RESEARCH ARTICLE

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The Risk of Melanoma due to Exposure to Sun and Solarium Use in Poland: A Large-Scale, Hospital Based Case - Control Study

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Abstract

Objective: The incidence of skin cancer is constantly growing, it is considered a serious problem of public health. Most cases of skin cancer are caused by a combination of non-modifiable genetic, and modifiable environmental risk factors. The study objective was to analyse the correlation between pigmentation traits, excessive sunlight exposure, solarium use and the risk of melanoma development. **Methods:** The study included 480 patients diagnosed with melanoma and 400 within the control group. Subjects diagnosed with the melanoma confirmed by histopathology were invited to take part in the study. The research was based on a clinical, direct, individual, structured, in-depth and focused interview. **Results:** The mean age of the study subjects was 44.3 ± 7.86, while in the control group 59.5 (7.93) Most frequently, melanoma was located on the upper extremities (64%). A family history of neoplastic diseases was found in 55% of the patients. The assessment of sunburns showed that only 15% of the respondents never experienced sunburn, 49% of the study subjects never used solarium. Among patients with multiple sunburns, the risk of developing skin cancer was 1.27 (AOR = 1,27; 95% CI, 1.07-1.55) compared with non-sunburns subjects. **Conclusions:** Risky behaviours including excessive exposure to UV radiation, both natural and artificial, are of special significance in women with fair complexion and fair hair. Indoor tanning is a probable factor of increased skin cancer incidence in younger women, as compared to men.

Keywords: melanoma- sun exposure- solarium

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Introduction

The incidence of skin cancer is constantly growing, both in Europe and in the United States, and although most cases of skin cancer may be prevented, it is considered a serious problem of public health. Skin cancer is one of the most active types of cancer in the present decade (Watson et al., 2016; Dildar et al., 2021). It is generally classified into two major categories: melanoma and nonmelanoma skin cancer (Elgamal, 2013). Basal cell carcinoma and squamous cell carcinoma are definitely the most common of all types of cancer, but it is melanoma which causes most of the skin cancer deaths. Melanoma is a hazardous, rare, and deadly type of skin cancer (Ashraf et al.,2020). According to statistics from the American Cancer Society, melanoma skin cancer cases are only 1% of total cases, but they result in a higher death rate (Am. Cancer Soc. Available , 2023). In the United States, about 5.4 million cases of basal and squamous cell skin cancers are diagnosed each year, while melanoma, according to the national statistics of cancer incidence, is one of ten most common invasive cancers, both in men and women (Watson et al., 2016; American Cancer Society, 2020; Cancer Statistics Center, 2020; International Agency for Research on Cancer, 2020). In Poland, 7,025 cases of skin cancer were recorded in women and 6,453 in men in 2017. In the same year, 1,989 cases of skin melanoma were recorded in women, and 1,796 in men (Rutkowski et al.,

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2017; National Cancer Registry, 2021; Polish Oncology Union, 2021; Dana, 2017). The American Cancer Society's estimates for 2021 are 106,110 new cases, including 62,260 cases in men and 43,850 in women, while the World Health Organization predicts a significant increase in the incidence of skin cancers in 2020-2040, i.e. by 13% in Europe and by 35% in the United States (American Cancer Society, 2020; International Agency for Research on Cancer, 2020).

Most cases of skin cancer are caused by a combination of non-modifiable genetic, and modifiable environmental risk factors. Strong genetic risk factors for skin cancer include pigmentation traits, such as fair skin tone, light eyes, blond or red hair, skin sensitivity to sunburn and tanning ability, and number of moles (Watson et al., 2016). Sunlight is the most common environmental factor affecting skin, and its harmful effects are primarily related to ultraviolet (UV) radiation (Postrzech et al., 2010). Long-term, excessive sunlight exposure often leads to early adverse effects, such as erythema or sunburn, and to late symptoms involving accelerated skin aging, or even sunlight-induced carcinogenesis. Periodic exposure and sunburns, which are an indicator of periodic exposure, have been shown to be risk factors for pigmented and non-pigmented skin cancers, including melanoma (Batycka-Baran et al., 2012; Stawczyk et al., 2011). As a result of UV radiation, DNA of epidermal cells is damaged via formation of pyrimidine dimers. Accumulation of DNA damage caused by UV rays has a complex mutagenic effect: on one hand, it impairs pathways leading to apoptosis of damaged cells, and on the other hand it promotes proliferation of altered, immature cells (Kciuk et al., 2020; Rastogi et al.,2010). Although exposure to the sun's UV radiation is the major established environmental risk factor for skin cancer, this correlation is complex. Studies suggest that the risk of cancer is higher with excessive exposure to sunlight during childhood, which is a sensitive period. Also, the risk increases with a growing number of sunburns in all life stages (Wolnicka-Głubisz et al., 2007; Bień, 2005; Jen et al., 2009; Lesiak et al., 2009). There is growing evidence that solarium use is associated with an increased risk of skin cancer at any age, with the strongest evidence for exposure before 35 years of age (Dessinioti et al.,2022; Schulman et al.,2009). The doses of radiation emitted by sun lamps are much higher than those acquired by skin during sun exposure, which may impair the body's defence mechanisms. Scientific research on the effect of artificial sources of UV radiation on the development of skin cancers have shown that more frequent and longer solarium use increases the risk of melanoma and squamous cell carcinoma (D'Orazio et al.,2013). As a result of numerous studies, the International Agency for Research on Cancer classified the radiation emitted by sun lamps as a carcinogenic factor for skin cancer, alongside other carcinogens, such as arsenic compounds, coal tar and soot (Stawczyk et al., 2011; Bień, 2005; Jen et al., 2009; Lesiak et al., 2009).

It is very worrying that young people, easily influenced by the image created by mass media presenting tanned skin as trendy and attractive, use solarium and are subject to excessive sun exposure. Both in the United States and in Europe, young adults show the highest rate of solarium use, estimated to be about 20-40% (Stawczyk et al., 2011). The risk assessment of skin cancer related to solarium use and excessive sunlight exposure in young subjects is important for public health, since such risky behaviours are becoming more and more common in developed countries, and the incidence of skin cancer is still on the rise (Watson et al., 2016).

Objective of the work

The study objective was to analyse the correlation between pigmentation traits, excessive sunlight exposure, solarium use and the risk of melanoma development. Our hypothesis is that among the risk factors for cancer in general, there are those specific to melanoma. Knowledge of these factors can influence targeted preventive actions.

Materials and Methods

Study design

A Large-Scale, Hospital Based Case–Control Study conducted among patients of the Cancer Center of the Provincial Hospital in Rzeszow. Patients diagnosed with histopathologically confirmed melanoma were invited to participate in the study. Patients in the control group without a diagnosis of melanoma were invited to participate in the study. The research was conducted in the Provincial Hospital of the Podkarpackie Province. The period of recruitment and research with data collection took place in 2019 and 2020. Due to the small sample size, the proportion of patients with fairly consistent characteristics was important. The predictors are age, gender, education, residence. Patients were given the opportunity to participate in a face-to-face interview or online interview. In our study, all patients chose direct contact.

Eligible patients received an information pack from the research group. The information package consisted of a letter describing the objectives of the study and its course, a consent form to participate in the study, which should be completed if patients are interested in the study, and a refusal sheet. After providing informed consent, the patient chose to participate in a face-to-face interview conducted in the clinic by an interviewer who was a member of the research group. The interview lasted approximately 40 minutes. The interview in the case of patient fatigue was divided into parts.

Participant recruitment, inclusion and exclusion criteria

All types of histopathologically confirmed melanoma cases, regardless of their stage, were included in the study. The main indicators of participation in the study were the diagnosis of cancer at least three months before the study, age over 18 (adult patients) and awareness of the diagnosis. The study excluded patients who did not want to participate in the study, who were subject to palliative care, and also if the diagnosis of skin cancer was shorter than three months, because the initial period of diagnosis and treatment is associated with a psychological burden, which could possibly introduce errors in the results. Patients who were too physically ill, too emotionally stressed, under the

age of 18 or unable to read Polish were also excluded. Patients without the cancer diagnosis were selected for control group. They were patients of the internal medicine ward of the Provincial Hospital. There was one control per one case. All patients recruited for the research, who agreed to participate in the study, took part in it. No one withdrew during the study.

Sample

The study included 480 patients diagnosed with melanoma and 400 within the control group. The average age of the patients was 44.37 ± 8.86 years, the control group 59.5 (7.93).

Questionnaire for the Patient

The study method was a direct, individual, structured clinical interview. The quality survey questionnaire was a standardised measurement tool, which was verified by testing a group of 30 patients within a month. The questionnaire included open-ended, single-choice or multiple-choice questions, which provided information on demographic and epidemiological factors, lifestyle and risky behaviours, as well as risk factors. The patients defined their natural hair colour (dark brown/black, brown, blond/yellow or red), eye colour (brown, grey-green or blue). The participants also recorded how their skin reacted to intense and prolonged exposure to the sun. They described their history of UV radiation exposure when they were 10–19, 20–29, 30–39 and 40–49 years old. For each age category, the patient was asked to specify how many times a year their skin was so sunburnt that it caused pain or blisters, and the average time of using solarium or a tanning lamp producing artificial UV light.

Ethical considerations

The study was approved by the Ethics Committee at the University of Rzeszów (Resolution No. 1/12/2019). Participation in the study was voluntary and the respondents were informed of their right to refuse or withdraw from the study at any time. Each participant was informed about the study objective and the time of study termination.

Data analysis

Data analysis was performed with the SPSS statistical package version 15.0 for Windows.

Descriptive analysis, bivariate, and multivariate logistic regression models were carried out. The adjusted odds ratio (AOR) was used to determine the association between the dependent variable and independent variables with a statistically significant level at a 95% confidence interval (CI). The data were tested for the distribution and the homogeneity of variance was validated before applying the parameter tests. Comparison of quantitative variables between groups was performed using ANOVA / Kruskal-Wallis Test. Quantitative comparison of the variables between the groups was done using the unpaired t / Mann-Whitney test. The comparison of qualitative variables between the groups was performed using the exact Chi-square / Fisher test. Statistical significance was used at the conventional 5% level ($p < 0.05$).

It was assumed that only interviews with complete data would be analysed - otherwise, they would be excluded. During the analysis of the collected data, no interview cards were excluded, as all elements of the interview cards were filled out properly. The reason for this is that the interviews were conducted by the members of the research group who participated in the research team from the very beginning.

Results

Demographics data

The study included 480 patients diagnosed with melanoma and 400 within the control group. The mean age of the patients was 44.3 ± 7.86 years, while in the control group 59.5 (7.93). Most frequently, melanoma was located on the upper extremities (64%), head (16%), trunk (10%), lower extremities (8%), and neck (2%). A family history of neoplastic diseases was found in 48% of the patients. The incidence of skin cancer correlated with both sex ($p < 0.0001$) and occupation ($p < 0.0001$). Multivariate logistic regression showed that the overall incidence of skin cancer was significantly higher in women (AOR = 1.78; 95% CI: 1.36; 2.85) and in the farmer profession (AOR = 02.69; 95% CI: 2.39- 3.08) compared with the corresponding groups. Other descriptive statistics identifying the study group are shown in Table 1, Table 2.

Pigmentation traits

An important element of the analysis was the assessment of the patients' pigmentation traits. Dark brown or black hair colour was observed in 25%, brown in 24%, blond in 33%, and red in 18% of the study subjects. Brown eye colour was found in 28%, grey-green in 15% and blue in 57% of the patients. The respondents also defined their skin reaction to intense sun exposure, with the most common reaction being red skin (53%), while 21% of the patients stated that their skin never turned brown as a result of regular and long-term sun exposure. The highest number of asymmetrical moles larger than 5 mm was observed on lower extremities (58%) and upper extremities (21%). One or two moles occurred in 39% of the patients. The percentage of subjects with one or more large, asymmetrical moles was higher in women (32%) than in men (18%) and higher among inhabitants of rural areas. The percentage of subjects with one or more large, asymmetrical moles was the highest among red and blond haired patients, both in women (34%), and in men (31%), and among blue-eyed females (43%) (Table 3). Thus, there was a correlation between hair colour and the risk of skin cancer. The risk was higher in women with blond and red hair, as compared with dark brown or black haired women. The risk was also increasing with higher skin sensitivity both to acute and chronic exposure to the sun ($p < 0.001$). Among fair-skinned subjects with acute and chronic exposure to the sun subjects, the risk of developing skin cancer was 1.56 (AOR = 1,56; 95% CI, 1.07-1.57) compared with non-acute and chronic exposure subjects. A strong positive correlation was observed between the number of asymmetrical moles larger than 5 mm and the risk of melanoma ($p < 0.001$). Eye colour was not

Table 1. Descriptive Statistics of the Examined Group of Patiens

Demographic Information	Cases (n=480)	Control group (n=400)	OR (95% Cl)	P
Characteristics % (N)				
Sex				
Women	54% (259)	88% (352)	1.78 (1.36-2.85)	0.01
Men	46% (221)	12% (48)	1.27 (1.07-1.51)	
The age of the study group				
SD	44.3 (7.86)	57,5 (7,83)	-	-
95%CI	<26; 65>	<35; 85>	-	
Place of residence				
City	42% (202)	36% (144)	1.01 (0.76-1.34)	0.19
Village	58% (278)	64% (256)	1.03 (0.77-1.37)	
Financial situation				
Very good	15% (72)	20% (80)	1.02 (0.66-1.24)	0.41
Good	44% (211)	51% (204)	1.03 (0.71-1.27)	
Average	30% (144)	20% (80)	1.07 (0.65-1.30)	
Bad	11% (53)	9% (36)	1.04 (0.88-1.43)	
Age groups				
18 - 29	15% (72)	12% (96)	1.01 (0.76-1.34)	0.71
30-40	35% (168)	22% (88)	1.03 (0.77-1.37)	
41-50	27% (130)	37% (148)	1.09 (0.85-1.40)	
51-69	23% (110)	29% (116)	1.14 (0.89-1.46)	
Education of the study group				
Higher education	4% (19)	20% (80)	1.02 (0.66-1.24)	0.01
Secondary education	25% (120)	71% (284)	1.09 (0.85-1.40)	
Vocational education	33% (159)	5% (20)	1.07 (0.65-1.30)	
Primary education	38% (182)	4% (16)	1.04 (0.88-1.43)	
Marital status				
Married	54% (259)	65% (260)	1.16 (0.99-1.60)	0.62
Widowed	12% (58)	11% (44)	0.98 (0.79-1.21)	
Unmarried	34% (163)	24% (96)	1.14 (0.89-1.46)	
Source of income				
Professionally active	89% (427)	75% (260)	1.07 (0.65-1.30)	0.59
Annuity	9% (43)	12% (96)	1.04 (0.88-1.43)	
Retirement	2% (10)	13% (36)	1.02 (0.66-1.24)	
Job				
Driver	13% (62)	20% (80)	1.67 (1.37-2.05)	0.01
Farmer	55% (264)	9% (36)	2.69 (2.39- 3.08)	
Office worker	20% (96)	51% (204)	1.27 (1.07-1.51)	
Teacher	7% (34)	13% (36)	1.16 (0.99-1.60)	
Seller	5% (24)	7% (28)	1.09 (0.85-1.40)	
Type of cancer in family				
Breast	30% (144)	9% (36)	1.16 (0.99-1.60)	0.01
Uterine	24% (115)	0% (0)	1.01 (0.76-1.34)	
Lung	20% (96)	15% (60)	1.04 (0.88-1.43)	
Colorectal	20% (96)	7% (28)	1.03 (0.71-1.27)	
Skin	6% (29)	0% (0)	1.02 (0.66-1.24)	

correlated with the risk of skin cancer ($p < 0.89$).

Sunburns

The assessment of sunburns showed that only 15% of the respondents never experienced sunburn. One sunburn per year was reported by 55% of the subjects, and more than two by 30%. Sunburns in the age group below 20 affected 21%, in the age group 20-30 years - 35% and in

Table 2. History of Illness among the Respondents

Recognized diseases	Cases (n=480)	Control group (n=400)	P
Characteristics /% (N)			
Diabetes	21% (101)	29% (116)	0.99
Ulcerative colitis	1% (5)	4% (16)	0.01
Crohn's disease	0% (0)	0% (0)	0.41
Intestinal polyps	0% (4)	0% (0)	0.55
Hypertension	26% (125)	45% (180)	0.88
Heart arythmia	4% (19)	18% (72)	0.74
Rheumatic disease	0% (0)	4% (16)	0

Table 3. Pigmentation Traits of Patients

Pigmentation traits	Cases (n=480)	Control group (n=400)	OR (95% Cl)	P
Characteristics % (N)				
Skin colour				
Pale pink	12% (58)	2% (8)	1.23 (0.96-1.57)	0.99
Very fair	44% (211)	23% (92)	1.19 (0.93-1.52)	
Fair	34% (163)	43% (172)	1,25 (0.98-1.51)	
Quite dark	10% (48)	20% (80)	1.11 (0.85-1.45)	
Olive-brown	0% (0)	10% (40)	1.09 (0.85-1.40)	
Dark	0% (0)	2% (8)	0.70 (0.47-1.05)	
Very dark	0% (0)	0% (0)	0.81 (0.54-1.47)	
Hair colour				
Black, dark brown	25% (121)	36% (144)	0.69 (0.42-1.15)	0.01
Brown	24% (117)	31% (124)	0.90 (0.55-1.49)	
Blond	33% (156)	28% (112)	1.65 (1.35-1.71)	
Red	18% (86)	5% (20)	2.13 (1,60-2,84)	
Eye colour				
Brown	28% (134)	30% (120)	1.05 (0.87-1.43)	0.89
Grey-green	15% (72)	7% (28)	1.03 (0.71-1.27)	
Blue	57% (274)	63% (252)	1.05 (0.61-1.28)	
Skin colour after intense sun exposure				
Turns brown	23% (110)	30% (120)	1.14 (0.89-1.46)	0.01
Red	53% (254)	59% (236)	1.36 (1.08-1.72)	
Red with pain	14% (68)	8% (32)	1.56 (1.07-1.57)	
Red with pain and blister	10% (48)	3% (12)	1.72 (1.33-2.23)	
Skin colour after repeated and prolonged sun exposure (suntan)				
Never/hardly ever brown	21% (100)	3% (12)	1,56 (1.07-1.57)	0.01
Light brown	57% (274)	67% (268)	1.26 (0.99-1.60)	
Brown	20% (97)	28% (112)	1.06 (1.01-1.72)	
Dark brown	2% (9)	2% (8)	1.16 (1.08-1.72)	
Number of moles > 5 mm				
0	50% (240)	60% (240)	190 (1.55-3.49)	0.01
1-2	29% (134)	31% (124)	1.41 (0.95-2.11)	
3-4	8% (38)	9% (36)	1.24 (0.84-1.82)	
≥5	13% (68)	0% (0)	1.63 (1.30-1.99)	
Location of moles				
Head, neck	16% (23)	12% (50)	0.71 (0.48-1.15)	0.88
Trunk	5% (7)	0% (0)	0.51 (0.34-1.46	
Upper extremities	21% (30)	17% (68)	1.14 (0.87-1.44)	
Lower extremities	58% (84)	10% (42)	1.11 (0.84-1.50)	

Table 4. Occurrence of Sunburn among Respondents

The number of sunburns	Age of sunburn in years				P	Sex		P	Place of residence		P
	10-19	20-29	30-39	40-49		Women	Men		City	Village	
Characteristics % (N)											
Cases											
0	2% (12)	4% (20)	5% (25)	3% (15)	0.27	4% (20)	11% (52)	0.88	8% (39)	7% (33)	0.51
≤ 1 per year	15% (73)	21% (101)	7% (34)	12% (56)	0.01	36% (173)		0.33	27% (129)	28% (135)	0.44
≥ 2 per year	7% (27)	14% (66)	6% (31)	4% (20)	0.33	9% (43)	21% (101)	0.55	13% (63)	17% (81)	0.51
Control group											
0	12% (48)	8% (32)	11% (44)	10% (40)	0.73	33% (131)	82% (33)	0.01	18% (72)	23% (92)	0.71
≤ 1 per year	10% (41)	12% (50)	21% (84)	10% (56)	0.12	43% (173)	2% (10)	0.01	16% (63)	34% (135)	0.21
≥ 2 per year	2% (7)	1% (6)	5% (20)	5% (20)	0.21	12% (48)	1% (5)	0.51	2% (9)	8% (32)	0.19

the age group over 30 - 14% of the study subjects (Table 4). Women were affected by sunburns significantly more often than men. The differences were statistically significant ($p = 0.03$). There were significant positive correlations between the risk of skin cancer and the number of sunburns below the age of 30 ($p < 0.001$). Among patients with multiple sunburns, the risk of developing skin cancer was 1.27 (AOR = 1,27; 95% CI, 1.07-1.55) compared with non-sunburns subjects. The place of living did not significantly affect the occurrence of sunburns ($p = 0.51$).

Solarium use

49% of the study subjects never used solarium, 44% used it occasionally, between 1 and 12 times per year, and 7% reported regular solarium use, with more than 12 sessions per year. 5-6 minutes of solarium use during one session was reported by 54%, 9-11 minutes by 25%, and 7-8 minutes by 21% of the study subjects. The median age at first use of solarium was 21 years, while the youngest reported age of the first use was 12. The most common facilities where sun lamps were used included solarium salons (73%), gyms (87%) and beauty salons (65%). A decision to start indoor tanning was made independently by 68%, on the advice of friends by 32% under the influence of the media by 42% and under the influence of general public opinion by 20% of the study subjects. As many as 73% of the study subjects used solarium despite their parents' opposition, 20% faced no opposition from their parents, and 7% started to use solarium following the example of their parents. The motivation for solarium use included: preparation for natural tanning before summer holidays (68%), maintaining tan after summer holidays (87%), improvement of mood (43%), and improvement of skin appearance (54%). In the group of subjects who used solarium, switching between indoor and natural tanning was reported by 82%, out of which 18% did it with small time intervals. Solarium burns were reported by 51% of the subjects, where 7% reported burns after each session (Table 5). Patients who started used solarium at an early age (AOR = 2.65; 95% CI: 2.55, 5.35) and used longer sessions (AOR = 8.42; 95% CI: 6.21, 10.98) had a 2.8 and 2.1 times greater risk of developing cancer . Subjects below the age of 30 and women used solarium significantly more often ($p < 0.0001$) and these groups significantly more often reported skin burns ($p = 0.03$).

Knowledge and protection

More than half of the respondents (68%) were aware of the harmful effects of UV radiation and sun lamps, with their source of information being the Internet (70%), media (23%) and the solarium salon staff (7%). 36% of the study subjects were informed by the staff about individual adjustment of session duration to the skin type. The most frequently reported consequences of tanning were: permanent skin pigmentation (85%), hair loss and nail brittleness (15%). Only 38% of the subjects knew the correct number of skin phototypes. Sunlight is especially dangerous between 10 am and 3 pm according to 43%, between 11:00 and 13:00 according to 38%, and between 12.00-16.00 according to 19% of the

Table 5. Using the Solarium among the Respondents

Number of burns	Age of using the solarium in years				P	Sex		P	Place of residence		P
	10-19	20-29	30-39	40-49		Women	Men		City	Village	
Characteristics % (N)											
Cases											
Never	12% (58)	5% (25)	9% (42)	23% (110)	0.27	6% (29)	43% (206)	0.25	8% (39)	7% (33)	0.51
≤ 1 for a month	11%(53)	21%(101)	6% (31)	5% (26)	0.33	42%(202)	2% (9)	0.03	27%(129)	28% (135)	0.44
≥ 2 for a month	1% (4)	4% (18)	2% (8)	1% (4)	0.41	6% (28)	1% (6)	0.27	13% (63)	17% (81)	0.51
Control group											
Never	17% (70)	7% (30)	10% (39)	10% (41)	0.19	37% (149)	8% (31)	0.01	19% (78)	25% (102)	0.64
≤ 1 for a month	6% (24)	13%(52)	17% (68)	13%(51)	0.62	38%(153)	3% (11)	0.01	14% (58)	31% (125)	0.55
≥ 2 for a month	1% (2)	2% (6)	10% (41)	6% (24)	0.21	12% (50)	2% (6)	0.19	2% (8)	7% (29)	0.19

study subjects. The reported benefits of tanning included improved appearance (72%), relaxation (21%), and health considerations (8%). When asked about protection against harmful UV rays, the respondents most frequently (79%) reported using SPF sunscreens while staying outdoors for over an hour on a sunny day. A correlation was observed between the protection used and the patient's age. The respondents less frequently used sun protection during adolescence ($p < 0.001$). There was a strong positive correlation between the number of asymmetrical moles larger than 5 mm and the use of sun protection ($p <0,001$). Patients no-using of sun protection (AOR = 2.65; 95% CI: 2.55, 5.75) and having large asymmetrical moles (AOR = 2.42; 95% CI: 1.21, 2, 98) had a 2.6 times greater risk of developing skin cancer.

Discussion

Unfortunately, in the last three decades, the cases of melanoma, one of the most malignant skin neoplasms, have doubled. There are many risk factors for the development of skin cancer. The major ones include low pigment content in the skin, light complexion, fair hair, tendency to sunburn, numerous pigmented moles, and exposure to UV rays. Searching for and understanding the factors affecting the subject with a developing skin cancer is of high prognostic value, since it allows future qualification of patients to a high risk group, but also gives an opportunity to use prevention (Kapka-Skrzypczak et al., 2014; Department of Health and Human Services, 2014).

Genetic factors have a strong effect on the risk of skin cancer development. Previous skin cancer diagnosis or family history, especially in the case of melanoma, or mutations in the TP53 gene increase the risk of cancer (Watson et al., 2016; Chen et al., 2014). Inherited changes play a decisive role in the development of about 10% of skin melanomas. If the disease developed in first-degree relative(s), the relative risk of cancer is between 2 and 3. If melanoma occurred in at least three family members of two or more generations, the relative risk is between 35 and 70 (Kapka-Skrzypczak et al., 2014). Genetic risk factors for skin cancer also include individual pigmentation traits. Carcinogenesis is especially promoted in skin phototype I and II, according to the classification developed by Thomas Fitzpatrick, where the average risk of non-melanocytic skin cancers is 30%. Patients with light complexion, light blue or green eyes, blond or red hair, and red or painful skin after prolonged sun exposure are considered a group with an increased risk of developing moles and skin cancers (Watson et al., 2016; Kapka-Skrzypczak et al., 2014; Chen et al., 2014; Veierød et al., 2010; Kuros et al., 2019). As shown by studies of Johnson et al., differences in the rate of photocarcinogenesis in fair and dark skin emphasise the benefit of having a darker, naturally defined level of constitutive pigmentation. Darker skin types have a natural sun protection factor around 13 (Johnson et al., 1998) and epidermal melanin in black skin type filters twice as much UVB radiation as in Caucasian types. Dark skin allows 7.4% of UVB and 17.5% of UVA to penetrate, as compared with 24% and 55%, respectively, regarding Caucasian skin (Gloster et al., 2006; Narayanan et al., 2010). As shown by studies of Horner et al., (2009) in the United States, people of the black race reveal 18-fold (women) and 26-fold (men) lower incidence of melanoma than people of the white race. Moreover, studies by Tadokoro et al., (2005) and Yamaguchi et al., (2006) show that constitutive skin pigmentation with higher melanin content protects epidermis against DNA damage in the form of cyclobutane pyrimidine dimers. Own studies revealed a correlation between hair colour and the risk of skin cancer. The risk was higher in women with blond and red hair, as compared with dark brown or black haired women. The risk was also increasing with higher skin sensitivity both to acute and chronic exposure to the sun ($p < 0.001$). Similar results were obtained in studies of Veierød et al., who showed a strong correlation between hair colour and the risk of melanoma, where the risk was twice as high in women with blond hair and 4 times as high in women with red hair, as in dark brown or black haired women. The risk of melanoma was also significantly higher with increased skin sensitivity both to acute and chronic exposure to the sun (Veierød et al., 2010). Our findings regarding hair colour are also confirmed by a meta-analysis performed by Gandini et al., where the correlation with skin type, skin colour and eye colour was lower than with hair colour, but it was statistically significant (Gandini et al., 2005).

Aside to skin tone, the risk of cancer is also correlated with the total number of moles. Melanomas often develop from moles, and moles indicate both a genetic predisposition to the development of melanoma and UV radiation exposure (Watson et al., 2016; Haenssle et al., 2016). Skin tone and number of moles are also correlated to a certain degree. As shown by studies of Wiecker et al., children with fair complexion, freckles and a tendency to sunburn have a much higher number of moles (Wiecker et al., 2003). In addition, the moles have different locations and appearance, depending on the type of skin (Watson et al., 2016; Tuma et al., 2015). Large congenital moles are characterised by an increased danger of malignant transformation, and the risk of melanoma may be even 10% higher in the whole life (Ebisz et al., 2015; Anger et al., 2010; Lawrence et al., 2009). Studies conducted in Norway and Sweden on a female population aged 30-50 have shown that the risk of melanoma is higher if there are asymmetrical moles on the body, and there were sunburns caused by sunlight exposure before the age of 30 (Kapka-Skrzypczak et al., 2014; Veierød et al., 2010). Own studies have shown a strong positive correlation between the number of asymmetrical moles larger than 5 mm and the risk of melanoma ($p < 0.001$), and a correlation between the number of moles and skin phototype. Veierød et al., (2010) found a strong positive correlation between the number of asymmetrical moles larger than 5 mm on the legs and the risk of melanoma. The highest percentage of one or more asymmetrical moles on the legs was observed among red-haired women, regardless of the fact if they were (46% of the red-haired, 25% of blondes or yellow-haired, 19% of brunettes) or were not (20% of the red-haired, 13% of blondes or yellow-haired, 14%

of brown-haired and 13% of dark brown or black-haired women) diagnosed with melanoma. The occurrence of moles as strong risk factor for melanoma was also shown in studies by Bataille et al., (2008); Olsen et al., (2009); Gandinie et al., (2005) and Chang et al., (2009), whereas Silva et al., (2009) showed a higher number of moles in red-haired women.

Excessive ultraviolet radiation exposure occupies a high position in the ranking of environmental factors posing a threat to human health. WHO classified UV radiation as carcinogenic. The absorbed doses of UV radiation are accumulated over time, and its harmful effects may be revealed only after many years. Epidemiological data indicate that an important risk factor for skin cancer are relatively short, but intense exposures to UV radiation, especially severe sunburns during childhood (Silva et al., 2009; Amstrong et al., 2001). It is estimated that as many as 90% of melanomas are caused by UV radiation exposure. The related literature includes studies on risky behaviours, wherein the analyses include populations of adults, children, adolescents, citizens of various countries, as well as outdoor workers. Most of the studies were conducted in the USA and Australia, where the highest incidence rates of skin cancer are observed (Dana, 2017; Ramirez et al., 2005; Kyle et al., 2014; Bränström et al., 2010; Maddoch et al., 2007; Lewis et al., 2006; Wickenheiser et al., 20013). The level at which UV exposure increases the risk of skin cancer in a given person depends on many factors, such as individual skin type, age at exposure, number and types of sun protection measures, or type of exposure (US Department of Health and Human Services, 2014). Studies conducted by Rivas et al., Levine et al., and Grodstein et al., have shown that subjects with fair complexion living on areas characterised by higher exposure to UV radiation, especially when they are younger, have a higher incidence rate of skin cancer, especially SCC (Rivas et al., 2012; Levine et al., 2013). Similarly, it is believed that melanoma is caused by sun exposure over the entire life, probably with more severe consequences in the early life, although exposure in adults significantly increases the risk, as well (Dennis et al., 2008). Numerous publications emphasise a highly harmful character of short periods of intense UV radiation exposure of people who are not accustomed to large doses of solar radiation. Symptomatic study results show that there is a correlation between the occurrence of melanoma in adulthood and high doses of UV radiation in childhood. Children born in the United Kingdom who moved to Australia early in their life have a higher risk of melanoma than people who emigrated as adults. Similarly, it is true for the citizens of Israel. Children born in Israel are at a higher risk than the immigrants born in Europe or North America who arrived in Israel as adults (Kapka-Skrzypczak et al., 2014; American Cancer Society, 2020; deGruijl, 1999). According to numerous studies, sunburn at any age increases the risk of skin cancer (Jemal et al., 2011; Karagas et al., 2006: Green et a., 2011), and meta-analysis of Gandini et al. and Dennis et al. showed a higher risk with a growing number of sunburns in all life stages, with no significant differences between sunburn occurring in the childhood and in the adulthood. Sunburns were not independent at different life stages, but they were related to the skin type and UV exposure (Dennis et al., 2008; Gandinie et al., 2005). Similar results were achieved by Veierød et al., who observed similar important consequences of sunburns before the age of 30. There were significant positive correlations between the risk of melanoma and the number of sunburns at the age <10, 10 to 19 and 20 to 29, with RR values of 1.67, 1.92 and 1.62, respectively, for two or more sunburns a year as compared to zero. The positive trend was much weaker with sunburns occurring between 30 and 39 years of age, and not apparent at all at the age between 40 and 49 (Veierød et al., 2010).We achieved similar results, showing significant positive correlations between the risk of skin cancer and the number of sunburns below the age of 30 ($p < 0.001$).

A separate problem is solarium use. A meta-analysis based on 9 reports from three continents has shown that there is a correlation between solarium use and an increasing risk of melanoma (Kapka-Skrzypczak et al., 2014; Veierød et al., 2010). According to studies conducted in 18 European countries as part of WHO Globalcan 2008, each visit to the solarium increases the risk of melanoma by 1.8%, and in subjects below 30 even by 75%, as compared with the subjects who have never used solarium (National Cancer Registry, 2021; Green et al., 2011). The Nurses' Health Study II, conducted in the United States, showed that four visits to the solarium per year increased the risk of benign skin cancers by 15% and the risk of melanoma by 11% (National Cancer Registry, 2021), while studies by Wehner at al. revealed that indoor tanning increased the risk of BCC by 29% and of SCC by 67% (Wehner et al., 2012). On average, a person using solarium receives additional 1.2 of the average annual dose of UVA radiation after 20 sessions, and subjects who often use solarium – from 4.7 to 12 average annual doses, depending on the type of sun lamps (Jou et al., 2012). Other studies presented by Autier prove that in the female population of Norway and Sweden, the risk of developing melanoma increases after regular visits to the solarium (Autier, 2004), while in Belgium, France, the Netherlands, and the United Kingdom, 53% of newly recorded cases of melanoma referred to subjects who used solarium (Bataille et al., 2005). In their analysis of 571 patients with melanoma conducted in 2000, Westerdahl et al. observed a significant increase in the risk of developing melanoma in subjects who regularly used artificial sources of UV radiation. They also revealed a dose-related correlation between the development of melanoma and the number of tanning sessions, and a higher risk in subjects who started to use solarium before the age of 36 (Westerdahl et al., 2000; Woźniak-Holecka et al., 2009). In our own studies, occasional solarium use, between 1 and 12 sessions per year, was found in 44%, while regular use with more than 12 sessions in 7% of the study subjects. 20% of the subjects reported solarium burns, out of which 7% had burns after each session. Solarium was significantly more often used by subjects below 30 and by females. Similar results were obtained by Suppa et al. in their studies conducted in thirty European countries, proving that in all the countries women showed

a significantly higher frequency of solarium use than men, regardless of age, education, skin type, and year of study. Multi-factor models showed that the frequency of solarium use was higher in young adults than in other age groups (Suppa et al., 2019). Boniol and IARC data emphasise a worrying increase in the risk of melanoma (75% and 237%, respectively) in young adults aged below 35, as a result of repeated and long-term solarium use in the period between 10 and 39 years of age (Veierød et al., 2010; International Agency for Research on Cancer, 2020; Bonil et al., 2012). A recent study conducted in Minnesota by Lazovich et al. showed that in the group of women diagnosed with melanoma below the age of 30, 97% practised indoor tanning, which means a 6-fold risk increase (Lazovich et al., 2016). Cust et al., (2011) proved that in comparison with subjects who never used solarium, the risk of melanoma was higher by 41% in subjects who ever used solarium, and was about twice as high in subjects who reported more than 10 sessions over the entire life. They also found that the risk of melanoma was higher when the first use of solarium took place at a younger age, and with an earlier onset of the disease. Subjects who reported more than 10 sessions in their life appeared to be six times more predisposed to the diagnosis of melanoma before the age of 30 than subjects who never used solarium.

The study included patients with diagnosed skin cancer. The achieved results support other study findings that an increase in periodic sun exposure and solarium use, combined with an unfavourable phototype, increases the risk of melanoma. Relative consequence of occasional sun exposure or solarium use differed depending on hair colour, skin sensitivity to the sun or presence of large asymmetrical moles. Probably the most important of findings is the evidence for a correlation between hair colour and large asymmetrical moles, identifying subjects with fair hair and large asymmetrical moles as those with a very high risk of skin cancer. However, certain limitation must be taken into account. The sample was too small for a subgroup analysis. The study should be interpreted as an exploratory study.

Conclusions

1. Risky behaviours including excessive exposure to UV radiation, both natural and artificial, are of special significance in women with fair complexion and fair hair.

2. Indoor tanning is a probable factor of increased melanoma incidence in younger women, as compared to men, having regard to the moment when the women started indoor tanning in relation to diagnosis. Indoor tanning remains to be a common problem of public health. These observations predict that without intervention, skin cancer will become more frequent and will require extensive preventive measures in the nearest future.

3. The results of this analysis may contribute to better prediction of the melanoma risk in young adults, and may indicate significant interactions with sun exposure early in life, which may be of importance for the risk of skin cancer in early and late adulthood.

Author Contribution Statement

Conceptualization, A.L.; T.L.; S.P; O.V.; data curation, A.L., formal analysis, A.L. and T.L.; funding acquisition, A.L.;T.L.; G.R.; M.P; S.R; W.W; investigation, A.L.; G.R; M.P; methodology, A.L.; S.P; O.V; project administration, A.L., and T.L.; resources, T.L.; software, T.L. ; supervision, A.L.; validation, A.L; S.R.; W.W; G.R.; M.P; S.P; visualization, T.L.; writing-original draft, A.L.; writing-review and editing, A.L. All authors have read and agreed to the published version of the manuscript..

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Approval

The research was not conducted as part of a student thesis or approved by a scientific body

Ethical approval

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by The Bioethics Committee at the University of Rzeszow (Resolution No. 1/12/2019).

Data Availability Statement

The data are not publicly available due to privacy and ethical restrictions. The data presented in this study may be available conditionally from the corresponding author.

Registering dataset

Not applicable, these were not clinical trials, guideline, meta analysis.

Conflicts of Interest

The authors declare they have no conflict of interests.

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