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Increasing Skin Cancer Prevention in Young Adults: the Cumulative Impact of Personalized UV Photography and *MC1R* Genetic Testing

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Abstract

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Declarations

Ethics Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Institutional Review Board at the University of Utah [IRB_00116807].

Consent to Participate/Consent to Publish Informed consent for study participation and publishing of their data was obtained from all individual participants included in the study.

Conflict of Interests The authors report there are no competing interests to declare.

Skin cancer has become increasingly common among young adults; however, this population does not consistently adhere to recommended methods for preventing the disease. Interventions in college settings have relied on appearance-focused appeals and have not been able to examine the cumulative effect of multiple behavior change and skin cancer risk communication strategies. The goal of the current study was to examine the unique and combined impacts of personalized ultraviolet (UV) radiation photographs, genetic testing for skin cancer risk, and general skin cancer prevention education. Participants were randomly assigned to one of four conditions: (1) skin cancer prevention education, (2) education + UV photo, (3) education + genetic testing, and (4) education + UV photo + genetic testing. Self-reported sun protection, tanning, and sunburn were assessed at baseline, immediately post-intervention, and 1 month post-intervention. The findings indicated benefits of the interventions to skin cancer prevention behaviors in the overall sample; however, the combined (UV photo + genetic testing) intervention had the most consistent positive effects on behaviors. Intervention effects were distinct across seasons. These results suggest that interventions containing multiple skin cancer risk communication strategies hold promise in benefitting health-promoting behavior changes in an at-risk, young adult population.

Keywords

Skin cancer; Prevention; Intervention; Young adult

Introduction

Globally, the most commonly diagnosed cancer is that of the skin and its incidence is increasing, including the deadliest form, melanoma [1, 2]. Melanoma is the third most common cancer among young populations [3]. Most melanomas are caused by ultraviolet radiation (UVR), predominately from sun exposure, but also from artificial sources such as indoor tanning beds [4–6]. Young adults do not consistently use recommended sun protection methods and consequently receive substantial UVR exposure. Among college students, up to 50% report outdoor intentional tanning [7]. Prevention of skin cancer by targeting sun protection and risk behaviors among young adults is therefore essential.

Most skin cancer prevention interventions for college students have relied on appearance-focused appeals, such as providing information about the damaging effects of UVR exposure (e.g., wrinkles, age spots) and ultraviolet (UV) photos that show underlying skin damage and thus modifiable, environmental contributors to skin cancer risk [8, 9]. These interventions have shown promise for improving some but not all sun protection outcomes. Other studies have tested alternative risk communication interventions including messages about personal cancer risk based on non-modifiable family history or biological factors, and have shown that these types of interventions also improve sun protection outcomes [10, 11]. Innovative, multi-component interventions that convey personalized risk from both environmental contributors and biological risk could be ideal for reaching young populations but have not yet been tested.

The current study extends existing work by examining the combined impact of a personalized UV photo conveying environmental contributors to skin cancer and the results of genetic testing or a biological vulnerability for developing skin cancer. The latter is a form of risk communication that leverages inherited variation in the melanocortin-1 receptor (*MC1R*) gene to motivate sun protection and tanning avoidance. A subset of *MC1R* variants is associated with a clinically significant, modest, 1.3–twofold, increased risk for melanoma. These variants are common and relevant to melanoma risk even in carriers with low risk based on skin phenotype [12, 13]. Building on the Elaboration Likelihood Model [14] and extensions of the common sense model of self-regulation theories that describe ways individuals process, react to, and cope with risk information [15], it is unknown to what extent UV photos and other risk communication strategies could have unique or complementary effects on skin cancer prevention behaviors. The current pilot study sought to examine the overall and unique effects on the primary outcomes of sun protection and tanning and the secondary outcome of sunburn of skin cancer prevention education, information on environmental contributors to skin cancer risk (UV photo), and genetic risk communication among young people in a college setting. We hypothesized that young people who received both the UV photo and genetic risk communication interventions would report improved sun protection and less tanning and sunburn compared to those who received only one or a control intervention. We also hypothesized that young people who received only the UV photo *or* genetic risk communication intervention would report improved sun protection and less tanning and sunburn compared to those who received a control intervention. Seasonality of sun protection has been documented [16]; however, the role that season has on skin cancer prevention intervention effects among college students has not yet been examined. We examined the potential role of season of intervention delivery to help guide decisions around seasonal timing of future interventions for this population.

Methods

Participants

In total, 92 college students were recruited from undergraduate courses at a public, 4-year university in the western region of the USA and through advertisements on the university campus (e.g., paper flyers, ads on campus shuttles). Recruitment and enrollment on campus occurred in the fall and spring. Students were eligible to participate if they were at least 18 years of age, were enrolled at the university, had at least one sunburn in the last year, and/or reported having intentionally tanned indoors or outdoors at least once in the last year, and/or reported using sunscreen plus one or more other sun protection behavior (protective clothing use, shade) infrequently [17]. Students were excluded if they did not read or speak English or reported a personal history of skin cancer.

Measures

Demographic Characteristics—At baseline, participants were asked to report gender, race and ethnicity, marital status, income, family history of melanoma, personal history of cancer, and skin type using the Fitzpatrick scale [18].

Sun Protection Behaviors—Reported use of eight sun protection behaviors (e.g., sunscreen use and re-application, shade-seeking, avoidance of peak UVR exposure) was assessed for the past month at each timepoint using a 5-point Likert-type scale ranging from "never" to "always." These items were adapted from the Sun Habits Survey [19]. A sun protection index was calculated as a sum score of the 8 sun protection items.

Tanning Behaviors—Participants were asked to report frequency of engagement in tanning in the past month [19, 20], including indoor tanning, outdoor intentional tanning ("spend time in the sun in order to get a tan"), and outdoor unintentional tanning ("end up with a tan, even if you didn't try to get one").

Sunburn—Sunburn occurrence in the past month and year (from "0 times" to "5 or more times") was assessed using an item from the Sun Habits Survey [19].

Procedures

Two hundred and twenty students completed screening over the phone or online. Of those, 203 were eligible and 92 enrolled in the study. Eligible students who did not enroll were unreachable. Reasons for ineligibility included not meeting the sunburn, tanning, and sun protection criteria ($n = 10$), not enrolled as a student ($n = 4$), under age 18 ($n = 1$), previous skin cancer diagnosis ($n = 1$), and did not read or write English ($n = 1$). There were no significant differences between participants and eligible non-participants in terms of age, gender or reported frequency of sunburn, tanning, and use of sun protection. Students who identified as Native Hawaiian/Pacific Islander, Multi-racial, or Other race were more likely to participate, whereas students who identified as Asian and White were less likely to participate ($\chi^2(6, N = 215) = 27.1$, $p < 0.001$).

Eligible students were invited to complete a baseline visit where they provided informed consent, completed questionnaires, and were randomly assigned (stratified by gender) using a randomization table to one of four groups: (1) skin cancer prevention education, (2) education + UV photo, (3) education + *MC1R* testing, or (4) education + UV photo + *MC1R* testing. Participants randomized to receive the UV photo had their photo taken and participants randomized to *MC1R* testing provided a saliva sample. A second in-person visit occurred 1 month later when participants received skin cancer prevention education and if applicable, risk feedback. All education and risk feedback information was provided to individual participants in an automated, self-paced modality via a computer. Skin cancer prevention education information (definition of skin cancer, definition of UV exposure, risk factors for developing skin cancer, methods to prevent skin cancer) was presented first. The order of presentation of UV photo and *MC1R* results for participants who received both was randomized. One month after the in-person visit where they received skin cancer prevention education and risk information, participants completed an electronic survey remotely. Participants were offered course credit or gift cards in appreciation of their time.

Participants who received the UV photo intervention viewed photos of their face in visible light and UV light. The UV photo was taken using the Visia-CR system and shows underlying skin damage [21] (Online Resource 1). Participants viewed text explaining what UV light is, that UVR causes skin damage that can lead to skin cancer, that UV light used in the camera reveals skin damage not visible in normal light, that dark spots on the UV photo revealed skin damage that occurred from UVR exposure, and that protecting one's skin during younger years will decrease skin cancer risk.

To generate the *MC1R* test feedback, participants were tested for seven variants in the *MC1R* gene using ThermoFisher TaqMan SNP genotyping assays (rs1805005, rs1805006, rs2228479, rs11547464, rs1805007, rs885479, rs1805009). Participants who were carriers for one or more variants were considered at "increased risk." Carriers were given feedback through two icon arrays comparing twofold risk to average risk; average risk for non-carriers was conveyed through a single icon array (Online Resource 2 and 3). Participants viewed text indicating that protecting one's skin especially during younger years will decrease skin cancer risk.

In total, 92 students completed baseline (22 group 1, 23 group 2, 24 group 3, 23 group 4). The second visit was completed by 84 participants (20 group 1, 20 group 2, 22 group 3, 22 group 4). The third assessment was completed by 71 participants (19 group 1, 15 group 2, 18 group 3, 19 group 4). There were no significant differences in demographics or outcomes between participants who completed the third assessment versus dropped out before. All study procedures were approved by the university Institutional Review Board.

Statistical Analyses

Descriptive statistics were calculated for demographic characteristics and sun protection and tanning outcomes. For inferential statistical analyses, missing data was handled via multiple imputation, which ensures valid inference under missingness-at-random [22]. Twenty complete data sets were generated and all analyses were based on these, with pooling via Rubin's rules [23]. Linear models were used to estimate change in outcomes from baseline to third assessment for the whole sample and to compare change between the four groups. Season of participation (fall versus spring) was included as an adjustment factor; outcomes were also examined separately within each season.

Results

In total, 92 students participated in the current study (mean age =22.4 years, SD =5.2; Table 1). Table 2 contains descriptive statistics for sun protection behaviors, tanning, and sunburn. At baseline, participants reported wearing shirts with sleeves and long pants most frequently. Participants reported an average of slightly more than 0 sunburns in the last month (17.4% had 1 or more sunburns in the past month) and slightly fewer than 2 in the last year (84.8% had 1 or more sunburns in the past year).

Outcomes Across the Entire Sample

Participants reported increased avoidance of peak UVR hours over time (0.55 mean improvement, $p = 0.005$), and the overall sun protection index score increased over time (1.24 mean improvement, $p = 0.038$). Indoor tanning increased over time (0.29, $p = 0.003$) and unintentional tanning decreased over time (0.37, $p = 0.009$). In contrast, sunburn increased over time (0.41 increase, $p = 0.018$). There was suggestive evidence that participants were more likely to wear long pants or a long skirt over time (0.34 increase, $p = 0.071$). Other sun protection and tanning behaviors did not change significantly pre to post-intervention.

Outcomes for Each Intervention Group and by Season

When comparing each group to education alone, there were no significant differences in sun protection (individual behaviors, sun protection index score) and tanning between groups. However, each intervention group was associated with significant changes in sun protection and/or tanning behaviors. Specifically, receipt of the UV photo plus *MC1R* result was associated with significant increases pre- to post-intervention in avoidance of peak UVR hours (0.80 mean improvement, $p = 0.029$). Receipt of *MC1R* result alone was significantly associated with decreased outdoor unintentional tanning (0.61 mean decrease, $p = 0.038$). In contrast, receipt of the UV photo alone was associated with a significant increase in sunburn occurrence post-intervention (0.72 mean increase, $p = 0.039$). Receipt of education only was associated with a significant increase in sunscreen re-application (0.61 mean improvement, $p = 0.039$).

For participants who received the intervention in the fall, receipt of the UV photo plus *MC1R* test result was significantly associated with decreased outdoor unintentional tanning post-intervention (0.93 mean decrease, $p = 0.022$). Receipt of the UV photo alone was significantly associated with decreased outdoor unintentional tanning (1.12 mean decrease, $p = 0.013$). Receipt of *MC1R* test alone was associated with significant decrease in use of sunscreen post-intervention (1.14 mean decrease, $p = 0.019$) and outdoor unintentional tanning (1.52 mean decrease, $p < 0.001$), and significant increase in wearing long pants or skirt (1.06 mean improvement, $p = 0.020$). Receipt of education only was significantly associated with increased wearing of long pants or skirt post-intervention (1.23 mean improvement, $p = 0.007$) and decreased outdoor unintentional tanning (1.08 mean decrease, $p = 0.008$).

For participants who received the intervention in the spring, receipt of the UV photo plus *MC1R* test was associated with significant increases in shade-seeking post-intervention (1.15 mean increase, $p = 0.026$), avoidance of peak UVR hours (1.04 mean increase, $p = 0.048$), and the overall sun protection index score (3.31 mean increase, $p = 0.034$). Receipt of the UV photo was associated with a significant increase in sunburn occurrence (1.18 mean increase, $p = 0.019$). There were no significant changes in outcomes among participants who received *MC1R* testing only or education only in the spring.

Discussion

The current pilot study findings indicate that the combination of personalized risk information about both environmental contributors to and biological risk can benefit young adults' skin cancer prevention and risk behaviors. Combined effects of UV photograph plus *MC1R* testing generally showed the most consistent change toward increased sun protection and skin cancer risk reduction. Further, seasonal effects were complex, and indicate that season is an important consideration for future intervention planning. Findings of significant increases in avoiding peak hours and sun protection usage among those who received all types of intervention argue for the receptivity of college students to skin cancer risk reduction intervention and their ability to respond within a few weeks. Some of the changes were in the direction of increased risk behavior, indicating sun protection and skin cancer risk behaviors assessed are complex.

No specific intervention component provided a clear efficacy benefit for all behaviors. All components had some demonstrated effects; however, the combined UV photo plus *MC1R* test appeared to be slightly more active than separate delivery. This novel combination capitalizes on promising effects of appearance-focused appeals [24], delivered via UV photos emphasizing skin damage [9], and health behavior-focused messaging that sun protection during younger years mitigates risk for skin cancer, as well as developing evidence for the role of skin cancer genetic feedback via *MC1R* testing in motivating sun protection and skin cancer screening [25]. Here, as with the changes overall in the cohort, there remained counterintuitive effects requiring additional inquiry for larger samples.

Our study found delivery of the intervention components in the fall semester resulted in a general trend to increase behaviors that are logical in cooler weather such as decreased outdoor tanning. In contrast, delivery of the intervention components in the spring led to a general trend to increase protection that might be logical as weather becomes hotter. Seasonality of sun protection has been documented [16], but we are unaware of other work in college students comparing intervention effects across season of the year. Overall, the different trends in the fall and spring indicate that timing of sun protection intervention matters, and that skin cancer risk reduction interventions may hasten the effects of natural changes in outdoor exposure, sun protection, and risk behaviors in young people as temperature and forms of outdoor recreation and work change. Further examination of these effects in future studies may help to optimize existing interventions or to further specify intervention components to specific seasons.

There are several limitations of the current study to note. The study recruited from a single geographical location, and included participants with similar education level, socioeconomic status and age. In addition, the sample's racial and ethnic diversity was limited; however, non-Hispanic Whites face the highest risk of skin cancer and our recruitment rate for non-White college students was relatively high (57%). There was limited reported sunburn in the month prior to study recruitment, so future work could recruit higher risk samples during high UVR seasons. And finally, given the pilot nature of this work, the sample size was limited and thus we were not able to examine differences between those who received increased versus average *MC1R* risk feedback.

Conclusion

We conducted a rigorous pilot investigation examining sun protection and tanning outcomes associated with provision of environmental risk feedback and skin cancer genetic risk feedback with young adults with recent histories of higher risk behavior. Our findings are promising indications that students are responsive to these interventions and motivated to change short-term skin cancer risk behavior, and that provision of intervention components in different seasons may have distinct impacts. Future work could test these intervention components in larger samples and test different mechanisms of their effects, and examine student characteristics such as typical patterns of sun exposure and protection that may impact outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Demographic characteristics of participants (*n* = 92)

	n* (%)
Age (M, SD)	22.4 (5.3)
Sex	
Male	27 (29.3)
Female	65 (70.7)
Race and ethnicity^	
Non-Hispanic White	65 (70.7)
Non-Hispanic and Multi-Racial	
White and Asian or Asian American	7 (7.6)
White and Black or African American	2 (2.2)
White and Native Hawaiian or Pacific Islander	1 (1.1)
White, Black or African American, and American Indian or Alaskan Native	1 (1.1)
Non-Hispanic Asian or Asian American	8 (8.7)
Non-Hispanic Black or African American	1 (1.1)
Hispanic White	5 (5.4)
Hispanic and Race Unknown	2 (2.2)
Marital status	
Married or marriage-like relationship	14 (15.2)
Never married	78 (84.8)
Family income	
< $50,000	19 (20.7)
> $50,000	42 (45.7)
Unsure	27 (29.3)
Prefer not to report	4 (4.3)
Fitzpatrick skin type	
I	4 (4.3)
II	19 (20.7)
III	35 (38.0)
IV	30 (32.6)
V	4 (4.3)
VI	0 (0)
Family history of melanoma	
Yes	28 (30.4)
No	32 (34.8)
Unsure	32 (34.8)
Personal history of cancer	
None	92 (100)
Received *MC1R* risk feedback	47 (51)
Average risk for developing skin cancer	19 (40)
Increased risk for developing skin cancer	28 (60)

* n and % reported, unless otherwise noted

^ Participants were instructed to mark all that apply

Table 2

Descriptive statistics for outcomes of interest at baseline and 1 month post-intervention (M, SD)

	Overall		Education (E) only		UV photo + E		*MC1R* + E		UV photo + *MC1R* + E	
Outcome	**Baseline**	**Post**	**Baseline**	**Post**	**Baseline**	**Post**	**Baseline**	**Post**	**Baseline**	**Post**
Sun protection										
Sunscreen	2.61 (1.19)	2.39 (1.31)	2.36 (1.22)	2.32 (1.29)	2.96 (1.19)	2.87 (1.19)	2.79 (1.25)	2.33 (1.61)	2.30 (1.06)	2.16 (1.12)
Sunscreen reapplication	1.86 (0.98)	1.76 (1.05)	1.64 (1.00)	2.16 (1.12)	1.91 (1.04)	1.53 (0.99)	2.00 (1.10)	1.67 (1.08)	1.87 (0.76)	1.63 (0.96)
Shirt with sleeves	3.83 (1.07)	4.10 (1.06)	3.86 (1.08)	3.84 (1.12)	3.96 (0.93)	4.47 (0.92)	3.88 (0.95)	3.94 (1.26)	3.61 (1.31)	4.21 (0.85)
Long pants/skirt	3.47 (1.25)	3.99 (1.05)	3.41 (1.14)	3.74 (1.10)	3.26 (1.21)	4.00 (1.13)	3.58 (1.21)	4.11 (1.02)	3.61 (1.47)	4.11 (0.99)
Hat	1.65 (0.93)	1.59 (0.84)	1.91 (0.92)	1.79 (0.79)	1.91 (1.24)	1.93 (1.28)	1.58 (0.83)	1.33 (0.59)	1.22 (0.42)	1.37 (0.50)
Shade	2.54 (0.98)	2.70 (1.18)	2.27 (0.98)	2.63 (1.01)	2.83 (1.11)	2.93 (1.22)	2.58 (0.93)	2.39 (1.29)	2.48 (0.85)	2.89 (1.20)
Avoiding peak UVR hours	2.15 (0.97)	2.73 (1.08)	2.09 (1.02)	2.53 (1.07)	2.43 (1.08)	3.00 (1.00)	2.08 (0.88)	2.61 (1.24)	2.00 (0.90)	2.84 (1.01)
Sunglasses	2.76 (1.29)	2.48 (1.42)	2.95 (1.09)	2.47 (1.43)	2.61 (1.44)	2.47 (1.81)	2.75 (1.22)	2.89 (1.13)	2.74 (1.42)	2.11 (1.33)
Index score	20.87 (3.82)	21.75 (3.93)	20.50 (3.23)	21.47 (4.54)	21.87 (4.00)	23.20 (3.38)	21.25 (4.50)	21.28 (3.95)	19.83 (3.26)	21.32 (3.67)
Sunburn (past month)	0.24 (0.62)	0.37 (0.93)	0.14 (0.47)	0.63 (1.30)	0.30 (0.56)	0.67 (1.18)	0.38 (0.88)	0.06 (0.24)	0.13 (0.46)	0.16 (0.50)
Sunburn (past year)	1.96 (1.38)	1.49 (1.24)	1.59 (1.26)	1.68 (1.16)	2.13 (1.60)	1.67 (1.54)	2.29 (1.23)	1.61 (1.24)	1.78 (1.38)	1.05 (1.03)
Tanning										
Outdoor intentional	1.54 (0.95)	1.41 (0.89)	1.77 (1.07)	1.68 (1.20)	1.35 (0.78)	1.27 (0.80)	1.50 (1.06)	1.11 (0.47)	1.57 (0.90)	1.53 (0.84)
Outdoor unintentional	2.08 (1.15)	1.52 (0.88)	2.27 (1.24)	1.95 (1.13)	2.00 (1.09)	1.20 (0.56)	2.08 (1.28)	1.22 (0.43)	1.96 (1.02)	1.63 (0.96)
Indoor	1.00 (0)	1.14 (0.52)	1.00 (0)	1.21 (0.71)	1.00 (0)	1.20 (0.56)	1.00 (0)	1.00 (0)	1.00 (0)	1.16 (0.50)