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Outdoor sports and risk of ultraviolet radiation-related skin lesions in children: evaluation of risks and prevention

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Summary

Background Excessive ultraviolet (UV) radiation exposure can cause skin cancers, skin photoageing and cataracts. Children are targeted by sun-protection campaigns because high sun exposure and sunburn in childhood increase the risk of melanoma in adulthood. Little information is available about UV radiation risk and exposure in children who take part in outdoor sports.

Objective To evaluate the risk of developing UV radiation-induced skin lesions run by children who practise outdoor sports, and UV radiation exposure and sun-protection measures during a soccer tournament.

Methods Firstly, we evaluated the relationship between melanocytic naevus – a skin lesion linked with exposure to UV radiation – and outdoor sports in 660 11-year-old children. Secondly, we used the occasion of a 1-day soccer tournament held in the spring to evaluate UV radiation-protective measures used by soccer players and the public. We also evaluated the UV radiation index and cloud cover during the tournament, and calculated the UV radiation dose and minimal erythema dose depending on skin phototype.

Results The naevus count and acquired naevus count measured over the 2 years of the study were higher in the 344 children who practised outdoor sports. Sun-protective measures were insufficient for soccer players and the public.

Conclusions This study shows that outdoor sports increase the risk of developing UV radiation-induced skin lesions in childhood. During a 1-day soccer tournament held in the spring, children and their parents were inadequately protected against the sun. These results suggest that sun-protection campaigns should be aimed at children who practise popular outdoor sports.

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Conflicts of interest
None declared.

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With the dramatic increase in ultraviolet (UV) radiation-induced skin cancers, melanoma, basal cell carcinomas (BCC) and squamous cell carcinoma, advocating the benefits of reasonable exposure to sunlight is a public health priority in most Western countries. Sun exposure is important for health. It is involved in vitamin D synthesis and may induce a feeling of well-being.[1–3] However, unprotected exposure to UV radiation rays is linked to the development of skin cancers, photoageing and cataracts.[4,5] The other main risk factors for melanoma include a high number of melanocytic naevi (MN) and fair skin.[6–8] Reducing exposure to the sun is probably the most effective way of decreasing the risk of skin cancers. Recommendations include avoiding the sun, wearing sun-protective clothing and using sunscreen.[9]

For many years, outdoor sports have been identified as a risk factor for UV radiation-induced skin cancers owing to chronic and repeated acute sun exposure and inadequate sun protection.[10,11] These studies mainly focused on an adult population and sports practised by minorities.[12–27] For example, recent sun-protection campaigns in France have focused on kite-surfing (http://www.syndicatdermatos.org/journee-nationale-de-depistage-des-cancers-de-la-peau-69.html) and surfing (http://blog.surf-prevention.com/tag/prevention-solaire/). The incidence of BCC is higher in patients practising water sports,[28,29] while atypical MN, solar lentigines and lesions suggestive of skin carcinomas are higher in marathon runners.[22,30] Precancerous skin lesions and skin carcinomas are more common in professional mountaineers.[16] Other studies have focused on UV exposure during sporting activities and on attitudes towards sun protection.[12–15,18–21,26]

There is little information about the UV risk correlated with outdoor activities in children. Most of the available information deals with school-related activities or UV radiation exposure.[31,32] Limited data are available concerning popular sports and children.[5] In this study, we analysed the UV radiation risk run by children practising outdoor extracurricular sports. We evaluated the risk in three stages based on two projects, Tête Brûlée and Risc-UV (http://www.gisclimat.fr/projet/risc-uv):[8,33,34] (i) do children who take part in outdoor sports have a higher risk of developing UV radiation-induced skin lesions (hereinafter referred to as MN)[35] as evaluated through the Tête Brûlée project; (ii) is UV radiation exposure in children and their parents high during a 1-day competition in spring, as evaluated through the Risc-UV project; and (iii) do children and parents protect themselves adequately during outdoor competitions?

Methods

Melanocytic naevi count in children who practise sports

In 2007 and 2009 we conducted a cluster-randomized study investigating the effectiveness of several sun-protection educational measures in primary schools located in the greater Paris area (the Tête Brûlée study). Details of this study have already been published. Briefly, 52 schools were randomly selected for four different interventions. Two trained nurses counted the MN on the arms and backs of the children. MN were recorded depending on their size (≤ 2 mm, > 2 mm), using a circular template on rigid transparent plastic.[8,33]

One of each child's parents completed a standardized case-report form in 2007 and 2009. In the 2009 questionnaire, two questions about sport were included: does the child practise sport, outside school? If 'yes', which sport? Sports were then classified as always practised outside (e.g. soccer, rugby, etc.), sometimes outside (e.g. tennis, swimming, etc.), and always indoor (e.g. basketball, dance, etc.). We included the children who practised at least one sport always or sometimes outside in the 'outdoor sport' group. Children who practised indoor sports only and those who did not practise any sport at all were included in the 'no outdoor sport' group.

Soccer tournament: evaluation of prevention in soccer players and public

We evaluated prevention using the example of a soccer tournament, football being the most popular sport in the investigators' home countries (i.e. France and Brazil) and enjoyed by more than 250 million people worldwide, for very young children (U7 and U8 – under 7 and under 8 years of age) in the greater Paris area. We preselected three weekend tournaments taking place in May–June 2009 in order to obtain one tournament for the study, the final choice depending on the weather forecast. The forecast for 1 June was sunny with clouds in the late afternoon and a maximum UV radiation index (UVI) of 6 (http://france.meteofrance.com). This tournament was located in Auvers-sur-Oise (longitude: 02°09′E; latitude: 49°04′N), and involved 16 U7–U8 teams each consisting of 6–8 children. The tournament started at 0900 h and finished at 1800 h.

To evaluate the sun-protection measures used both during and between matches by soccer players, we administered a study-specific questionnaire to the children of six teams. The questions included the three sun-protection measures applicable to the children, i.e. use of sunscreen, wearing sunglasses and wearing a cap or hat.

At 1400 h (the time of the peak solar elevation angle in France) we took photographs of the spectators at various points in the whole stadium (Fig. 1). We then used a specially developed case-report form to evaluate sun-protective measures used by spectators (hat or cap, sunglasses and seeking the shade). We separated children from adults. If there was doubt (e.g. we had the back view of a teenager), the person was included in the adult group.

Fig 1. Evaluation of sun protection at 1400 h. Cloud cover = 3–4 octas. UV index = 6·5.

Ultraviolet radiation exposure

UV radiation exposure was evaluated with UVI measurements and UV radiation dose and minimal erythema dose (MED) calculations. UVI is a standardized tool. It expresses the erythemal power of the sun and should be accompanied by photoprotection advice. A UVI score of 1–2 is considered to represent weak sun, 3–5 is average, 6–7 is strong, 8–10 is very strong and over 11 is extreme.[36,37] UVI was evaluated with a Solarmeter UVI meter model 6.5 (Solartech Inc., Harrison Twp, MI, U.S.A.) every 10 min from 1000 h to 1700 h, in the centre of the stadium. The sensitivity of this instrument was validated in a previous study (ref. d1973).[34] UVI measurements performed on 1 June 2009 are shown in Figure 2a, along with estimates of UVI in cloud-free situations. Cloud-free UVI are obtained from theoretical calculations (theoretical UV radiative transfer model), which take into account the effects of solar elevation, ozone and aerosols.

The biologically effective dose of UV radiation was evaluated by calculating UV radiation doses and MED. UV radiation doses (J m^{-2}) were evaluated from UVI measurements as follows:

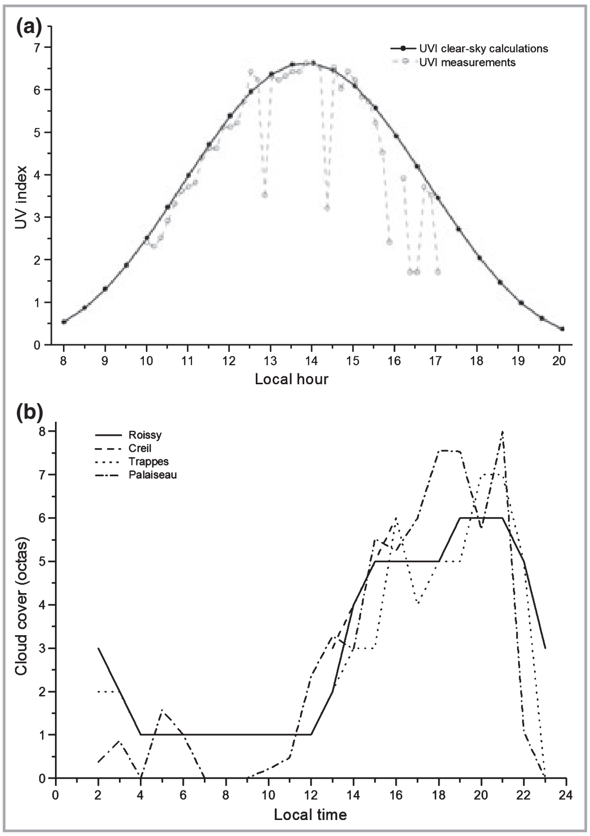

Fig 2. Weather conditions [UV index (UVI) and clouds] during the Auvers-Sur-Oise soccer tournament. (a) UVI was evaluated with the Solarmeter UVI meter model 6·5 (Solartech Inc., Harrison Twp, MI, U.S.A.). The 1600 h UVI measurement has not been evaluated because of medical assistance of the investigator at this time. (b) Cloud cover (octas) observed at four locations about 30 km north, south and east of Auvers-sur-Oise (data source Meteo-France and SIRTA/CNRS).

UV radiation dose = (UVI/40) × time in min between two UVI measurements × 60. The MED is defined as the quantity of UV radiation needed to cause slight erythema with clearly defined edges 16–24 h after exposure. This quantity varies depending on individual sensitivity to the sun. We assessed this sensitivity using Fitzpatrick's[38] skin phototype (SP) classification, focusing on white-skinned phototypes (SPI to SPIV). We then evaluated the time required to reach the MED depending on SP (MED for SPI: 200 J m^{-2}; SPII: 250 J m^{-2}; SPIII: 300 J m^{-2}; and SPIV: 450 J m^{-2}) as a function of when exposure to the sun started.

Cloud cover

Cloud cover is estimated by human observers at weather stations operated by Météo-France and by a whole sky-imager at the SIRTA observatory in Palaiseau, France.[39] For this study, we used data obtained from four stations located about 30 km north, east and southwest of Auvers-sur-Oise (Météo-France stations at Creil, Roissy and Trappes, and the SIRTA observatory in Palaiseau). Cloud cover is given in octas (0–8), which represent the portion of the sky that is covered by clouds. A measure of 0 octa corresponds to a cloud-free sky, while 8 octas corresponds to an overcast sky. The diurnal variations of cloud cover on 1 June 2009, shown in Figure 2b, were consistent at the four stations, with clear skies in the morning (0–1 octa from 0900 to 1200 h), partly cloudy skies between 1200 and 1400 h (2–4 octas), and mostly cloudy skies from 1500 to 1700 h (> 5 octas). The regional consistency amongst the four stations implies that these observations are a reasonably reliable reflection of cloud-cover variations at Auvers-sur-Oise.

Statistics

The data were summarized using descriptive statistics. Quantitative data were expressed as the mean ± standard deviation and qualitative data as frequency and percentage. Comparison of means were performed using the Mann–Whitney nonparametric test when necessary. $P < 0{\cdot}05$ was considered to be statistically significant. Statistical analyses were performed using SAS software 9.2 (SAS Institute Inc., Cary, NC, U.S.A.).

Results

Melanocytic naevi development in children taking part in outdoor sports

The Tête Brûlée study included 828 children. For 660 (79·7%) of these children (mean age: 10·8 years, sex ratio: 1), we obtained MN counts in 2007 and 2009, and information about their sporting activity. Sports were practised by 558 (86·0%) children, and 344 (52·1%) practised at least one outdoor sport.

In 2007, there was no difference in MN count according to sporting activity (Table 1). In 2009, children with outdoor

Table 1 Melanocytic naevus (MN) count in 660 children taking part (n = 344) or not taking part (n = 316) in outdoor sports[a] (mean ± SD)

	Melanocytic nevus count				
	< 2 mm	> 2 mm	Back	Arms	Total
No. MN in 2007					
Outdoor sport	14·0 ± 7.2	3·3 ± 3·8	6·6 ± 4·8	10·6 ± 6·2	17·3 ± 9·7
No outdoor sport	12·9 ± 7·6	3·2 ± 4·6	6·0 ± 5·0	10·1 ± 6·9	16·2 ± 10·8
No. MN in 2009					
Outdoor sport	17·2 ± 8·2**	5·0 ± 5·7	9·4 ± 6·5‡	12·8 ± 7·0	22·1 ± 12·2†
No outdoor sport	15·0 ± 8·6	4·8 ± 6·0	8·1 ± 6·5	11·7 ± 7·6	19·9 ± 13·0
No. new MN in 2009 vs. 2007					
Outdoor sport	3·3 ± 4·7‡	2·4 ± 3·5	2·8 ± 3·5‡	2·3 ± 3·9†	5·0 ± 6·0‡
No outdoor sport	2·1 ± 5·3	2·2 ± 3·3	2·1 ± 3·4	1·6 ± 4·9	3·7 ± 6·5

[a]Sporting activity was evaluated in 2009. The outdoor sports were soccer (30·9%), tennis (30·9%), riding (21·8%), cycling (5·7%), rugby (5·3%), athletics (4·6%), multisports activity (3·4%), climbing (1·9%), golf (1·9%), rollerskating (1·1%), canoeing (0·8%), French bowls (0·4%) and archery (0·4%).
†$P < 0·05$; ‡$P < 0·01$; **$P < 0·001$ when we compared the MN count of children who practise outdoor sports vs. those who do not.

sporting activity had more MN (22·1 vs. 19·9, P = 0·012). Most of these measured < 2 mm (17·2 vs. 15·0, P = 0·0018). Children who took part in outdoor sports had more MN on their backs (9·4 vs. 8·1, P = 0·0028) (Table 1). When we evaluated the number of MN acquired since 2007, these tendencies were also statistically significant. Results were independent of SP (data not shown). Boys showed an increase in back MN count (10·2 vs. 8·6, P = 0·022), but girls did not (data not shown).

Soccer competition: prevention

Of the 38 soccer players evaluated, 8 (21.1%) wore a cap, 13 (34.2%) had applied sunscreen, and 0 wore sunglasses. If good sun-protection clothing measures for spectators are considered to be using a hat or a cap, wearing long sleeves, skirts or trousers and using sunglasses,[9,37] these measures were applied by less than 40% of adults and children < 9% of people watched the matches from the shade (Table 2).

Table 2 Sun-protective measures applied by spectators

	At 1400 h (UVI = 6·5)	
Sun-protection measures	Children	Adults
Head, No. evaluable	53	128
Hat, n (%)	0	2 (1·6)
Cap, n (%)	17 (32·1)	38 (29·7)
Trunk and arms, No. evaluable[a]	22	121
Long sleeve, n (%)	1 (4·6)	9 (7·4)
Short sleeve, n (%)	18 (81·8)	86 (71·1)
Sleeveless, n (%)	3 (13·6)	25 (20·7)
Bare-chested, n (%)	0	1 (0·8)
Legs, No. evaluable[a]	20	106
Trousers or long skirt, n (%)	6 (30·0)	41 (38·7)
Long shorts or skirt below knees, n (%)	7 (35·0)	25 (23·6)
Shorts or skirt above the knees, n (%)	3 (15·0)	35 (33·0)
Shorts/short skirt, n (%)	4 (20·0)	5 (4·7)
Sunglasses, No. evaluable	31	72
Yes, n (%)	0	25 (34·7)
People in shade, No. evaluable	57	139
Yes, n (%)	1 (1·8)	12 (8·6)

[a]Soccer players were excluded from these analyses. UVI, ultraviolet radiation index.

Soccer tournament: UV exposure and cloud cover

The UVI values obtained between 1000 and 1500 h were very close to cloud-free values. From 1500 h onwards, these values dropped to significantly below cloud-free values, due to increasing cloud cover (Fig. 2a). UVI was considered to be average for about 3·5 h and strong for 2·5 h, with a few transient decreases as a result of clouding.

Maximum solar elevation occurs at about 1400 h. In cloud-free conditions, the UVI could therefore be expected to be equivalent from 1100 to 1200 h and 1600 to 1700 h. We found that the mean UVI was 4·3 at 1100–1200 h, whereas it was 2·6 between 1600 and 1700 h. The mean value at maximum solar elevation was 6·5. This shows that while cloud cover remains below 4 octas, UVI is mainly dictated by solar elevation and only slightly influenced by cloud cover. However, when cloud cover reaches 5–6 octas, UVI can drop significantly when compared with cloud-free conditions.

The total UV radiation dose reached about 3000 J m^{-2} (Fig. 3a). This corresponds to 6·5–14·7 MED from SPIV to SPI (Fig. 3b). At 1200 h, people with SPI, SPII, SPIII and SPIV had reached 3·5, 2·8, 2·4, and 1·6 MED, respectively. The time required to reach 1 MED evaluated as a function of SP was < 60 min for SPI and SPII when sun exposure started at 1000 or 1600 h. If sun exposure started between 1200 and 1400 h, SPI–IV reached MED in < 50 min (Fig. 3c).

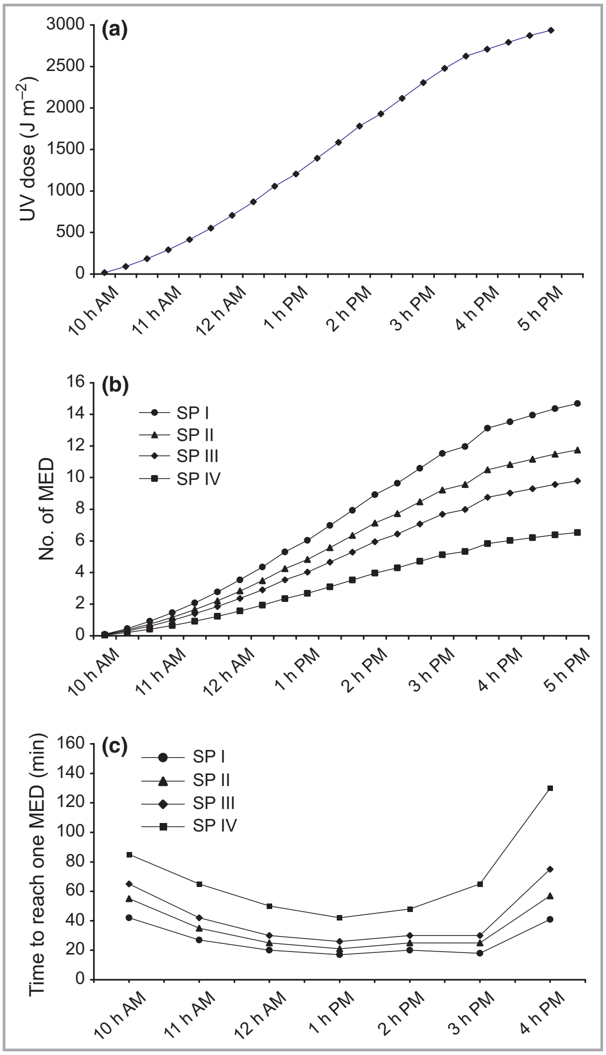

Fig 3. Ultraviolet (UV) radiation exposure, evaluated from UV index (UVI). (a) Evaluation of UV radiation dose. (b) Evaluation of number of minimal erythema (MED) dose throughout exposure, depending on skin phototype (SP) (white-skinned phototypes). (c) Evaluation of time required to reach 1 MED depending on sun exposure start time and SP. UV radiation dose was evaluated from the UVI: UV radiation dose = (UVI / 40) × time between two UVI measurements (min) × 60. SP was defined according to Fitzpatrick's classification:[38] I: very white or freckled, always burns, never tans (MED = 200 J m^{-2}); II: white, always burns, then tans (MED = 250 J m^{-2}); III: white to olive, sometimes burns, always tans (MED = 300 J m^{-2}); IV: brown, always tans, rarely burns (MED = 450 J m^{-2}).

Discussion

Our study suggests that early in life, outdoor sports increase the risk of developing UV radiation-induced skin lesions. The sun-protection measures used by children and their parents during a football tournament were found to be inadequate. Children are not sufficiently protected against the sun both during and between their matches. It is important to take into account both situations, as the children only actually play for a total of 1 h (6 × 10 min matches) during the 9-h competition. UV radiation measurements show the high UV radiation dose received during this tournament, with a high UV radiation risk as evaluated by the time to sunburn and the high number of MED for people with a white-skinned SP. Although the weather was cloudy in the afternoon of our tournament, the UVI was still high (> 5) for most of the measures.

These studies have a number of limitations. (i) Is this 1-day UV radiation evaluation representative of UV radiation conditions in France? For 7 of the possible 11 weekend days in the period from 30 May to 28 June 2009 during which we selected our tournament, the UVI forecast was 6 or more in the Ile-de-France region. Moreover, in four major French towns which are considered to be geographically representative of France as a whole i.e. Marseille (south), Lyon (east), Lille (north), and Brest (west) – the UVI forecast was 6 or more for 10/11, 8/11, 5/11, and 7/11 days, respectively (http://france.meteofrance.com). During the period covered by our study, the UV conditions were therefore representative of probably more than 60% of weekend days throughout France. (ii) We only evaluated 38 soccer players for sun-protection measures. Nevertheless, when we evaluated all the spectators in the stadium, the results were comparable. (iii) There are no shaded areas at the Auvers-sur-Oise soccer stadium as shown in Figure 1, but what about other soccer pitches? Generally speaking, professional soccer stadiums are required to have large-capacity stands. This is not the case for amateur stadiums where children's matches are held. So our very low rate of people under shade (9%) can be explained not only by behavioural considerations, but probably also by architectural considerations, because the architecture of the pitch does not provide opportunities for spectators to seek the shade. An evaluation of the shade provided by various stadiums, including soccer pitches and tennis courts, could be of interest. (iv) In the Tête Brûlée part of the study, we did not take into account how often the children took part in outdoor sports, or for how many years. These preliminary results require further confirmation in larger studies. (v) It does not seem feasible for soccer players to adopt hats or sunglasses, which are considered to be good sun-protective measures, during the tournament. In this soccer tournament for very young players (U7–U8), children played six 10-min soccer matches during the 9-h sun exposure. So we tried to evaluate their sun protection during the 8 h during which they did not play and we can consider that during this time they should respect sun-protective measures.

Several reasons have been put forward for the role played by outdoor sports in UV radiation-induced skin tumours. Clothing worn while practising outdoor sports may provide incomplete protection, either because it has been selected for its comfort rather than its protective potential, or because it is obligatory for a given sport;[10] sweating, exposure to water and friction may make sunscreen less effective; sweating caused by sports increases sensitivity to UV radiation;[40] sportswear does not have specific solar-protective properties even though all clothing attenuates UV radiation;[41] and competitions and training often take place during peak hours. In children, these hypotheses are probably still correct. Another aspect is that children who practise outdoor sports tend to stay outside longer (for example, young soccer players tend to play soccer during school breaks or after school) than those who do not practise sports.

Children who take part in popular outdoor sports could be very interesting targets for sun-protection campaigns for at least two reasons. Firstly, our study shows that children have a higher risk of developing UV radiation-induced skin lesions very early in life. Contradictory results have been published on this topic. In one study, there was a positive association between swimming in childhood and melanoma in adults.[42] In another, outdoor sports in childhood were not associated with an increased risk for melanoma.[43] In fact, it is quite difficult to evaluate retrospectively sun exposure in childhood for adults with skin cancers and most evaluations are based on the word of patients themselves, as melanomas or skin carcinomas are believed to take at least 20–30 years to develop.[44] Finally, there are educational reasons. It is easier to learn safe sun habits at an early age than to 'unlearn' harmful habits at a later stage.[45] Moreover, both children and their parents tend to benefit more from joint educational programmes on the benefits of a healthy attitude towards sun exposure.[8]

Our UV radiation exposure results are very alarming, but must be considered with caution. UVI was evaluated as recommended by the supplier of the UV radiation dosimeter and is based on a horizontal surface evaluation. These measurements do not take into account the true UV radiation intensity on skin evaluated by MED: the UV radiation dose received by the crown is reduced by head hairs, depending on their colour and size.[46] Moreover, on the face and the body, UV radiation erythemal doses decrease depending on the angle of the horizontal ambient UV radiation and the solar angle.[47,48] So our measures overstate UV radiation intensity and MED in most of parts of the body while people remain standing.

Our results show the high UV radiation to which children involved in a 1-day soccer tournament were exposed. These and other competitions often take place in spring because the weather conditions are better and children's summer holidays start in July. France is considered to be a moderate risk zone for developing skin tumours because of its relatively high latitude. Surprisingly, despite high cloud cover (more than 40%), the UVI remained high, showing that cloud does not provide significant protection against UV radiation. On the other hand, this rather high cloud cover could explain, in part, the inadequacy of sun-protective measures during the afternoon evaluation. Moreover, we have shown that the risk of sunburn (MED) is present before and after peak hours, i.e. 1200–1600 h, during which sun-protective measures are not traditionally recommended. Both of these factors could prompt changes in the sun-protection recommendations issued for these competitions: protection measures must be taken early in the day, before peak hours, and should be maintained despite high cloud cover.

In conclusion, we would like to suggest UV radiation risk-free conditions for children who take part in outdoor sports: where possible, sports should be practised in the shade or outside peak hours and children should wear sun-protective sportswear all day long, except during months with lower UV radiation exposure. These conditions may appear excessive, but could be a basis for further reflection about sun protection in general. Suggestions for future improvement include increasing the number of shaded areas available for spectators and children who are not playing, promoting sun-protection messages issued by sports federations and sports clubs, holding children's 1-day competitions in March or April rather than May or June, and encouraging manufacturers to develop UV radiation-protective sportswear.

These results suggest that popular outdoor sports practised by children should be the target of sun-protection campaigns for several reasons: (i) the MN count in children practising outdoor sports increases very early and MN are, in part, UV radiation-induced skin lesions; (ii) children and their parents are inadequately protected against the harmful effects of UV radiation during competitions; (iii) UV radiation exposure during a 1-day competition can be very high; (iv) people taking part in outdoor sports form quite a close-knit body through which a message can be easily spread and repeated; and (v) sun-protection messages in sports could easily reach children and their parents.

What's already known about this topic?

- Outdoor sporting activities can be associated with high ultraviolet (UV) radiation exposure.
- Intense outdoor sports increase UV radiation-induced skin damage and cancers in adults.
- The melanocytic naevus (MN) count increases mainly in children with fair phototype and high sun exposure.
- High common and atypical MN counts are risk factors for melanoma.

What does this study add?

- The MN count in early life increases as a result of exposure to the sun during outdoor sports in childhood.
- In France, children taking part in soccer matches on sunny days are exposed to high levels of UV radiation.
- Young soccer players and their parents are inadequately protected from the sun during soccer matches.

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