JA, Gibbons FX, Gerrard M, Harrell J. Effects of appearance-based interventions on sun protection intentions and self-reported behaviors. *Health Psychol* 2003;22:199–209. [PubMed: 12683740]
- Mahler HI, Kulik JA, Harrell J, Correa A, Gibbons FX, Gerrard M. Effects of UV photographs, photoaging information, and use of sunless tanning lotion on sun protection behaviors. *Arch Dermatol* 2005;141:373–380. [PubMed: 15781679]
- Milne E, English DR, Johnston R, Cross D, Borland R, Giles-Corti B, et al. Reduced sun exposure and tanning in children after 2 years of a school-based intervention (Australia). *Cancer Causes Control* 2001;12:387–393. [PubMed: 11545453]
- Muizzuddin N, Marenus K, Maes D, et al. Use of a chromameter in assessing the efficacy of anti-irritants and tanning accelerators. *Journal of Social and Cosmetic Chemistry* 1990;41:369–378.
- NCI. SNP500Cancer Database. National Cancer Institute; 2007.
- O'Riordan DL, Field AE, Geller AC, Brooks DR, Aweh G, Colditz GA, et al. Frequent tanning bed use, weight concerns, and other health risk behaviors in adolescent females (United States). *Cancer Causes Control* 2006;17:679–686. [PubMed: 16633915]
- Pagoto S, McChargue D, Fuqua RW. Effects of a multicomponent intervention on motivation and sun protection behaviors among midwestern beachgoers. *Health Psychol* 2003;22:429–433. [PubMed: 12940400]
- Ries, LAG.; Melbert, D.; Krapcho, M.; Mariotto, A.; Miller, BA.; Feuer, EJ., et al. SEER Cancer Statistics Review, 1975-2004. Institute, NC., editor. Bethesda, MD: 2006. Based on November 2006 SEER data submission
- Robinson JK, Rigel DS, Amonette RA. Trends in sun exposure knowledge, attitudes, and behaviors: 1986 to 1996. *J Am Acad Dermatol* 1997;37:179–186. [PubMed: 9270501]
- Seitz JC, Whitmore CG. Measurement of erythema and tanning responses in human skin using a tri-stimulus colorimeter. *Dermatologica* 1988;177:70–75. [PubMed: 3169336]
- Sjöberg L, Holm LE, Ullen H, Brandberg Y. Tanning and risk perception in adolescents. *Health, Risk & Society* 2004;6:81–94.

- Steffen AD, Glanz K, Wilkens LR. Identifying latent classes of adults at risk for skin cancer based on constitutional risk and sun protection behavior. *Cancer Epidemiology Biomarkers and Prevention* 2007;16:1422–1427.
- Thieden E, Philipsen PA, Sandby-Moller J, Wulf HC. Sunscreen use related to UV exposure, age, sex, and occupation based on personal dosimeter readings and sun-exposure behavior diaries. *Archives of Dermatology* 2005;141:967–973. [PubMed: 16103325]
- Weinstock MA, Rossi JS, Redding CA, Maddock JE, Cottrill SD. Sun protection behaviors and stages of change for the primary prevention of skin cancers among beachgoers in southeastern New England. *Ann Behav Med* 2000;22:286–293. [PubMed: 11253439]

Figure 1.

Gender as a moderator of subjective and objective reports.

Note: L* of the cheek is centered. Zero reflects the average L* of the cheek in the current sample. Higher L* values indicate lighter skin color.

Table 1

Scale means and standard deviations.

Rating Scale (range)	Mean	Standard Deviation
<i>Observer</i>		
Natural Skin Color (1-6)	1.66	0.84
Current Skin Color (1-6)	2.72	1.31
UV Photo Damage (1-5)	2.63	1.14
<i>Self</i>		
Natural Skin Color (1-7)	2.71	1.24
Fitzpatrick Skin Type (1-6)	3.52	1.39
Long-term Damage (1-7)	1.35	1.35
<i>Spectrophotometry</i>		
Lower-Outer Arm L* (0 to 100)	60.05	7.92
Upper-Inner Arm L* (0 to 100)	65.80	7.31
Facial Cheek L* (0 to 100)	63.21	7.53

Note: Higher ratings from spectrophotometry indicate less pigment.

Table 2

Correlation matrix.

	Natural Skin Color			Current Skin Color			Cumulative UV Damage	
	Self	Observer	L* upper arm	Observer	L* lower arm	L* cheek	Self	UV photo rating
Natural								
Self		0.10	-0.70**	0.73**	-0.70**	-0.71**	-0.41**	-0.54**
Observer			-0.16	0.16	-0.32*	-0.12	0.10	-0.15
L* upper arm				-0.67**	0.79**	0.82**	0.22*	0.50**
Current								
Observer					-0.77**	-0.74**	-0.36*	-0.63**
L* lower arm						0.88**	0.25*	0.53**
L* cheek							0.32**	0.50**
Cum.								
Self								0.25*
UV photo rating								

Note: Higher ratings from spectrophotometry indicate less pigment.

* p < .05.
** p < .01

Table 3

Self-rated long-term damage versus UV photo rated damage between groups

	Self-rated (1-7) M (SD)	UV Photo-rated (1-5) M (SD)
<i>Ethnicity</i>		
African American	1.80 (1.10) ^{*,+}	1.20 (0.45) ^{**}
Caucasian	3.86 (1.24) ⁺	2.91 (1.07) ^{**,+}
Other	3.59 (1.54) [*]	1.74 (0.85) ⁺
<i>Natural Skin Color</i>		
Lighter	4.04 (1.35) ^{**}	3.28 (1.06) ^{**}
Darker	3.44 (1.30) ^{**}	2.09 (0.91) ^{**}
<i>L* scale Cheek</i>		
Lighter	4.00 (1.28) [*]	3.17 (1.06) ^{**}
Darker	3.42 (1.37) [*]	2.08 (0.96) ^{**}
<i>Gender</i>		
Men	2.89 (1.41) ^{**}	2.44 (1.26)
Women	3.89 (1.28) ^{**}	2.66 (1.12)

*
 $p < .05$.**
 $p < .01$.+
 $p < .01$