Sun protection and Vitamin D

Louise Reiche

Dermatologist, Aorangi Hospital, Palmerston North, New Zealand

Abstract Sun protection relies on behavioural sun avoidance, appropriate high UV protective clothing, sunglasses, broad-rim hats and sunscreen. Daily use of broad-spectrum sunscreen can significantly reduce UV-induced skin damage, BCC and SCC skin cancers and if used regularly in early life, can reduce lifetime skin cancers by 80% and might reduce naevus counts and subsequent melanoma risk. Sunscreen components are grouped into inorganic/physical and organic/chemical filters. Inorganic sunscreens are photostable, non-absorbed, non-sensitising and work by reflecting and diffusing UVR. Microionised forms improve cosmesis. Organic filters absorb UVR energy within specific wavelength ranges and are variably photostable or photoreactive. Sunscreen effectiveness varies among products due to composition, age, storage conditions, and consumer application. UVB filter effect is graded by SPF (sun protection factor) but there is no universally agreed grading for UVA, infra-red, visible light, or immunosuppression. UVA exposure may be more relevant for melanoma and photoageing. Physiological health benefits from UVA exposure are currently unidentified. Vitamin D is maximally produced in the skin at suberythemal doses within the UVB spectrum. The majority of epidemiological studies have found adequate Vitamin D levels in those using regular sunscreen. Hopefully future sunscreens will provide better protection beyond UVB.

UV effects

Nonmelanoma skin cancer incidence is directly related to latitude, and long-term chronic ultraviolet (UV) exposure whereas melanoma risk is better related to annual, ambient and acute intermittent high UV exposure, (De Gruifi 2002, Armstrong & Kricker 2001). UVB impacts directly on cell DNA and proteins whereas UVA is a strong immune suppressant, penetrates deeper into the skin and contributes to photocarcinogenesis and photoageing by producing damaging oxygen free radicals (Pathak 1997, Urbach 2001). Effects of excessive UV exposure persist lifelong. Vitamin D, important for general health (Holick *et al* 1980), is optimally produced in the skin from UVB, at a very low dose 0.25 of the minimal erythema dose. Maximal UVB levels are typically found around noon. The ratio of UVA to UVB is 20:1 (Kullavanijaya 2005). So longer sun exposure in any day increases cumulative UVA-induced damage. Daily use of broad-spectrum sunscreen can significantly reduce UV-induced skin damage, basal and squamous cell carcinomas (BCC, SCC), dysplastic naevi and if used regularly in early life, might reduce naevus counts and subsequent melanoma risk (Fourtainer *et al* 2003, Marks 2000, Naylor *et al* 1995, MacLennan *et al* 2003, Huncharek *et al*, Rigel 2002).

Sun protection

The NZ Cancer Society recommends sun avoidance behaviour during peak UV index (UVI >8) hours and combined measures of sun protection using appropriate clothing, wide-brimmed hat, sunglasses and broad spectrum sunscreen when outdoors in UVI >3.

UV protection factor (UPF), assessed by measuring transmission of UVA and UVB through fabrics with a spectrophotometer, grades UV protection from clothing. Higher UPF is achieved by tighter weave, darker colours, and distance of fabric from the skin. Hydration alters UPF differently in different fabrics e.g. a typical summer cotton T-shirt provides UPF=7 but when wet the UPF =3, whereas fabrics made of viscose or silk may increase UPF when wet. Clothing UPF should be > 30 and the design should cover the upper body (base of neck down to hip and across shoulders down to ¾ of upper arm), and lower body from waist to knee (Kullavanijaya 2005).

Depending on the fabric, design, brim width and the way they are worn, hats provide variable sun protection for the head, face and neck. A wide brimmed hat (>7.5cm) has SPF 7 for nose, 3 for cheek, 5 for neck and 2 for chin. Medium-brimmed hats (2.5cm-7.5cm) provide SPF 3 for nose, 2 for cheek and neck and none for chin. Narrow-brimmed hates provide SPF 1.5 for nose and little protection for chin and neck (Carolyn *et al* 1997).

Sunglasses which absorb 99-100% of the full UV spectrum (up to 400nm) should be worn to protect against cataracts and eye cancer (Davis 1990).

Non-clothed skin may achieve partial sun protection from the use of sunscreen. Sunscreen components are grouped into inorganic (physical /non-chemical) and organic ('chemical") filters. Titanium dioxide and zinc oxide are inorganic, photostable, not absorbed systemically, and have not been reported to sensitise (cause allergic skin reactions). They work by reflecting and diffusing UVR (Forestier 2008). Decreasing particle size from 200-500nm to microionised form (10-50nm) reduces the cosmetically unacceptable white colour but shifts protection towards shorter wavelengths unless the titanium dioxide and zinc oxide particles are coated with dimethicone or silica. Organic filters absorb UVR energy variably within a specific range of wavelength depending on their chemical structure and the absorbed energy is converted to unnoticeable infrared energy (Kullavanijaya 2005). The chromophores are "photostable" if able to absorb UVR photons repetitively, "photounstable" if the filter rapidly loses its absorption capacity and protective potency and "photoreactive" if absorbed UV photons create photoexcited molecules which then interact with skin biomolecules, ambient O_2 or other sunscreen ingredient. Effective UVB filters include para-aminobenzoic acid (PABA) derivatives (e.g. octyl dimethyl para-aminobenzoic acid), cinnamates, salicylates, octocrylene and phenylbenzimidazole sulfonic acid. Octyl methoxycinnamate degrades into a photoproduct when exposed to sunlight but this is mitigated if encapsulated into nanoparticles. In addition to titanium dioxide and zinc oxide, effective UVA filters include benzophenones, avobenzone, and menthyl anthranilate. Benzophenones and avobenzone are photolabile so are frequently combined with other ingredients e.g. salicylates, micronised zinc oxide or titanium dioxide to enhance their photostability. “Broad-spectrum” filters have a high level of absorption in both the UVB and UVA ranges. Because sunscreen stability (particularly UVA cover) is variable, sunscreens should be frequently re-applied, stored away from heat and sunlight and discarded at expiry date.

The standard method for Sun Protection Factor (SPF) rating, the ratio of the time to produce minimal UVB-induced skin erythema from the sunscreen compared to unprotected skin, involves applying 2mg/cm of the product, much more than the 0.5mg / cm typically applied by consumers (Bech-Thomasen *et al* 1993). The *effectiveness* of sunscreen SPF may be exponentially related to the amount applied so the true SPF may be as little as a 4th root of the claimed SPF! Arguably the SPF rating ought to be assigned as consumers use the product i.e. at 0.5mg/cm rather than 2mg/cm. There is no universally agreed grading for UVA, infra-red, visible light, or immunosuppression. Perspiration, swimming and clothing reduce skin sunscreen. Both the Cancer Society and the Health Sponsorship Council of NZ recommend that an average-sized adult needs to use one teaspoon of sunscreen on each limb, on both torso sides, and half a teaspoon to the face, neck and ears to achieve adequate coverage, and to reapply frequently.

Vitamin D not reduced by sunscreen use

Theoretically a high SPF-rated sunscreen provides better UVB protection and thus would impair Vitamin D production. However, normal regular sunscreen usage has not been associated with Vitamin D insufficiency in most studies (Farrerons *et* al 2001, Marks *et* al 1995, Norval *et* al 2009) except (Matsouka *et* al 1987), possibly because insufficient sunscreen is applied and sunscreen users may expose themselves to more sun (Im *et al* 2010).

Photo-antioxidants may help reduce UVA-induced damage. Topical antioxidants tend to be unstable but may enhance sunscreen efficacy e.g. Vitamins C and E. Dietary photoprotection flavonoids and polyphenolic compounds found in many fruits and vegetables, some plant extracts, and omega-3 polyunsaturated fatty acid are probably better (Kullavanijaya 2005).

Current best photoprotective recommendations involve judicious sun avoidance, photoprotective clothing, wide-brimmed hat, sunglasses and use of broad spectrum sunscreens. Additional protection may be gained from dietary photoantioxidants. Future sunscreens may incorporate better UVA and immune protection, without impeding Vitamin D production.

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