Sunlamp use and the risk of cutaneous malignant melanoma: a population-based case-control study in Connecticut, USA

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Background The relationship between cutaneous malignant melanoma and sunlamp use is examined in a Caucasian population in Connecticut, United States.

Methods Cases were diagnosed between 15 January 1987 and 15 May 1987 with a first primary cutaneous melanoma. Controls were obtained from the general population, frequency matched to cases by sex and age, through random digit dialling of Connecticut telephone numbers.

Results Of all study subjects, 141 (23%) cases and 95 (19%) controls reported ever having used sunlamps. The crude odds ratio (OR) for developing malignant melanoma after ever having used sunlamps was 1.30 (95% confidence interval [CI] : 0.97–1.74). This was reduced to 1.13 (95% CI : 0.82–1.54) after further adjusting for cutaneous phenotype and recreational sun exposure. Those who used more than one type of sunlamp had a threefold higher risk for melanoma compared to never users. Subgroup analyses showed that sunlamp use was associated with a greater increase in risk for melanoma among those who used sunlamps at home and those who were first exposed to sunlamps prior to 1971. The first use of sunlamps before the age of 25 showed somewhat higher risk for melanoma compared to first use later in life.

Conclusion The current study provides limited evidence that use of sunlamps increases the risk of melanoma. For future studies, it is crucial that type of sunlamp, year of first use and amount of exposure are all taken into account. The association between melanoma and tanning with both UV-A and UV-B lamps and tanning under sunlamps early in life merits further investigation.

Keywords Cutaneous malignant melanoma, sunlamp use, ultraviolet radiation, Connecticut

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The current study investigated the association between sunlamp exposure and melanoma in a population-based case-control study in Connecticut.

Material and Methods

Study subjects
Study subjects consisted of 624 newly diagnosed cases of primary invasive cutaneous malignant melanoma and 512 controls. All were Caucasian and Connecticut residents, and had been interviewed as part of a case-control study of skin self-examination and survival from melanoma.\(^{10}\)

Details of the study subjects have been presented elsewhere.\(^ {10,11}\) Briefly, all incident first primary cases of cutaneous malignant melanoma diagnosed from 15 January 1987 to 15 May 1989, among Connecticut residents were ascertained by the Rapid Case Ascertainment System of the Cancer Prevention Research Unit (CPRU) at Yale University. One dermatopathologist (RLB) conducted standardized histopathologic review for final determination of eligibility (invasive melanoma versus in situ or non-melanoma lesions) and for determination of histologic subtype.

A total of 650 subjects were determined to have invasive malignant melanoma, and 624 had no missing values in major variables for this analysis (see below) and were the case group for this study.

Controls were obtained from the general population through random digit dialling of Connecticut telephone numbers.\(^ {12}\) Controls were selected according to the anticipated sex and age distribution of the cases. Initially, 814 eligible control subjects were identified through random digit dialling; 70% (\(n = 573\)) were interviewed. Twenty-four of these were not Caucasian, resulting in 549 Caucasian controls. Of these, 512 had no missing values in major variables (see below) for this analysis and were the control group for this study.

Data collection and study variables

Nurse-interviewers administered a structured questionnaire and examined the arms and backs of subjects for nevi. Most interviews took place at the subject's home, although some were carried out at the place of employment or a public place, such as a library.

Information on sunlamp use history was obtained by asking the following questions: (1) Have you ever used a sunlamp, tanning lamp, or sun reflector in order to get a tan? (2) What type of sunlamps did you use, desk top, floor model, bed, or walk-in booth (Figure 1; show card)? (3) At what age did you first use it? (4) Approximately how many times have you used it? (5) Did you use it at home or outside at a tanning salon, beauty parlour, or health spa? (6) Did you ever get a burn from the lamp that required a doctor's attention? And (7) Which part of your skin was most badly burned? Calendar year of first use of sunlamp was calculated by summing year of birth and age at first use of sunlamp.

Information on constitutional and sun exposure-related risk factors, which could potentially confound the association between sunlamp use and melanoma, was collected. These factors include hair colour, eye colour, skin colour, skin type (ability to tan), total number of nevi on arms and backs, history of recreational sun exposure, and history of occupational sun exposure. Two indices were created and included in the multivariate models.

To avoid collinearity of sun sensitivity variables, a cutaneous phenotype index was created by assigning scores to three constitutional variables (hair colour, eye colour, and skin type or tanning ability) and summing these scores. Natural hair colour at age 20 years was graded visually by the subject against a colour sample chart. The interviewer assessed eye colour by direct inspection against a group of standardized photos of eye colours. Skin type was determined by asking the question: after repeated and prolonged exposure to sunlight, would your skin become (1) only freckled or no suntan at all (skin type I); (2) only mildly tanned due to a tendency to peel (skin type II); (3) moderately tanned (skin type III); (4) very brown and deeply tanned (skin type IV)? A higher index indicates a greater risk due to a more sensitive cutaneous phenotype.

A recreational sun exposure index was created by assigning scores to two recreational sun exposure history variables (number of vacations to places sunnier than the usual residence and number of days spent in outdoor recreational activities per year) and summing the scores for two periods of time (before age 16 and during the last 10 years). A higher score (level) indicates a greater amount of recreational sun exposure. This variable has a dose-response relationship to melanoma consistent with most other studies.\(^ {10}\) Analyses adjusting for the variables of skin colour, hair colour, eye colour, sunny holidays and recreational outdoor activities separately were also performed. Essentially similar results were found as those adjusting for the composite phenotypic and sun exposure indices.

Anatomic site of melanoma was categorized as head and neck, upper limb, lower limb, and trunk. Histologic type of melanoma was standardized by one dermatopathologist as superficial spreading melanoma, nodular melanoma, lentigo maligna melanoma (LMM), and other.

Data analysis

Odds ratios (OR) and 95% confidence intervals (CI) were calculated based on the logistic regression parameters and their standard errors obtained from the logistic regression model. Crude OR and their 95% CI were calculated with adjustment for the composite sex and age since these two factors were frequency matched in the study design. Confounding was assessed by literature review and by comparing the discrepancy between the crude estimate and the adjusted estimate after confounding is removed.\(^ {13}\) Variables examined for confounding included hair colour, eye colour, skin type or tanning ability, cutaneous phenotype index, number of nevi, and recreational sun exposure index. Only cutaneous phenotype and recreational sun exposure index showed a greater discrepancy (more than 10%) between the crude and adjusted OR and were included in the multivariate analysis. Multivariate-adjusted OR and their 95% CI were calculated by including sex, age, the cutaneous phenotype index, and the recreational sun exposure index in the model. Subjects with missing values for any of these variables were excluded from the analysis.

All statistical tests were considered significant at \(P < 0.05\) level. Observations with missing and unknown values were excluded from the analyses. When appropriate, tests for linear trend were performed using the Wald’s chi-square test (the ratio of the estimated coefficient to its standard error obtained from the logistic regression model) for continuous variables.\(^ {14}\)
Results

Case-control comparisons of sunlamp-related variables, including ever use of sunlamps, total number of sunlamp uses, age at first use of sunlamp, type of sunlamp, and number of types of sunlamps used, are presented in Table 1. Among 624 cases and 512 controls, 141 (23%) cases and 95 (19%) controls reported ever using sunlamps. An overall crude OR (adjusted for sex and age) of 1.30 (95% CI: 0.97–1.74) was borderline significant. The OR decreased after further adjusting for the cutaneous phenotype index and the recreational sun exposure index to 1.13 (95% CI: 0.82–1.54). Risk for melanoma was not associated with the total number of times a sunlamp was used. A dose-response relationship between the number of times a sunlamp was used and risk of malignant melanoma was not observed.

After adjusting for total number of sunlamp uses, those who first used sunlamps before the age of 25 had a higher risk for melanoma than those who first used sunlamps later in life (Table 1). Relative to never users, those who first used sunlamps before the age of 25 were more likely to develop melanoma (crude OR 1.58; 95% CI: 1.05–2.39), whereas first use of
sunlamps later in life was not associated with the development of melanoma.

Types of sunlamps were grouped into four categories: desk top, light weight floor models, heavy weight floor models, and room size (Figure 1). Subjects who used more than one type of sunlamp had a more than threefold higher risk of melanoma compared to those who did not use sunlamps (adjusted OR 3.46; 95% CI: 1.32–9.11) (Table 1). There was a significant linear trend between greater number of types of sunlamp used and higher risk of melanoma ($P < 0.001$). Melanoma risk by type of sunlamp was also evaluated among those who reported using only one type of sunlamp. No statistically significant findings were observed, although a higher risk for melanoma seemed to be associated with desk top lamps and heavy weight floor model lamps.

Analyses stratified by gender did not show notable differences in sunlamp-related variables and melanoma risk between males and females (Table 2). Ever use of sunlamps seemed to have a stronger association with melanoma in males than in females. Use of sunlamps $>10$ times in life was associated with higher risk of melanoma in females but not in males. Those who first used sunlamps before the age of 25 showed consistently higher risk for melanoma in both males and females (Table 2).

Case-control comparisons of sunlamp-related variables are presented in Table 3 by location of sunlamp use comparing use at home with use in commercial settings, such as tanning salons, beauty parlours and health spas. Of 236 sunlamp users, 147 (62%) used sunlamps at home, 88 (37%) used sunlamps in commercial settings, and one had no information available on location of sunlamp use. A significant association was observed between sunlamp use at home and melanoma risk. For home users, ever use of sunlamps increased risk of melanoma with crude and adjusted OR of 1.63 (95% CI: 1.12–2.37) and 1.40 (95% CI: 0.97–2.04), respectively. Significantly increased risks of melanoma were also found to be associated with sunlamp use at home $<10$ times and for those who first used sunlamps at home before the age of 25. Sunlamp use in commercial settings was not associated with subsequent development of melanoma.

To evaluate whether first use of sunlamps before a specified year increased the risk of melanoma, case-control OR were
computed for sunlamp-related variables by calendar year at first sunlamp use (before or during 1970 versus after 1970) as presented in Table 4. Year 1970 was selected as the cutpoint for subgroup comparison because roughly half (56%) of the controls started sunlamp use in 1970 or before and because it would allow a reasonable latent period for melanoma development among those who began sunlamp use after 1970.

An increased risk of melanoma was associated with first use of sunlamps in earlier years. For those who first used sunlamps in 1970 or before, ever using sunlamps was associated with crude and adjusted OR of 1.53 (95% CI: 0.98–2.39) and 1.33 (95% CI: 0.84–2.12), respectively. Those who first used sunlamps before the age of 25 were at increased risk for melanoma (adjusted OR 1.62; 95% CI: 0.93–2.81), whereas those who

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**Table 2** Case-control odds ratio (OR) and their 95% confidence intervals (CI) for sunlamp-related variables among 624 malignant melanoma cases and 512 population-based controls by sex, Connecticut, 1987–1989*

<table>
<thead>
<tr>
<th>Sunlamp variables</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever used sunlamp</td>
<td>Cases</td>
<td>Controls</td>
<td>ORc (95% CI)b</td>
<td>ORa (95% CI)c</td>
</tr>
<tr>
<td>No</td>
<td>269</td>
<td>256</td>
<td>1.30 (0.86–1.96)</td>
<td>1.20 (0.78–1.84)</td>
</tr>
<tr>
<td>Yes</td>
<td>68</td>
<td>50</td>
<td>5.0 (2.4–11.4)</td>
<td>4.6 (2.1–10.1)</td>
</tr>
<tr>
<td>Total number of sunlamp uses</td>
<td></td>
<td></td>
<td>1.38 (0.81–2.34)</td>
<td>1.36 (0.79–2.35)</td>
</tr>
<tr>
<td>Linear trend</td>
<td></td>
<td></td>
<td>1.38 (0.81–2.34)</td>
<td>1.36 (0.79–2.35)</td>
</tr>
<tr>
<td>Age at first use of sunlamp</td>
<td></td>
<td></td>
<td>1.38 (0.81–2.34)</td>
<td>1.36 (0.79–2.35)</td>
</tr>
</tbody>
</table>

* Number of cases and controls do not always add up to total due to missing information.

b Crude odds ratio adjusted for sex and age.

c Odds ratio adjusted for sex, age, cutaneous phenotype index, and recreational sun exposure index.

d Crude linear trend adjusted for sex, age, and ever used sunlamp (yes/no). Multivariate-adjusted linear trend adjusted for sex, age, cutaneous phenotype index, recreational sun exposure index, and ever used sunlamp (yes/no).

e Odds ratio adjusted for total number of sunlamp uses, in addition to variables mentioned above.

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**Table 3** Case-control odds ratio (OR) and their 95% confidence intervals (CI) for sunlamp-related variables among 579 malignant melanoma cases and 468 population-based controls by location of sunlamp use, Connecticut, 1987–1989*

<table>
<thead>
<tr>
<th>Sunlamp variables</th>
<th>Home</th>
<th>Commercial Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever used sunlamp</td>
<td>Cases</td>
<td>Controls</td>
</tr>
<tr>
<td>No</td>
<td>483</td>
<td>417</td>
</tr>
<tr>
<td>Yes</td>
<td>96</td>
<td>51</td>
</tr>
<tr>
<td>Total number of sunlamp uses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear trend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at first use of sunlamp</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Number of cases and controls do not always add up to total due to missing information.

b Crude odds ratio adjusted for sex and age.

c Odds ratio adjusted for sex, age, skin susceptibility index, and total recreational sun exposure index.

d Crude linear trend adjusted for sex, age, and ever used sunlamp (yes/no). Multivariate-adjusted linear trend adjusted for sex, age, cutaneous phenotype index, recreational sun exposure index, and ever used sunlamp (yes/no).

e Odds ratio adjusted for total number of sunlamp uses, in addition to variables mentioned above.
first used sunlamps later in life were not. No associations were observed between the first use of sunlamps after 1970 and the development of melanoma (Table 4).

The relationship between sunlamp use and risk of melanoma by anatomic site and histologic type was not significant (data not shown). Sunlamp use seemed to have stronger associations with lentigo maligna melanoma and melanoma of the lower limbs. However, no consistent patterns were found between sunlamp use and melanoma of different anatomic sites and histologic types.

There were significant differences in types of sunlamp used in the home and used commercially before and after 1970 ($P < 0.001$). For subjects who began sunlamp use in 1970 or before, the majority used desk top lamps or lightweight floor models (59%, n = 85) and almost all sunlamp use took place at home. In contrast, for subjects who began sunlamp use after 1970, the majority used the heavyweight floor models or room size lamps (69%, n = 55) and sunlamp use was mostly in commercial settings (74%, n = 59).

Only 8 controls and 11 cases reported ever having been burned from sunlamp use severely enough to require a doctor's attention. Due to the small numbers, no further analyses of the relationship between burns from sunlamps and melanoma were performed.

### Discussion

In the current study, the crude analysis with adjustment for sex and age showed a borderline significant association between sunlamp use and the risk of malignant melanoma. This association was not statistically significant after the adjustment of cutaneous phenotype index and total recreational sun exposure index. A more than threefold higher risk of melanoma was found among those who used more than one type of sunlamp, i.e. who might have experienced excessive exposure to sunlamps, compared to never users.

Subgroup analyses further showed a significant or borderline significant increase in melanoma risk among subjects who used sunlamps at home and among subjects who were first exposed to sunlamps prior to 1971. These observations could be because there are fewer controls on their use at home and because the earlier equipment is less safe in terms of both the type and amount of UV emissions. Similar findings were reported previously. Walter et al. reported significant age-adjusted case-control OR for sunlamp exposure at home, but not in commercial settings. Autier et al. found that those who were first exposed to sunlamps for tanning purposes before 1980 with ≥10 hours exposure had significantly higher risk.

Sunlamp users were different from non-sunlamp users in sun exposure factors ($P < 0.001$) but not in phenotypic factors. Sunlamp users had greater amount of recreational sun exposure compared to non-sunlamp users (total recreational sun exposure index IV 42% versus 27%, $P < 0.001$). It is likely that the observed relationships between sunlamp use and melanoma risk could be explained by the residual confounding of inadequate measurement of sun exposure factors.

The nature of sunlamps has changed over time, from substantial UV-B emitters to predominantly UV-A emitters. Prior to the mid-1970s, sunlamps were generally unfiltered medium or high pressure mercury arc lamps which emitted substantial UV-C and UV-B radiation. Duration of exposure using these lamps was short and frequently overexposure resulted in burns or blistering. These earlier sunlamps were highly portable (desktop or lightweight floor models) and were used primarily at home. In the late 1970s and early 1980s, the development of UV-A fluorescent lamps made tanning with UV-A radiation...
possible. It was thought that a tan induced by UV-A was safer than that induced by UV-B. These more recent UV-A lamps are frequently heavy-weight floor model sunbeds or room size sunlamps which consist of banks of fluorescent tubes and are used mainly at commercial salons and tanning booths.

Because of the association with sunlamp use in the home prior to 1970 that primarily emitted UV-B, it may be tempting to conclude that UV-B and not UV-A is associated with the development of melanoma. However, these data should be interpreted with extreme caution. UV-C was often emitted in the earlier lamps used at home. Melanoma likely has a long latent period. Studies published to date, including the current study, which collected data in the late 1970s and 1980s do not have the power to establish an association between melanoma and the use of sunlamps that emit predominantly UV-A, if one exists, in commercial settings. One recent study has shown that repeated doses of UV-A among those sensitized by the drug Psoralen greatly increases risk of melanoma.

In general, studies of the overall impact of sunlamp use on the subsequent development of melanoma have been inconclusive. Three previous studies in Australia, Canada and Denmark found no association between sunlamp use and the development of melanoma. However, these earlier studies did not collect sufficient information to explore appropriately the relationship between sunlamp use and the risk of melanoma. Significant associations between sunlamp use and melanoma were reported in several more recent studies in Scotland, Canada, Sweden and Belgium, France and Germany. In these studies, the OR for the association between ever used sunlamps and melanoma risk ranged from 1.3 (95% CI: 0.9–1.8) to 2.9 (95% CI: 1.3–6.2). Autier et al. examined the risk of melanoma from ever having been exposed to sunlamps or sunbeds for tanning purposes and reported a crude OR of 1.77 (95% CI: 1.00–3.23). Walter et al. reported sex-specific OR of 1.86 (95% CI: 1.20–2.98) in males and 1.45 (95% CI: 0.99–2.13) in females. Positive dose-response relationships between sunlamp use and melanoma were reported in these four studies. It should be pointed out that Walter’s study did not adjust for the major potential confounder total sun exposure and Swerdlow’s study was based on a relatively small number of subjects who had ever used sunlamps (38 cases and 10 controls).

In the present study, the first use of sunlamps early in life was in general related to an elevated risk of melanoma, especially among those who were exposed to sunlamps at home and prior to 1971. Those who first used sunlamps aged under 25 had a higher risk for melanoma than those who first used sunlamps later in life, even after adjusting for the total number of sunlamp uses. Previous studies have reported higher risk among those who use sunlamps earlier in life or among those diagnosed with melanoma at an earlier age. These findings suggest that first exposure at a younger age may have a greater impact on the subsequent development of melanoma. The observation could also be due to a long latent period between the onset of exposure and the occurrence of melanoma.

Our subgroup analyses did not find an association between sunlamp use and melanoma by anatomic site and histologic type. Other studies have reported elevated age-adjusted OR between sunlamp use and lentigo maligna melanoma histologic type, melanoma of the face/head/neck and arms, and melanoma of the trunk. A number of limitations in the current study might have hampered the evaluation of sunlamp use and melanoma risk. While data were collected on number of sunlamp uses, we did not collect data on average duration of use, which might explain the lack of linear trends between greater total number of sunlamp uses and higher risk for melanoma in the overall and subgroup analyses. Only 59 of our subjects used sunlamps in commercial settings after 1970 which prevented us from adequately addressing the impact of commercial sunlamp use on melanoma risk in the more recent years. Furthermore, since the study population was selected between 1987 and 1989, we could not assess the effects of sunlamp exposure occurring during the past decade. Finally, inherent in subgroup analysis is the fact that multiple comparisons have been made and some associations may have been noted by chance.

Several concerns about sunlamp use that could provide further understanding of the etiology of melanoma could not be addressed in the current study. The relationship between burns due to sunlamp use and melanoma could not be examined, since only information on skin burns that led to doctor’s attention was requested. It would have been particularly interesting to examine this on an anatomic Site specific basis. One previous study reported a strong positive association between burns due to sunlamp use and melanoma.

The biological effects of sunlight and sunlamps on the development of melanoma may be similar. Both emit UV-A and UV-B radiation. Use of sunlamps, similar to exposure to intermittent solar radiation, could be a risk factor for melanoma through unrepaird UV damage, immunologic effects, and oxidative phenomena. Studies on the association between UV radiation exposure and the risk of melanoma are of critical importance, especially as sunlamp use has increased substantially during the past decade at a much younger age. Lifetime UV radiation exposure from all sources—solar or non-solar, of all patterns—cumulative or intermittent, and at any time in life—childhood or adulthood, should be considered simultaneously to elucidate the mechanism by which UV radiation is associated with melanoma. Furthermore, the UV radiation emissions vary substantially according to type of device. For future studies on sunlamp use and melanoma risk, it is crucial that one take into account type of sunlamps, year at first use, and cumulative amount (duration) of sunlamp exposure so that the effect of sunlamp use, UV radiation exposure, and the development of malignant melanoma can be adequately examined.

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References


