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Sun Protection for Children: A Review

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Chronic ultraviolet exposure results in premature skin aging (photoaging), dyspigmentation, sallow color, textural changes, loss of elasticity, and premalignant actinic keratoses. UVB radiation is mainly responsible for acute damages such as sunburn, and long-term damage including melanoma. Today the sun's ultraviolet radiation (UVR) induced skin cancer is a major issue worldwide. History of sun exposure and sunburns are the most important behavioral risks. Childhood sun exposure is considered as a substantial risk because a child's skin has a thinner stratum corneum, lower levels of protective melanin, and a higher surface area to body-mass-ratio. Thus, protection against UVR in childhood is essential. Research has shown that people who have had a sunburn in childhood or were in the sun unprotected are more likely to have skin cancer. In this article, we review the literature to address the protection of children against sun and skin cancer.

Keywords: Sunlight; Infant; Ultraviolet Ray; Sun Protection Factor

1. Context

The skin has the innate immune response in addition to its role as an active physical barrier. Immunosuppression and skin cancer genesis are widely studied as the main toxic effects of ultraviolet radiation (UVR) on adult skin. Infant and toddler skin is more sensitive in comparison with adults but there is little information about acute or long-term effects of UVR on infant skin. Infant skin is immature and doesn't act enough as a barrier against hazardous agents such as UVR. The skin's characteristics during the first two years of life may begin as early as exposure to the sun during their first summer in an infant's life (1). There is evidence that incidences of sunburn increase the risk of developing malignant melanoma especially sunburn in childhood (2). Skin carcinoma including melanoma and non-melanoma cancers are the most commonly diagnosed cancers in the USA with an incidence rate for melanoma has increased over the last 25 years and is increasing faster than most other cancers (3, 4). Sun-exposure has long been introduced as a major environmental risk factor for non-melanoma skin cancer and melanoma (5).

Recognition that sun exposure early in life is an important risk factor for cutaneous melanoma in Caucasians (6) has led to efforts to minimize sun exposure particularly in children for populations at high risk of skin cancer (7). The skin as the outer surface of the body is naturally exposed to a plethora of noxious environmental agents including UVR. The adverse effects of solar UV include the induction of cutaneous tumors, such as actinic keratoses, basal cell carcinomas, squamous cell carcinomas, and, possibly, malignant melanoma (8). Infants and babies are particularly sensitive to the damaging effects of UVR. The earlier in life that the DNA has been exposed to UVR the greater the chance of mutations due to a larger number of cell replications over time. In addition, infants have a high surface area to low body mass ratio with increased potential for absorption of chemical compounds from sunscreens. The metabolic system of infants may not yet be capable of handling or detoxifying these chemicals. Finally, the earlier in life sun exposure begins, the longer the period over which damages will occur. Therefore, total sun protection is recommended particularly for infants under 6 months of age by all health directions. Vitamin D may be prescribed for breastfed infants (most supplement formulas contain vitamin D) as there is uncertainty whether the amount of vitamin D that passes through breast milk is sufficient for infant needs (9, 10).

Sun protection in children has recently become an interesting topic for health care professionals who deal with skin health issues. The strongest driving factor for this issue is skin cancer prevention. This relatively recent skin cancer epidemic has been causally linked to excessive UVR exposure (9, 11). Schoolchildren are at risk of spending excess periods outdoors and, therefore, will

likely experience sunburns. The results of other research has been shown that factors such as outdoor activities and water sports were predictably apparent with patients being burned on days with extremely high UVR ratings (12, 13).

2. Evidence Acquisition

To address the protection of children against sun and skin cancer, several databases such as PubMed in Medline area, Google scholar, Ovid, Cochrane, and Iranian databases such as SID, Iranmedex, were reviewed for articles published in both English and Persian languages by searching the following keywords: Sunlight; Infant; Ultraviolet Ray; Sun Protection Factor. The qualitative results obtained from the reviewed articles are presented here.

3. Results

3.1. Infant Epidermis Structure

The significant structural and functional differences between adult and infant skin suggest a greater susceptibility of infants to transdermal absorption of chemical sunscreens and penetration of UVR. However, few studies have been performed to address UVR-induced responses in infants or specifically the kinetics of melanogenesis. The outermost layer of epidermis, the stratum corneum (SC), protects inner layers of skin from adverse environmental conditions, including UVR penetration, invasive micro-organisms, physical disruptions, and systemic absorption of topically applied materials such as sunscreens (Figure 1) (1, 14).

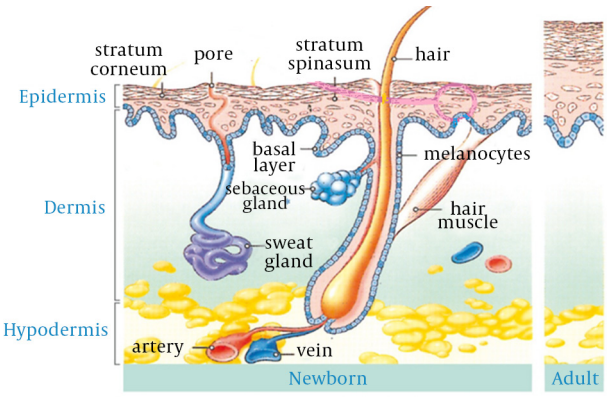

Figure 1. Infant's Skin Structure

3.2. Epidermis

The Epidermis is comprised of several layers including stratum corneum (horny layer), which is the outermost layer exposed to the environment; stratum granulosum (granular layer), stratum spinosum (prickle cell layer), and stratum basale (basal layer) (15).

3.3. Dermis

The dermis (or corium) is 3-5 mm thick and is composed of some connective tissues especially collagen fibrils and elastic tissues that respectively provide support and flexibility to the dermis (15).

3.4. Photo Carcinogenesis

UVB radiation has a carcinogen effect and can generate squamous cell carcinomas in mammals. This effect for the generation of squamous cell carcinoma occurs mostly in the UVB range. Although there is a peak of activity in the UVA range (320-400 nm), whereas UVB is affective on tumor initiation, UVA predominantly causes tumor promotion. UVB generates more oxidative stress at levels found in sun radiation when compared with UVA for which UVA is 10 times more efficient than UVB at causing lipid peroxidation. UVA has a greater cytotoxic effect than UVB, UVA damages DNA by causing strand breaks and oxidation of nucleic acids (16-18).

3.5. Radiation and Its Effects

Sunlight contains three types of UVR, grouped according to evoked biological effects and wavelength as follows:

-UVA (320-400 nm);
-UVB (290-320 nm);
-UVC (200-290 nm).

UVA and UVB penetrate the atmosphere and can damage human skin even though the upper atmosphere, ozone layer, filters out UVC. Epidemiologic research results, including from case-control studies, have linked intense and intermittent exposure to UVR and sunburn during childhood and adolescence to increased risks of melanoma (19, 20), and basal cell carcinoma later in life. UVR has a well-established risk factor effect for skin carcinoma and photo aging. The incidence of skin carcinoma continues to rise in part due to increased sun exposure. Multiple studies have concerned the association between UV exposure in childhood and adolescence as well as the development of skin cancer (21). Excess sun exposure can lead to deleterious sequelae such as skin cancer, photo aging, immune-suppression, and exacerbation of photo toxicities. Sun protection is critical for the pediatric age group, because studies have proven that the amount of sun exposure during this period is related to subsequent risks for melanoma and other skin cancers (22).

3.6. Carcinogenic Agents in Children

Exposure to chemical compounds with a carcinogenic effect during early life stages has major risks for carcinoma in adolescence and the elderly because organ systems have high division rate in cells during childhood when compared with adolescence. Clinical manifestation for cancers caused by carcinogens have a greater chance to develop during characteristically long latency periods

because young people have a longer expected number of years of life. There are several chemical compounds with a carcinogenic effect in the body. These compounds increase risk for all types of carcinomas. Mutagenic, non-mutagenic, or epigenetic mechanisms and disruptions of endocrine systems are the main mechanisms of carcinogen agents. Chemical carcinogens are components of our food and drink as well as from the air and other environmental conditions. These facts complicate their risks (23).

Carcinogens can be taken into the body by ingestion, inhalation, or transdermal routes. These chemicals can be ingested via contaminated food, water, and, even, breast milk (24). Ingestion is the current pathway for exposure to carcinogenic compounds and heavy metals. There are polycyclic aromatic hydrocarbons (PAHs), known to be carcinogenic, in charred foods. Smoked and preserved meats contain nitrosamines, which are known to be carcinogenic. Although many carcinogens are produced synthetically, others are natural substances or metals. Arsenic, for example, tops the list of chemicals that concern the Agency for Toxic Substances and Disease Registry (25). Studies of those exposed to ionizing radiation have shown the strongest evidence that exposure to a carcinogen early in life poses a greater risk than exposure during adulthood. Much of what we know about ionizing radiation and cancer comes from evaluations of atomic bomb survivors (26). Those children who were younger than age 5 at the time of the nuclear blasts at Hiroshima and Nagasaki that ended Word War 2 had a greater than two-times chances for the relative risks of cancer incidences later in life compared with older children who were between the ages of 5-15 at the time of the blasts (19). In today's world, children often suffer from other sources of radiation, including background radiation, radiation from medical treatments, radon, and UVR from the sun. Of particular concern are children living in areas with high levels of radon rays (27) and exposure to frequent computed tomography scans (28). The incidences of malignant melanoma (MM) and non-melanoma skin cancers (NMSCs) have been increasing at alarming rates. NMSCs are basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). There is evidence that exposure to UVR is associated with the incidence risk of MM and NMSCs. Even though NMSC mainly affect the elderly, 2-3% of MMs occur in children and adolescents (29).

3.7. Burden of Skin Cancer

The two most common kinds of skin cancer, basal cell carcinoma and squamous cell carcinoma, are highly curable. However, melanoma, the third most common type of skin cancer and one of the most common cancers among young adults is more dangerous. In 2001, approximately 1.3 million new cases of BCC or SCC were diagnosed with approximately 2,000 deaths from their combination. Melanoma, by contrast, will be diagnosed in 53,600 persons and accounts for 7,400 deaths, which is more than three fourths of all skin cancer deaths (16, 30).

3.8. Risk Factors for Melanoma

The association between sun exposure and risks of melanoma seems complex. Melanomas are believed to arise from several casual pathways, with relationship to sun exposure differing by the anatomical site of the melanoma, and the pattern as well as age period of sun exposure (31). The main risk factors for melanoma are as follows:

-Personal or family history of melanoma;

-Light skin or sun-sensitive skin types (i.e. sunburns easily and tans poorly);

-Presence of moles and freckles;

-History of excessive sun exposure, including severe sunburn; and/or,

-Exposure to indoor tanning booths occurring early in life (32, 33).

3.9. Risk Factors for Basal and Squamous Cell Cancers

Cutaneous squamous and basal cell carcinoma (SCC) incidence is increasing worldwide. The main risk factors for basal and squamous cell cancer are as follows:

-Chronic exposure to the sun light;

-Personal or family history of skin cancer;

-Light skin color; and/or,

-Having actinic keratosis (e.g. scaly patches of skin) (33, 34).

3.10. Measures to Prevent Skin Cancer

The main guides for prevention from skin cancer are as follows:

-Avoid direct exposure to the sun, especially between the hours of 10 a.m. and 4 p.m. when UV rays are the most intense.

-Cover the skin by wearing hats with a brim wide enough to shade face, ears, and neck as well as clothing that adequately covers the arms, legs, and torso.

-Apply adequate and repeated amounts of broad-spectrum sunscreen lotion with a sun protection factor (SPF) of 15 or higher to exposed skin.

-Avoid indoor tanning booths (solarium) and sunlamps (30, 35).

-Use of vitamin E and C as active anti-oxidative agent (36).

Sunscreens are frequently applied as protective agents against UV-induced damage to the skin. The effectiveness of sunscreens, as expressed by their sun protection factor (SPF), is usually determined by their ability to prevent and delay the development of skin erythema (8).

3.11. UVR Exposure Behaviors

UVR damage of unprotected skin should be minimized by limiting the amount of UVR exposure, by timing out-

door activities when UVR rays are less intense, by using protective clothing and applying suitable amounts of sunscreen, and by avoiding tanning booths and sunlamps (30). Previous studies have indicated that many adults and adolescents in the USA do not regularly protect themselves when outdoors on sunny days (37). In 2009, the results of one study showed that 9.3% of US high school students used sunscreen routinely. Additionally, this was the only sun-protection practice assessed at the time (Table 1). In adults, national data showed that of the 32.6% who reported always or often using sunscreen when outside for an hour or more on a warm, sunny day in the past 12 months, and of the 31.5% who reported seeking shade, while fewer adults reported clothing protection behaviors, including using hats (14.3%) or long-sleeved shirts (11.6%) (Table 1) (30, 38).

National surveys of parents and caregivers were conducted in 1997 and 1998 to determine the prevalence of sun protection for children. For children aged 12 years or younger, parents and babysitters reported the use of one or more measures of sun protection for three quarters of the children. The use of sunscreen (61.8%) and shade (26.5%) were reported most frequently (39).

Table 1. Ultraviolet Radiation Exposure Behaviors, US High School Students and Adults 18 Years and Older, USA, 2009-2010[a]

Variable	Total	Male	Female
High school students, 2009			
Apply sunscreen	9.3	6.5	12.4
Used indoor tanning device	15.6	6.7	25.4
Adults, 2010			
Apply sunscreen	32.1	32.6	42.2
Wear a hat	12.8	13.0	12.5
Seek the shade	37.1	30.3	43.7
Wear long-sleeved shirt	11.5	12.2	10.9
Wear long pants	32.7	38.6	27.1
Used indoor tanning device (2008)	15.0	12.0	17.8

[a] Data are presented as %.

3.12. Effects of Sunscreens

Sunscreens are produced and clinically examined to reduce skin erythema from exposure to UVR. In this sense, they can be said to have a beneficial, protective effect when properly applied by the consumer that is consistent with the claims of the marketer (9, 40).

3.13. SPF

The sun protection factor (SPF) is introduced as an integer number. SPF = T1/T0 where T0 is the time interval during which one person can stay in the sun without sunscreen before having accumulated enough damage to develop erythema, and T1 is the time interval necessary to accumulate the same amount of skin erythema after using sunscreen (9).

3.14. Sun Protection for Infants and Children

In vivo sun protection tests for infants and children remain suboptimal despite a growing understanding of infant skin's unique vulnerabilities and needs. Sunburn incidences among American children remain substantial, ranging from 29-83% for the summer season and between 7-13% for a single summer weekend. Skin cancer prevention can be amended by four sun protection strategies: cessation of deliberate tanning by either natural or artificial light (tanning booths), avoiding excessive outdoor activities between 10:00 AM and 4:00 PM, use of protective clothing such as a broad brimmed hat, sunglasses, and protective clothing (tightly woven fabrics in long-sleeved shirts and long pants), and daily use of a broad-spectrum sunscreen with a SPF greater than 15. Broad-spectrum sunscreens, which were widely introduced in the Midwestern United States in 1993, provide UVA protection (320-340 nm), and the SPF indicates the amount of blocking of UVB rays (32, 41, 42).

There are several hazardous effects of sunlight on children and adolescents (Box 1). Photosensitivity disorders include genetic and metabolic diseases as well as idiopathic conditions in which the cause is unknown. In addition, several other disorders are aggravated on exposure to sunlight (Box 2). The adults and children are affected by photosensitivity disorders, although those due to genetic defects (Box 3) have manifestations in childhood (26). Photo immune suppression is another harmful effect of sunlight, which refers to the suppression of the immune system by UVR. UVA and UVB participate in the suppression of immunity (43). Using sunscreen and clothing are the two main ways for sun protection for children. The comparison of these two methods has been discussed in several papers. Although a previous study indicated that it has estimated that if sunscreen were used on sun-exposed areas of children from birth to age 20, their lifetime risk of non-melanoma skin cancer would be reduced by 85%. Furthermore, the risks of developing melanoma may be reduced by half by eliminating blistering sunburns before age 20 (44). Nevertheless, recent research shows that no sunscreen is ideal in terms of efficacy, safety, and practicality. Many properties, including solar protection, physical stability, photo stability, skin penetration, microbial resistance, and wash resistance were considered in formulating and preparing sunscreens. The reason for this is that one property was often sacrificed for another. Sunscreens that stain clothing or are hard to spread, greasy, or opaque may not be used in suitable amounts, if at all, regardless of potential to screen UVR (45-47).

Choosing effective, safe, and suitable sunscreen preparations for infants and toddlers is even more complicated. Baby sunscreens should be non-irritating and non-sensitizing to the skin and eyes in addition to providing suitable sun protection. Photo-stability and ease of spreading on skin are the main characteristics that

need to be considered but transparency and water resistance of sunscreens are considered less important. For example, a mother may use an invisible sunscreen for her own skin but prefer an opaque sunscreen that leaves a temporary film on her infant's skin to ensure complete coverage (1). Sunscreen products that do not have eye irritancy are also important because infants often rub topical products into or near their eyes. Infant lacrimal secretion is still developing and the involuntary blinking that protects the eyes continues to mature throughout the first year of life, which increases vulnerability (48, 49). Studies have shown that by wearing sunglasses and a hat was more effective than the use of sunscreens to prevent sunburn and skin cancer (50, 51).

There are other important ways to protect infants from the harmful rays of the sun. They are as follows:

-An umbrella and wide brimmed hat for shade,

-A cooler for liquids,

-A bottle for hydration, and/or

-Clothing for covering the skin (52).

The best protection is to keep infants in the shade and if possible, keep from the sunlight altogether. If there is no natural shade, create it with an umbrella or the canopy of a stroller (52). In addition, lifestyle changes and the education of parents in child sun protection (53-56). Several studies have shown that mothers have the main role in children's sun behavior and exposure (57).

3.15. Changes in Lifestyle

The development of leisure activities and utilization of holidays have resulted in greater exposure of the skin to UVR. Any effective preventive approach has to encourage changes in lifestyle such as limiting outside activities during the midday period and utilizing early mornings and late afternoons for sports. The objective is to decrease the time of exposure of skin to UVR. Educational programs and media participation are important in changing long-held concepts about sun exposure and the harmful effects of UVR (29).

3.16. Sun Protection Guidelines for Children

Some of the considerations for infant sun-screening are as follows:

-Reduce exposure to sun UV radiation, especially between 10:00 AM and 4:00 PM DST (9 AM-3 PM ST).

-Wear suitable clothing (e.g., wide-brimmed hats, UV protective sunglasses, long-sleeved shirts, and pants).

Box 1. Harmful Effects of Ultraviolet Radiation

Harmful Effects of UVR
Photosensitivity disorders
Suppression of the immune system
Photo-aging of the skin
Development of skin cancer

Box 2. Classification of Photosensitivity Disorders

Variables
Metabolic and Genetic
Cockayne syndrome
Pellagra
Xerodermapigmentosum
Chronic actinic dermatitis
Juvenile spring eruption
Photo aggravated disorders
Connective-tissue diseases
Darier disease
Herpes simplex
Reticular erythematous mucinosis
Bloom Syndrome
Hartnup disease
Porphyria
Idiopathic and allergic
Hydroavacciniforme and hydroa
Polymorphous light eruption
Actinic lichen planus
Dermatomyositis
Disseminated superficial actinic
Pityriasis alba
Rosacea
Actinic Prurigo of Native Americans
Kindler syndrome
Rothmund-Thompson syndrome
Actinic prurigo
Estivale
Solar urticarial
Atopic dermatitis
Lupus erythematosus
Porokeratosis
Pemphigus foliaceus
Transient acantholyticdermatosis

Box 3. Genetic Photosensitive Disorders

Genetic Photosensitive Disorders
Bloom syndrome
Cockayne syndrome
Hartnup disease and aminoacidurias
Kindler syndrome
Rothmund-Thompson syndrome
Xerodermapigmentosum

Hats with a 10 cm brim all around are best because it protects the neck, ears, eyes, and scalp.

-Always use sunscreen products while outdoors, especially when sand, snow, or water are present, and at high elevations or in southern locations.

-Avoid artificial tanning devices, such as solariums and sunlamps.

-Use hats, clothing, and shading rather than sunscreen for children less than 6 months old.

-Use the UV Index when planning outdoor activities.

-Use sunscreens with an SPF of 15 or greater (including protective SPF lip balm) and repeat it every 2 hours (11).

Physicians and other healthcare personnel are in an ideal position to promote sun protection among adolescents and their parents. While there is growing evidence supporting the role of physicians in affecting adolescent primary skin cancer behaviors, it is necessary for future interventions to establish this relationship conclusively and to study the relative efficacy of physician counseling vis-à-vis other channels of sun protection information (57).

4. Conclusions

The suitable use of sun protective agents according to children is improvable. Consequently, future prevention efforts should promote the regular and combined use of multiple sun protection measures for children in the general population. The remaining in shade, using clothes, and hats before sunscreen should be clarified. A need for sun protective products also for darker skin types has to be emphasized. An extended and regular presentation of the UV protective value should be achieved to improve the awareness of the UVR hazard and the need of protection.

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