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A multicentre epidemiological study on sunbed use and cutaneous melanoma in Europe

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Abstract

A large European case–control study investigated the association between sunbed use and cutaneous melanoma in an adult population aged between 18 and 49 years. Between 1999 and 2001 sun and sunbed exposure was recorded in 597 newly diagnosed melanoma cases and 622 controls in Belgium, France, The Netherlands, Sweden and the UK. Fifty three precent of cases and 57% of controls ever used sunbeds. The overall adjusted odds ratio (OR) associated with ever sunbed use was 0.90 (95% CI: 0.71–1.14). There was a South-to-North gradient with high prevalence of sunbed exposure in Northern Europe and lower prevalence in the South (prevalence of use in France 20%, OR: 1.19 (0.68–2.07) compared to Sweden, prevalence 83%, relative risk 0.62 (0.26–1.46)). Dose and lag-time between first exposure to sunbeds and time of study were not associated with melanoma risk, neither were sunbathing and sunburns (adjusted OR for mean number of weeks spent in sunny climates >14 years: 1.12 (0.88–1.43); adjusted OR for any sunburn >14 years: 1.16 (0.9–1.45)). Host factors such as numbers of naevi and skin type were the strongest risk indicators for melanoma. Public health campaigns have improved knowledge regarding risk of UV-radiation for skin cancers and this may have led to recall and selection biases in both cases and controls in this study. Sunbed exposure has become increasingly prevalent over the last 20 years, especially in Northern Europe but the full impact of this exposure on skin cancers may not become apparent for many years.

Keywords: Melanoma; Case–control study; Sunbed; Sun exposure; Naevus

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1. Introduction

The fashion of using sunbeds to acquire a tan is widespread among fair skinned populations, particularly in Northern Europe where the levels of natural ultraviolet radiation (UVR) are low. Many case–control and latitude studies have shown that exposure to the sun is the major environmental risk factor for cutaneous melanoma [1,2]. As UVR is deemed to represent the part of the solar spectrum involved in the genesis of melanoma, it has been suggested that sunbed use could also contribute to melanoma incidence in Caucasian populations [3].

In the absence of a valid animal model for human melanoma, epidemiological studies are required to provide evidence of an association between sunbed use and melanoma. Many epidemiological case–control studies have explored the relationship between exposure to sunbeds and cutaneous melanoma [4,5]. Only 6 have found a positive association between melanoma and sunbed exposure although the magnitude of the risk was usually low [6–11]. Results are conflicting and a review by Swerdlow [12] concluded that the data on sunbed available in 1998 did not provide conclusive evidence for an association between sunbed use and cutaneous melanoma. Two recent studies have also reported conflicting results with one case–control study not finding an association in the UK, whilst the only cohort study reported a moderate increased risk in melanoma in a large cohort of Norwegian and Swedish women [13,14]. Most studies included melanoma patients of all ages but sunbed use is especially prevalent in younger age groups. The objective of our study was to investigate whether sunbed use represents a risk factor for cutaneous melanoma in Europe in individuals below 50 years of age.

2. Patients and methods

A multi-centre case–control design was carried out in Sweden, the Netherlands, United Kingdom, Belgium and France. In all participating institutions, Local Ethical Committees cleared the study protocol.

2.1. The group of cases

Consecutive melanoma cases aged 18–49 years with histologically proven first primary cutaneous melanoma diagnosed between December 1998 and July 2001 were recruited for the study. Melanoma cases were flagged up via dermatologists, pathologists, plastic surgeons, oncologists and melanoma databases. Patients were excluded if: (a) had a lentigo malignant melanoma or *in situ* melanoma or a secondary melanoma or if the melanoma was not a first primary; (b) was unable to respond or understand the questionnaire (e.g., too sick or mentally impaired); and (c) was non-Caucasian. Five hundred and ninety seven cases were included in the analyses.

The method of recruiting cases varied between countries as follows:

Sweden: 89 cases were recruited. Most cases were seen at the Karolinska Institute in Stockholm. As fewer cases were diagnosed at the Karolinska Institute than expected, cases were also recruited at Uppsala hospital. In the Uppsala area some interviews were also done by telephone, because of long distances. Naevus counts were not performed for cases from the Uppsala area who were unable to visit the hospital.

The Netherlands: 146 cases were recruited. Thirty five percent of cases originated from a tertiary reference centre (the Daniel den Hoed Cancer Center in Rotterdam), the remaining 65% were recruited through general hospitals from South of the Netherlands. To ensure selection of a representative melanoma population, recruitment of cases was monitored using the cancer registry of South of the Netherlands [15].

United Kingdom: 153 cases were recruited via dermatologists, oncologists, plastic surgeons and pathologists located in the Greater London area.

Belgium: 42 cases were recruited from Oncology and Surgery clinics in a teaching hospital in Brussels (Jules Bordet Institute, Brussels) as well as a from a large dermatology clinic in another teaching hospital in Brussels (Erasmus Academic Hospital).

France: 167 cases were recruited from several dermatology clinics and cancer hospitals throughout France (Burgundy, Lille, Thionville, Paris and Bordeaux).

2.2. Selection criteria for controls

In each country, controls were recruited to match age and gender of the cases. Age groups for frequency matching purpose were 18–29, 30–39 and 40–49 years old.

Exclusion criteria for the controls were: (a) a history of skin cancer; (b) unable to directly respond to questionnaires; and (c) non-Caucasian. A total of 622 controls eligible for the study were included in the analyses.

The recruitment of controls followed three procedures, varying between countries:

(i) random selection of controls from population registries; (ii) recruitment from general practices which matched the geographical areas of the controls; and (iii) door-to-door search (“neighbourhood controls”). The latter method was successfully used in a previous study of melanoma in Belgium, France and Germany [10,16].

Recruitment of controls for each country was done as follows:

Sweden: 91 controls were derived from a random sample of population registries. A letter was sent to

potential controls asking for participation. In the Uppsala area, some interviews were done by telephone because of long distances.

The Netherlands: 167 controls were recruited. Most controls were derived from the same GP practices as the cases that matched the geographical area of the cases. Additionally, about 40 cases were obtained from other GP-practices and an advertisement in a regional newspaper resulted in the recruitment of another 25 controls.

United Kingdom: 161 controls were derived from lists of patients attending GPs within the Greater London area, which matched the geographical area of the cases.

Belgium and France: controls were recruited using the door-to-door search (Belgium: 40 controls, France: 163 controls).

2.3. Interviews

Trained professional interviewers conducted all interviews. Interviewers were trained to provide a standard application of the questionnaires and to minimise interview bias, *i.e.* had to apply the questionnaires in the same manner to both cases and controls and interviews had to take place outside the hospital or doctor's office setting as much as possible.

As the melanoma excision was often visible when examining the skin and details were collected regarding the location and date of diagnosis of the tumour, blinding of the case/control status was not possible.

During the interview, the interviewer performed a naevus count of naevi larger than 2 mm on both arms in both cases and controls. However, for 34 subjects in Sweden recruited from Uppsalla for whom the interview was conducted by phone there was no naevus count data collected.

2.4. Questionnaires

Standard questionnaires were devised using past experiences of epidemiological studies of melanoma in Europe [8,10,17]. They were tested before the start of the study in a subset of cases and controls in Belgium and France. Questionnaires were translated and tested before use.

Questions were asked on skin type (reaction of the skin to the sun in early summer according to Fitzpatrick classification), sunburn experiences and family history of melanoma. More detailed questions were asked on sun exposure (number of weeks of holidays spent in sunny climates and sunbathing habits, time of exposure, duration, body sites exposure and time spent living in (sub) tropical countries) and sun protective behaviours (clothing habits, seeking the shade and sunscreen use).

Sunbed use was first recorded as "ever used sunbed in a lifetime" and was divided in two age groups (<15 years of age and ⩾15 years of age). Cases and controls were asked to recollect each episode of sunbed exposure in terms of type of device used. Twelve photographs were shown to assist subjects in the selection of sunbed devices. These pictures comprised mercury lamps, which were popular in Northern Europe in the 1940s and 1950s, but also various portable ultraviolet units, which generally displayed three to six short fluorescent lamps of only high-pressure UV lamps for tanning of the face only. Tanning units for the whole body were also shown: medium size horizontal sunbeds with 8–12 fluorescent lamps installed on a single panel unit or large horizontal double-panel UV units comprising more than 12 fluorescent lamps with or without high-pressure UV lamps for the face or high pressure units for the whole body as well as vertical units.

For each episode, the following was also recorded: location of use (gym, beauty parlour, hairdresser, hospital or home), numbers of sessions, duration (in minutes) of each session and the year of start and end for each episode. Potential side effects of sunbed use such as redness, itching or severe sunburn was also recorded.

2.5. Statistical analysis

Statistical analyses followed standard procedures for analysis of case–control data, using the odds ratio (OR) as estimate of the relative risk. All analyses were done using unconditional logistic regression methods. ORs and 95% confidence intervals (95% CI) were derived from these models [18]. When not specified, adjustment of melanoma risk was done for age, sex, skin type (4 groups according to the Fitzpatrick classification) [19], sunburns before and after the age of 15, hair colour (3 categories) and the average number of holiday weeks spent in sunny areas after the age of 15 years. All P values were two-sided. When the data had a non-Gaussian distribution, descriptive statistics used the median and the interquartile range. χ^2 tests for trend were based on the deviance obtained from the likelihood ratio and one degree of freedom. Trend tests did not include a separate intercept parameter for level zero and were based on the linear scoring for the groups shown in tables.

3. Results

Five hundred and ninety seven melanoma cases and 622 controls with a mean age of 38 and 37 years, respectively, were included for analysis. An excess of females (63%) was seen in cases from all countries.

The most frequent histological subtype was superficial spreading melanoma (77%) followed by nodular melanoma (14%) with the remaining 10% belonging to other histological subtypes. The mean Breslow thickness was 1.48 mm (median: 0.90 mm). Thinner melanomas

were observed in Sweden (mean 1.2 mm) and the UK (mean 1.3 mm) compared to other countries (France 1.7 mm and the Netherlands 1.6 mm) but this was attributed to different referral patterns. In Belgium, data on Breslow thickness were not available.

Fair skin and hair were more frequent amongst cases with adjusted OR of 2.30 (95% CI 1.82–2.90) for fair hair (red or blond) compared to dark hair (brown or black). Sunburn history during childhood and adulthood was associated with an increased melanoma risk, but this association disappeared after adjusting for age, sex and skin type (Table 1). The adjusted OR for melanoma associated with the mean number of weeks spent in sunny climates after the age of 14 years was 1.12 (95% CI 0.88–1.43). A family history of melanoma in first or second-degree relatives yielded an OR for melanoma of 1.52 (95% CI 0.91–2.26). The association between melanoma risk and high numbers of naevi was confirmed with a highly significant trend in risk of melanoma with increasing numbers of naevi on both arms (adjusted χ^2 test for trend 18.7, $P < 0.0001$) (Table 1). This remained highly significant after adjusting for age sex and skin type. Further adjustment for sunbed use, weeks of holiday abroad and country of origin did not affect the results (data not shown). No association was found between sunbed use and mean numbers of naevi (data not shown).

Fifty three percent of cases and 57% of controls reported at least one sunbed use (Table 2). Use of sunbeds was reported by 61% and 34% of female and male cases, respectively. For controls, 61% of females ever used sunbeds, compared to 49% of males. The lower prevalence of sunbed use in males compared to females was observed in all participating countries except France. Mean age of sunbed users was 37 years compared to 39 years in non-users and this did not reach statistical significance. Prevalence of sunbed use was more common in skin type 2 and 3 (57% and 64%, respectively) compared to skin type 1 (42%) and skin type 4 (49%). These differences in sunbed use between skin types were similar when cases and controls were analysed separately. The OR for melanoma associated with ever use of sunbeds was 0.90 (95% CI 0.71–1.14). Further adjustment for sunburn before and after 15 years of age and number of weeks of holiday

Table 1
Characteristics of cases and controls included in the study

	Cases $n = 597$ (%)	Controls $n = 622$ (%)	Crude OR	95% CI		Adj. OR[b]	95% CI	
Age								
Mean	38	37	1.01	1.00	1.02	1.02	1.00	1.03
Standard deviation	7.8	7.8						
Sex								
Female	378 (63)	408 (66)						
Male	219 (37)	214 (34)	1.10	0.87	1.38	1.20	0.94	1.52
Skin type								
IV (good tanner)	61 (10)	118 (19)	1.00 (ref.)	–	–	1.00 (ref.)	–	–
III	194 (32)	273 (44)	1.42	1.00	2.02	1.26	0.88	1.82
II	245 (41)	171 (27)	2.78	1.95	3.97	2.22	1.51	3.28
I (never tan)	97 (16)	60 (10)	3.05	1.98	4.71	2.36	1.49	3.74
Haircolour[a]								
Dark	122 (20)	183 (30)	1.00 (ref.)	–	–	1.00 (ref.)	–	–
Medium	283 (47)	324 (52)	1.29	0.98	1.69	1.21	0.92	1.60
Red or blond	191 (33)	115 (18)	2.45	1.78	3.36	1.97	1.40	2.76
Naevi count (arms)								
0–9	160 (28)	327 (55)	1.00 (ref.)			1.00 (ref.)		
10–19	131 (23)	126 (21)	2.12	1.56	2.89	2.15	1.60	2.95
20–49	187 (33)	110 (19)	3.47	2.57	4.70	3.50	2.60	4.79
$\geqslant 50$	88 (16)	27 (5)	6.66	4.16	10.67	6.50	4.00	10.58
Sunburn before age 15								
No	308 (52)	375 (61)						
Yes	289 (48)	247 (39)	1.42	1.13	1.79	1.20	0.95	1.54
Sunburn after age 14								
No	174 (30)	230 (37)						
Yes	423 (71)	392 (63)	1.43	1.12	1.81	1.16	0.90	1.49
Familial history of melanoma								
No	546 (91)	586 (94)						
Yes	51 (9)	36 (6)	1.52	0.97	2.36	1.44	0.91	2.26

[a] Dark (black or dark brown), medium (clear brown or auburn), red or blond (red or blond).
[b] ORs adjusted for age sex and skin type apart for age and sex which were adjusted for skin type and sex and skin type and age, respectively.

Table 2
Ever sunbed use and risk of cutaneous melanoma according to country

Country	Ever sunbed use after 14 years old	Cases		Controls		Crude OR	95% CI		Adj. OR[a]	95% CI	
		($n = 597$)	%	($n = 622$)	%						
Sweden	No	18	20	12	13	1.00 (ref.)			1.00 (ref.)		
	Yes	71	80	79	87	0.60	0.27	1.33	0.62	0.26	1.46
The Netherlands	No	40	27	35	21	1.00 (ref.)			1.00 (ref.)		
	Yes	106	73	132	79	0.70	0.42	1.18	0.86	0.49	1.51
UK	No	79	52	74	46	1.00 (ref.)			1.00 (ref.)		
	Yes	74	48	87	56	0.79	0.51	1.24	0.89	0.56	1.41
Belgium	No	14	33	15	38	1.00 (ref.)			1.00 (ref.)		
	Yes	28	67	25	62	1.20	0.48	2.97	1.11	0.41	2.99
France	No	131	78	132	81	1.00 (ref.)			1.00 (ref.)		
	Yes	36	22	31	19	1.17	0.68	2.00	1.19	0.68	2.07
All	No	282	47	268	43	1.00 (ref.)			1.00 (ref.)		
	Yes	315	53	354	57	0.84	0.67	1.06	0.90	0.71	1.14

[a] Adjusted for age, sex and skin type.

in sunny climates did not affect the results (data not shown). Restricting the analysis to subjects with skin type I/II, or red/blond hair did not change the results. When melanoma risk was examined by gender, most of the apparent protective effect of sunbeds was found in males with an adjusted OR of 0.63 (95% CI 0.43–0.92, $P = 0.02$) compared to 1.01 (95% CI 0.76–1.35, $P = 0.9$) in females. There was a sharp North-to-South gradient regarding the prevalence of sunbed use: in Sweden 87% of controls ever used sunbeds, compared to 19% in France (Table 2). Similar differences were observed in cases. Country of origin did not significantly affect the risk of melanoma in relation to sunbed use as country or origin did not affect the odds ratios for melanoma in the multivariate analyses (Table 2).

Cumulative sunbed use (hours of exposure) was calculated for each subject from birth to interview. Fourteen percent of cases and 15% of controls reported a cumulative sunbed use of >30 h (Table 3). A dose–response relationship could not be shown between hours of exposure and melanoma risk (Table 3). Of note is that the proportions of cases and control subjects in each stratum of cumulative sunbed use follow a similar pattern in both groups. Mean age at time of first use was 24 years and mean age at last use of sunbed was 32 years with the mean number of years between last use and diagnosis of melanoma of 5 years. Time since first use of sunbed was also calculated, being more or equal to 15 years before the interview in 18% of the cases and controls. This time lag was not associated with melanoma risk (Table 3). As for the prevalence of sunbed use, numbers of hours of exposure and lag time since first use increased from South-to-North within Europe (data not shown). The lag time in years between last use of sunbed and melanoma diagnosis did not affect melanoma risk either.

Median duration of exposure over a lifetime varied greatly between countries and amongst skin types (Table 4). Sweden and the Netherlands showed the highest cumulative exposure to sunbeds. A trend was observed with greater exposure to sunbeds in individuals with darker skin types in both cases and controls ($P = 0.001$) (Table 4). The prevalence of sunbed use measured as cumulative hours of exposure over a lifetime was slightly greater amongst females compared to males in cases and controls (Table 4). After adjusting for age and sex, no effect of sunbed use on Breslow thickness was found amongst cases.

Overall, 4% of cases and 2% of controls reported sunbed use before the age of 15, but for Sweden this was reported in 16% and 9% of the cases and controls, respectively. Use of sunbed before the age of 15 was associated with an OR of 1.82 (0.92–3.62) after adjustment for age, sex and skin type (Table 3). There was a very strong association between sunbed use before the age of 15 and total number of hours of sunbed use: the median hours of total lifetime hours of sunbed use was 34 h in those using sunbeds below the age of 15 years compared to 9 h in those using it only after the age of 15 years. This strong association between early use (before age 15) and long-term use was seen in all countries.

Amongst sunbed-users, 40% of use occurred at home in cases compared to 38% in controls. Use in beauty parlours or the gym was reported in 53% and 50% of case users and control users respectively. Location of sunbed use did not affect the risk of melanoma as patterns of use were comparable between cases and controls (data not shown). Use of sunbeds at home was most common amongst Dutch controls: more than 70% compared to 48% in the UK, 24% in France, 23% in Sweden, and 20% in Belgium. Type of sunbed devices used differed significantly according to place of exposure whether at

Table 3
Lifetime sunbed use and risk of cutaneous melanoma

	Cases	Controls	Crude OR	95% CI		Adj. OR*	95% CI	
	($n = 597$) (%)	($n = 622$) (%)						
Ever sunbed use	315 (53)	354 (57)	0.84	0.67	1.06	0.90	0.71	1.14
Ever sunbed use before age 15	23 (4)	14 (2)	1.74	0.89	3.42	1.82	0.92	3.62
Cumutative lifetime sunbed use (in hours)								
0	282 (48)	268 (44)	1.00**			1.00***		
<10	163 (28)	168 (28)	0.92	0.70	1.21	0.95	0.71	1.25
10–30	56 (10)	76 (13)	0.70	0.48	1.03	0.75	0.50	1.11
31–60	25 (4)	37 (6)	0.64	0.38	1.09	0.75	0.43	1.30
61–100	17 (3)	17 (3)	0.95	0.47	1.89	1.10	0.55	2.24
>100	40 (7)	38 (6)	1.00	0.62	1.60	1.19	0.73	1.93
Time (in years) between first sunbed use and interviews								
0	282 (47)	268 (43)	1.00****			1.00*****		
<6	44 (7)	58 (9)	0.80	0.52	1.24	0.91	0.58	1.42
6–10	79 (13)	81 (13)	0.94	0.66	1.34	1.01	0.70	1.45
11–14	82 (14)	101 (16)	0.78	0.56	1.09	0.81	0.81	1.15
⩾15	109 (18)	114 (18)	0.92	0.68	1.26	0.97	0.70	1.34

Data for cumulative used and lag time was available for sunbed users only and was missing for one sunbed user regarding lagtime and for 32 sunbed users for cumulative use.

* Adjusted for age, sex, skin phototype.

** Test for trend $P = 0.74$

*** Test for trend $P = 0.37$.

**** Test for trend $P = 0.56$.

***** Test for trend $P = 0.79$.

Table 4
Relationship between cumulative hours of exposure to sunbed over a lifetime with skin type, country and gender

	Median number of hours of exposure over a lifetime	
	Cases	Controls
Country		
France	2.2	2.3
England	3.7	3.0
Belgium	6.7	7.5
Netherlands	19.2	22.5
Sweden	20.0	18.4
Skin type		
I	5	6
II	7	5
III	10	17
IV	16	10
Gender		
Males	7.6	7.5
Females	8.5	11.3

home or outside home (beauty parlours or gyms). Small or medium size UV units were used by 85% of controls who used sunbeds at home, whereas 88% of controls using sunbeds outside home reported using large double-panel UV units. Type of devices used did not affect melanoma risk (results not shown). Sunbed use for tanning purposes was reported by 198 cases (32%) and 229 controls (35%) (Adjusted OR: 0.85; 95% CI: 0.65–1.12). Sunbed use for reasons other than to get a tan was reported by 127 (20%) cases and 134 (21%) controls (Adjusted OR: 0.86; 95% CI: 0.64–1.17). Reporting of itching, redness or severe sunburn following sunbed use was not associated with melanoma risk (data not shown).

Sunbed use affected sites of melanoma in women with a shift towards more melanomas on the trunk and less on the legs compared to non-users ($P < 0.003$). No differences were observed when comparing male users and non-users.

4. Discussion

The prevalence of sunbed exposure in cases and controls in this study were the highest ever reported. More than 70% of controls in Sweden and the Netherlands used sunbeds in contrast to around 20% in France. UK stood in the middle with a prevalence of use around 50%. The cumulative duration of sunbed exposure was also very high with 14% of subjects being exposed to 30 h or more. A typical annual programme proposed by many tanning parlours comprises 12–20 sessions of 20 min, *i.e.* 4–6 h per year. Thus, a cumulative exposure of 30 h would correspond to "UV-tanning" programmes repeated over 6–9 years. Previous studies have reported similar high prevalence of sunbed use in young adults in countries like Sweden [20]. The pronounced North-to-South gradient in the prevalence of sunbed use observed

in our study has previously been reported by other groups [10]. Our study also found a significant proportion of subjects using sunbeds in childhood, especially in Sweden, where the overall prevalence of sunbed use was over 80%.

Our study confirmed the expected associations between melanoma and fair skin, positive family history and numbers of naevi but did not find a significant association with exposure to the sun and/or sunbeds. Before discussing these results further, limitations of the studies need to be considered.

Within a multi-centre case–control study in five European countries with different health care systems and UV-awareness, it proved difficult to implement a standardized method in terms of recruitment of cases and controls. When a population-based cancer registry was not available, recruitment of cases had to be done from oncology/dermatology and plastic surgery clinics as well as pathology departments. As expected, cancer centres and tertiary referral clinics tended to recruit more advanced melanoma cases, compared with dermatology clinics. However, overall histological subtypes of melanoma, mean thickness and male to female ratio reflected population-based data in Europe so it is unlikely that this has affected the results.

We found no association between melanoma and risk factors related to UV exposure such as sunbed use, sunbathing or number of weeks of holidays in sunny areas, in contrast to previous European studies [16,21,22]. For information on these risk factors, we relied on self-reported measures of sun and sunbed exposure, which are amenable to recall bias and possibly selection bias.

Recall bias could lead to under-reporting of sun and sunbed exposure by cases. There are some support for this: a sub-study based on the Dutch participants of this case–control study suggests the presence of recall bias [23,24]. In a study of melanoma in twins, recall bias (under-reporting) was influenced by prior knowledge that sunbathing was a risk factor for melanoma [25]. In Sweden, possible under-reporting of sunbed use and sunbed-induced sunburns was reported [20]. Behavioural scientists have shown that reported sun exposure and sun protection habits rarely corresponded to actual behaviours [1,26,27]. It is clear that collecting reliable information on sun and sunbed exposure is very difficult at a time of intense awareness of the dangers of sun exposure which may lead to feelings of guilt.

Selection bias may also have been an issue in controls. Overall, sunbed use was slightly more common in controls than cases, especially in males. Subjects may have self-selected on the basis of their exposure to sunbeds when they were informed that the study looked at the role of ultraviolet radiation in melanoma and provided a skin examination. Sunbed use in similar areas in previous studies was indeed much less prevalent than in our study, supporting a potential self-selection of controls on the basis of past sunbed exposure [23].

We also studied the effect of risk factors that were not related to behaviour and were not self-reported such as hair colour and naevus counts. These should not be affected by recall bias but could have been affected by selection bias. The melanoma risks associated with these risk factors were consistent with previously published studies in Europe so a significant recruitment bias on the basis of having a skin phenotype at risk of skin cancer in controls is unlikely [17,28].

In examining potential biases, we cannot rule out the possibility that cases may have over-reported their previous exposure to sunbeds as a way to explain their cancer, whilst controls may have a poorer recall than controls as they are less interested and focused on their past exposure, although known risk behaviours for disease (smoking, alcohol use, energy intake) are usually under-reported by cases [29–31].

The North-to-South increase in risk of melanoma with sunbed use (although non-significant) observed in our study, parallels an inverse South-to-North increase in sunbed use, with highest prevalence of use in the North (Table 2). If sunbed use would have had a significant impact on melanoma risk, this association should have been especially observed in Nordic populations that have the highest prevalence and longest history of sunbed use in Europe. The observed decrease in risk with increasing use suggests either a protective effect or could be explained by recall bias with cases under-reporting their true exposure. Recently, a large prospective cohort study investigating sunbed use and melanoma risk reported a modest but significant increased risk for melanoma after sunbed use in Sweden and Norway (relative risk $= 1.55$ for using sunbeds $\geqslant$ once a month in females aged 10–39 years) [13]. The mean age at diagnosis of melanoma in the Veirod study above was slightly older than in our study and this may explain the differences in risk and exposure.

The relationship between UVR and melanoma is very complex and, despite many studies on the topic, remains a controversial issue. Some patterns of sun exposure may also offer protection, as some studies have suggested that people with heavy occupational exposure to the sun exhibit a lower risk for melanoma compared to individuals with intermittent sun exposure [32].

In conclusion, sunbed and sun exposure were not found to be significant risk factors for melanoma in this case–control study performed in five European countries. The results could, however, be affected by recall bias and self selection in controls. The deleterious effect of frequent sunbed use, however, remains an issue which is not yet fully answered. In terms of skin ageing and non-melanoma skin cancers, regular sunbed use is harmful with significant morbidity and health

costs. Regulations for sunbed use seem to be too lax in most countries or are not enforceable, partly because a large part of the exposure takes place at home and sunbed parlours have a conflict of interest in advising potential customers. Children or individuals with very fair skin, freckles, many naevi and/or family history of skin cancers should be discouraged by sunbed parlours from using sunbeds. The prevalence of sunbed use and type of sunbed devices have changed dramatically over the last 20 years [33]. The increase in sunbed exposure at younger ages with more potent devices could lead to an increase in melanoma risk in the next 10–20 years and data will need to be collected to fully assess this risk.

Conflict of interest statement

None declared.

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