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Review

Protection against Solar Ultraviolet Radiation in Childhood

Nives Pustišek[1] and Mirna Šitum[2]

[1] Children's Hospital Klaićeva, »Sestre milosrdnice« University Hospital Center, Zagreb, Croatia
[2] Department of Dermatology and Venerology, »Sestre milosrdnice« University Hospital Center, Zagreb, Croatia

A B S T R A C T

In the last decade, awareness of the harmful effects of solar ultraviolet radiation has increased. Modern lifestyles, outdoor occupations, sports and other activities make total sun avoidance impossible. Children spend more time outdoors than adults and there is compelling evidence that childhood is a particularly vulnerable time for the photocarcinogenic effects of the sun. Sun exposure among infants and pre-school age children is largely depend on the discretion of adult care providers. It is important to learn safe habits about sun-safety behaviours during the childhood. Children deserve to live and play in safe environments, and it is the responsibility of every adult to help children stay safe. Protecting children from excessive sun exposure is protection from sunburn today and other forms of sun damages, especially skin cancers, in the future.

Key words: *ultraviolet radiation, photoprotection, childhood*

Introduction

In the last decade, awareness of the harmful effects of solar radiation has significantly increased[1]. Modern way of life, outdoor activities and sports among other occupations make total sun avoidance impossible. Children spend much more time outside than adults, and it has been shown that childhood and adolescence are particularly vulnerable periods for the photocarcinogenic effects of the sun[1]. Negative effects of solar radiation accumulate during lifetime and up to 80% of total lifetime accumulation takes place in childhood and adolescence. Child skin is more sensitive than the adult skin because natural defence mechanisms are not fully developed. A short exposure to midday sun may result in sunburns. Epidemiological data demonstrate higher incidence of melanoma among individuals who suffered from sunburns in childhood and adolescence[1,2]. During childhood, the behaviour of children is determined by the behaviour of their social environment: parents, carers and others. Maternal sun habits are predictive of the level of sun exposure in children[3]. It is important to pass on to children knowledge about solar radiation and positive sun habits. Sun protection is not about avoiding outdoor activities, but about protecting the skin from excess sun effects. Correct sun protection includes protection from solar radiation, sunburns today and other forms of skin damages, especially skin carcinoma, in the future.

Avoiding Excess Sun Exposure

More than 70% of ultraviolet (UV) solar radiation reaches the surface of the earth between 10 am and 4 pm. During this period of the day it is best to stay away from the direct sun effect. Shade provides only partial protection, because of reflection. Reflection from the surface of the snow ranges from 30 to 80%, from the surface of the sea 20%, of the sand 6 to 25%, and from the grass 0.5 to 4%[4]. Exposure to artificial sources of UV radiation is as dangerous as the exposure to natural sun. Sun or tanning beds (solaria) are popular among adolescents, poorly supervised and often do not conform to regulations[5].

Clothing and Hats

Clothing provides an excellent method of sun protection, though it protects much better from UVB than UVA rays[4]. In 1996, the concept of ultraviolet protection factor (UVF) was first introduced. It refers to clothing, de-

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fining the level of protection as the factor of time that may be spent in the sun without the risk of sunburns[6]. UPF is analogous to sun protection factors (SPF) in sunscreens. Spectrophotometer is used to measure the transmittance of UVA and UVB rays through the fabric. According to the European Committee for Standardization, for the clothes to be photoprotective, its UPF must be over 30 and the average transmittance of UVA rays under 5%. Clothing must cover upper and lower trunk, from the base of the neck to the thighs, over the shoulders covering ¾ of the arms and then from the waist down to the knees[7]. Factors affecting UPF are the permeability of the fabric; type of the fabric; washing of the clothes; stretchiness and colour of the clothes as well as its distance from the skin[8,9]. Tightly woven, impermeable fabric provides a higher level of protection. Wool and synthetic fabrics such as polyester have a high UPF, while the UPFs of cotton, linen and artificial silk are all below 15[10]. A typical summer cotton T-shirt has an UPF of 5–9, and when wet just 3–4[10]. It has been shown that UPF increases significantly after washing of the clothes and especially after the first wash because the clothes shrink[11]. Stretchy fibres, such as lycra, block UV 100% when they do not adhere to the body; yet stretched, tight lycra is far less effective and has an UPF of 2[12]. Dark clothes provide a much higher level of protection than light clothes, and the closer the clothes is to the skin, the lower the sun protection factor[8,9].

There is now clothing made of fabric with added protection, treated during production with finely distributed particles of titanium dioxide of the size of 500 nm. Except repelling UV rays, this clothing also repels infrared or heat rays so the temperature is up to 10 degrees cooler than in »normal« clothes[12,13].

A wide-brimmed hat is a compulsory item of clothing in the sun. Hats with narrow brim (under 2.5 centimetres) provide an SPF of 1.5 for the skin of the nose and almost no protection for the chin and the neck. Hats with medium-sized brims (2.5 to 7.5 cm), so-called baseball hats, provide protection at the level of SPF 3 for the nose and SPF 2 for the cheeks and neck, but the chin remains unprotected. Only a hat the brim of which measures over 7.5 cm provides adequate shade for the face (nose SPF 7, cheeks SPF 3, neck SPF 5 and chin SPF 2)[4,8].

Sunglasses

Sunglasses must have glass with UVA and UVB protection[14,15]. The effectiveness of sunglasses against UV radiation depends on their shape, size, UV-absorbent materials built in the glass and reflection from the posterior surface of the glass. Usually the glass blocks rays the UV rays under 320 nm. UVA rays pass through »normal« glass so a plastic film containing zinc, chrome, nickel and other materials is used to protect from UVA rays. The USA Ophthalmological Association recommends wearing glasses that absorb 99–100% of UV spectrum (400 nm), while the additional retinal protection may be achieved using glass that reduces UV light transmission. To combat lateral exposure, it is advised to use glasses with lateral protection[14,15].

Window glass blocks UVB rays but it does let in UVA rays. For complete UV protection, it is necessary to equip window panes in houses and cars with additional protection: plastic films with zinc, chrome, nickel and other materials that block wide spectrum of UV radiation[8].

Sunscreens

Sunscreens protect the skin from harmful effects of solar UV radiation but cannot entirely prevent photoageing[4,16]. Depending on the mode of action, they may be divided into chemical and physical sunscreens. *Chemical* or *organic sunscreens* act by absorbing photons of UV radiation with excitation to a higher energetic level. Chemical sunscreens are aromatic compounds that contain electron-releasing and electron-accepting groups. These types of chemical structures absorb photons of UV radiation causing delocalization of electrons from electron-releasing to electron-accepting groups, causing the molecule to move to a higher energetic state, following which the molecule returns to its original state while emitting energy[4,16]. Chemical sunscreens have a specific absorption spectrum and are divided into UVA and UVB chemical sunscreens. *UVB chemical sunscreens* include para-aminobenzoic acid (PABA) and its esters (280–320 nm; λmax 311 nm), cinnamates (290–320 nm; λmax 311 nm), salicylates (290–320 nm; λmax 307 nm), octocrylenes (290–320 nm; λmax 303 nm), ensulizoles (λmax 310 nm), camphor derivates (λmax 300 nm). Although para-aminobenzoic acid (PABA) is the strongest agent in this group, it also frequently causes allergic reactions so for this reason it is rarely found in sunscreens today (PABA-free products). *UVA chemical sunscreens* include benzophenones (250–365 nm; λmax 288 and 325 nm), avobenzones or Parasol 1789 (305–385 nm; λmax 358 nm), anthranilates (λmax 336 nm), Mexoryl SX (λmax 345 nm), Mexoryl XL (λmax 303 i 344 nm), Tinosorb M (λmax 303 and 358 nm) and Tinosorb S (λmax 348 nm). Benzophenones provide protection from both UVA and UVB rays. Chemical sunscreens are effective against UVB rays and they absorb more than 80% of UVB rays on the surface of the skin. Therefore, they prevent UVB-ray-caused sunburns. However UVA protection is not complete and only short-wavelength UVA rays (UVA II spectrum) are absorbed[4,16–19].

Physical or nonorganic sunscreens (sunblock) act as a physical barrier that reflects or scatters UV rays. They are defined as opaque agents the action of which depends on the diameter or the size of the particles as well as the thickness of the layer that reflects and scatters UV radiation[4,19]. New physical sun protection products come in the shape of micro particles and partially act through absorption as well[4,19]. Physical sun protection products may be divided into products that reflect and scatter the visible spectrum and UV radiation; that reflect and scatter the visible spectrum but absorb UV radiation; and those that reflect, scatter and absorb both the visible

spectrum and UV radiation[4,19]. The most commonly used physical UV filters are titanium dioxide, zinc oxide, magnesium silicate and oxide, iron oxide and barium sulphate. Today the most commonly used products from this group are titanium dioxide and zinc oxide. Titanium dioxide and zinc oxide in the form of micro particles may absorb UV rays and reflect and scatter the visible spectrum and UV radiation. Zinc oxide protects from UVB and a wide spectrum of UVA radiation including UVA1 (up to 380 nm). Titanium dioxide protects from UVB and UVA2, but is less effective against UVA1 radiation. Titanium dioxide has a higher index of refraction, which makes it whiter[19,20]. Physical filters for sun protection are photostable and safe. They do not case irritation or sensitisation: for instance, zinc oxide has been approved in products for the prevention and treatment of nappy dermatitis. Most modern sunscreens are a combination of these chemical and physical agents.

Sun protection factor

Sun Protection Factor (SPF) is a laboratory measure of the effectiveness of a sunscreen. SPF is defined as a ratio of the UV dose that causes 1 minimal erythema dose (MED) on the skin protected with the sunscreen, and the UV dose causing 1 MED on the unprotected skin. SPF is based on the measuring of photoprotection against UVB radiation-caused erythema (sunburns). According to this definition, a person who »burns« in the sun in (for example) 20 minutes, will, with SPF 3, burn only after the exposure of 1 hr. It is important to apply 2 milligrams of the sunscreen per 1 square centimetre of the skin. In other words, SPF tells us how long we can stay in the sun without burning, that is, it informs us of the level of protection against UVB radiation. A universal protocol for testing UVA protection does not exist[4,8]. In August 2007, FDA suggested that a 4-star scale on sunscreen packaging should be used to indicate the level of UVA protection, whereby one star would correspond with a low-level of UVA protection and four star the highest UVA protection. If a sunscreen does not protect from UVA radiation, its packaging must clearly state »no UVA protection« [19].

Vehicles

In a sunscreen its vehicles determines its efficacy, especially after swimming and sweating, and its tolerability[4,8]. *Lotions* and *creams* are the most frequently used forms of sunscreens. *Gels* penetrate better and provide excellent protection but many people found them irritable, in particular if applied on the face and around the eyes. *Sticks* are difficult to apply but excellent for protecting small areas, such as lips, nose, and eye area. *Aerosols* are easy to use and can cover a wide area fast, but may be difficult to apply evenly[4].

Sunscreens may also be divided with respect to their water resistance[4]. The label of a *water-resistant product* confirms that the product will retain its SPF level after 40 minutes of immersion into water. The label *very water-resistant* or *water-proof product* denotes retaining the SPF level after 80 minutes of immersion into water[4].

Using sunscreens in infants

In 1999, FDA recommended against the use of sunscreens in children under 6 months of age, as the infant skin has different absorption characteristics and the ability to metabolize and excrete the absorbed medication may not be fully developed. The best method of protection for this age group is to avoid direct exposure to sun and to use appropriate clothing and shade. If necessary, controlled and occasional use of sunscreens is allowed on the exposed parts of the body[8].

Educational Programmes

Protection from harmful effects of the sun is becoming the focus of health educational programmes in Australia, New Zealand, North America and Europe[21–25]. Numerous studies have shown that sun protection is still inadequate. Only 20% of school-age children receive adequate sun protection, and 78% of the examined believes that sun exposure is associated with temperature of the environment[22–24]. In spite of the numerous warnings, especially girls and young women (16–34 years of age) use sunbeds. In the U.S., the sunbed industry earns up to 5 billion $ per annum[5].

Education should start at the earliest possible age[21,25]. Its purpose is to increase awareness, knowledge and understanding of the harmful effects of sun radiation and means of skin protection. The goal of education is prevention of short-term and long-term harmful consequences of excess harmful sun effects upon children's health.

Conclusion

Negative effects of sun radiation accumulate during lifetime and it has been proven that up to 80% of the total lifetime accumulation takes place before 18 years of age. This is why it is essential to introduce sun protection at the earliest age and to teach children positive habits and attitudes. Infants under six months of age should not be exposed to direct sun. For older children, avoidance of direct sun exposure between 10 am and 4 pm, when sun radiation is the strongest, as well as wearing suitable hats and sunglasses, along with regular application of sunscreens with UVA and UVB filters, will provide adequate protection.

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N. Pustišek

Children's Hospital Klaićeva, »Sestre milosrdnice« University Hospital Center, Klaićeva 16, 10 000 Zagreb, Croatia
e-mail: nives.pustisek@kbcsm.hr

ZAŠTITA OD SUNČEVOG ULTRALJUBIČASTOG ZRAČENJA U DJETINJSTVU

S A Ž E T A K

U posljednih desetak godina osvješćivanje o štetnosti sunčevog zračenja značajno je poraslo. Suvremen način života, igre na otvorenom, sportske aktivnosti i drugo onemogućavaju potpuno izbjegavanje sunčevog zračenja. Djeca provode puno više vremena na otvorenom nego odrasli, a dokazano je da je djetinjstvo i adolescencija posebno vulnerabilno razdoblje u fotokarcinogenom djelovanju sunca. Tijekom djetinjstva, ponašanje djece je određeno ponašanjem njihove okoline, roditelja, odgajatelja itd. Vrlo je važno znanja i pozitivne navike o pravilnoj zaštiti od sunca prenjeti djeci. Svrha zaštite od sunca i nije izbjegavanje aktivnosti na otvorenom, nego zaštita kože od prekomjernog štetnog djelovanja sunca. Pravilna zaštita od sunca znači zaštitu od sunčevog zračenja, sunčanih opeklina danas te drugih oblika oštećenja kože, osobito kožnih karcinoma u budućnosti.