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**Sunscreens**

Excessive exposure to ultraviolet (UV) radiation is associated with sunburn, photoaging, and skin cancer.¹,² Sunscreens are widely used to reduce these risks, but some questions remain about their effectiveness and safety.

**UVA and UVB** — UV radiation capable of injuring the skin is classified based on wavelength as UVA1 (340-400 nm), UVA2 (320-340 nm), and UVB (290-320 nm). UVA, which makes up 95% of terrestrial UV radiation, penetrates the dermis and causes long-term damage. UVB, which is mostly absorbed in the epidermis, is largely responsible for the erythema of sunburn. Both UVA and UVB can cause photoaging and skin cancer. UVB is strongest at midday and is present primarily in late spring, summer, and early autumn in temperate climates. UVA is constant throughout the day and the year and, unlike UVB, is not filtered by clear glass.

**SPF** — Sun Protection Factor (SPF) is the ratio of the time required to develop a minimally detectable sunburn while wearing a sunscreen product to the time required without wearing the product. It represents the fraction of erythema-producing UV light (primarily UVB) that penetrates through the product to reach the skin. When properly applied, an SPF 15 sunscreen allows penetration of 1/15th (7%) of erythemogenic UV photons, an SPF 50 sunscreen transmits 1/50th (2%), and an SPF 100 sunscreen transmits 1/100th (1%). Accordingly, SPF 50 and 100 sunscreens are only moderately more protective than SPF 15 sunscreens: 98% or 99% vs 93%.

There is no specific rating system in the US for the amount of UVA protection provided by a sunscreen. The FDA allows sunscreens to be labeled “broad-spectrum” if they provide UVA and UVB protection and the UVA protection is proportional to the UVB protection. Broad-spectrum sunscreens with an SPF ≥15 can claim that they can reduce the risk of skin cancer and early skin aging if used as directed with other sun protection measures. The FDA and the US Preventive Services Task Force (USPSTF) both recommend use of a broad-spectrum sunscreen with an SPF ≥15.³,⁴ The American Academy of Dermatology recommends use of a product with an SPF ≥30.⁵

**SUNSCREEN ACTIVE INGREDIENTS** — Organic — Several organic (chemical) sunscreens that absorb different wavelengths of UV light are approved by the FDA (see Table 1). Avobenzone is an effective UVA absorber and also absorbs some UVA2, but its efficacy decreases by about 60% after 60 minutes of exposure to sunlight due to photolability; the photostability of avobenzone is improved by combining it with other photostable UV filters. Octinoxate is a potent UVB...
Table 2. Some Sunscreen Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Formulation</th>
<th>Active Ingredients</th>
<th>UV Protection</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPF 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthelios SX SPF 15 (La Roche-Posay)</td>
<td>Cream (3.4 oz)</td>
<td>Avobenzone 2%, ecamsule® 2%, octocrylene 10%</td>
<td>UVB/UV-A1/UVA1</td>
<td>$34.00</td>
</tr>
<tr>
<td>Badger Active SPF 15 (W.S. Badger)</td>
<td>Cream (2.9 fl oz)</td>
<td>Zinc oxide 10%</td>
<td>UVB/UV-A1/UVA1</td>
<td>$13.60</td>
</tr>
<tr>
<td>Banana Boat Protective Dry Oil SPF 15 (Edgewell)</td>
<td>Spray (6.0 fl oz)</td>
<td>Avobenzone 1.5%, homosalate 5%, octocrylene 3.5%</td>
<td>UVB/UV-A1</td>
<td>$10.99</td>
</tr>
<tr>
<td>Coppertone Sport SPF 15 (Bayer)</td>
<td>Spray (6.0 fl oz)</td>
<td>Avobenzone 2%, octisalate 4.5%, octocrylene 7%</td>
<td>UVB/UV-A1</td>
<td>$11.49</td>
</tr>
<tr>
<td>Hawaiian Tropic Sheer Touch SPF 15 (Edgewell)</td>
<td>Lotion (8.0 fl oz)</td>
<td>Avobenzone 1.5%, homosalate 3%, octisalate 4.5%, octocrylene 3%</td>
<td>UVB/UV-A1</td>
<td>$11.79</td>
</tr>
<tr>
<td>No-Ad SPF 15 (No-Ad)</td>
<td>Lotion (16 fl oz)</td>
<td>Avobenzone 1.2%, homosalate 7.5%, octisalate 5%</td>
<td>UVB/UV-A1</td>
<td>$7.57</td>
</tr>
<tr>
<td>Banana Boat Sport SPF 35 (Panama Jack)</td>
<td>Cream (2.9 fl oz)</td>
<td>Zinc oxide 22.5%</td>
<td>UVB/UV-A1</td>
<td>$13.60</td>
</tr>
<tr>
<td>Banana Boat Sport Performance SPF 30 (Edgewell)</td>
<td>Spray (6.0 fl oz)</td>
<td>Avobenzone 1%, octocrylene 7.7%, oxybenzone 3%</td>
<td>UVB/UV-A1</td>
<td>$9.99</td>
</tr>
<tr>
<td>Blue Lizard Australian Regular SPF 30+ (Crown)</td>
<td>Lotion (8.75 fl oz)</td>
<td>Octinoxate 7.5%, octocrylene 2%, oxybenzone 3%, zinc oxide 6%</td>
<td>UVB/UV-A1</td>
<td>$22.99</td>
</tr>
<tr>
<td>Kiss My Face Sun Spray Lotion SPF 30 (Kiss My Face)</td>
<td>Lotion (8.0 fl oz)</td>
<td>Octinoxate 7.5%, octisalate 5%, zinc oxide 1.7%</td>
<td>UVB/UV-A1</td>
<td>$13.69</td>
</tr>
<tr>
<td>Neutrogena Cool Dry Sport SPF 30 (Neutrogena)</td>
<td>Spray (5.0 fl oz)</td>
<td>Avobenzone 3%, homosalate 8%, octisalate 4%, octocrylene 4%, oxybenzone 5%</td>
<td>UVB/UV-A1</td>
<td>$11.49</td>
</tr>
<tr>
<td>SPF 50(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthelios SPF 60 Melt-In Milk (La Roche-Posay)</td>
<td>Lotion (5.0 fl oz)</td>
<td>Avobenzone 3%, homosalate 10.72%, octisalate 3.21%, octocrylene 6%, oxybenzone 3.86%</td>
<td>UVB/UV-A1</td>
<td>$36.00</td>
</tr>
<tr>
<td>Babyganics SPF 50+ (Babyganics)</td>
<td>Spray (6.0 fl oz)</td>
<td>Zinc oxide 11.2%, octinoxate 7.5%, octisalate 5%</td>
<td>UVB/UV-A1</td>
<td>$11.99</td>
</tr>
<tr>
<td>Banana Boat Kids Sport SPF 50+ (Edgewell)</td>
<td>Lotion (6.0 fl oz)</td>
<td>Titanium dioxide 4.5%, zinc oxide 6.5%</td>
<td>UVB/UV-A1</td>
<td>$11.49</td>
</tr>
<tr>
<td>Banana Boat Sun Comfort SPF 50+ (Edgewell)</td>
<td>Spray (5.0 fl oz)</td>
<td>Avobenzone 3%, homosalate 10%, octisalate 5%, octocrylene 3%, oxybenzone 4%</td>
<td>UVB/UV-A1</td>
<td>$11.49</td>
</tr>
<tr>
<td>Bull Frog Land Sport Quik Gel SPF 50 (Chattem)</td>
<td>Gel (1.5 oz)</td>
<td>Avobenzone 3%, homosalate 15%, octisalate 5%, octocrylene 10%, oxybenzone 6%</td>
<td>UVB/UV-A1</td>
<td>$12.49</td>
</tr>
<tr>
<td>Coppertone Kids Tear Free SPF 50 (Bayer)</td>
<td>Lotion (6.0 fl oz)</td>
<td>Octinoxate 7.5%, octisalate 5%, zinc oxide 14.5%</td>
<td>UVB/UV-A1</td>
<td>$12.49</td>
</tr>
<tr>
<td>Neutrogena Beach Defense Water + Sun Protection Stick SPF 50+ (Neutrogena)</td>
<td>Stick (1.5 oz)</td>
<td>Avobenzone 3%, homosalate 10%, octisalate 5%, octocrylene 10%, oxybenzone 3%</td>
<td>UVB/UV-A1</td>
<td>$11.49</td>
</tr>
<tr>
<td>No-Ad Sport Stick SPF 50</td>
<td>Stick (1.5 oz)</td>
<td>Avobenzone 3%, homosalate 10%, octisalate 5%, octocrylene 10%, oxybenzone 3%</td>
<td>UVB/UV-A1</td>
<td>$6.99</td>
</tr>
</tbody>
</table>

1. Sunscreens are also found in many cosmetic products including facial moisturizers, lip balms, foundations, and powders and sprays marketed for application over makeup.
2. Individual stores may carry their own brand of sunscreen.
4. Meroxyl SX, patented by L’Oreal.
5. May also provide UV-A2 protection.
absorber. Octisalate and homosalate are weak UVB absorbers; they are generally used with other agents for additional UVB protection. Octocrylene absorbs UVB and is photostable; when combined with other sunscreens, it can improve the photostability of the entire product. Ecamsule is photostable and absorbs both UVB and UVA2.6

**Inorganic** – The two FDA-approved inorganic (physical) sunscreens, zinc oxide and titanium dioxide, prevent UVB, UVA1, and UVA2 penetration. Micronized (nanoparticle) formulations that improve cosmetic acceptability are now widely used; they are less visible on the skin, but may also be less effective.7

**EFFECTIVENESS** – In the amounts customarily applied to skin, no sunscreen product provides the labeled degree of protection. The FDA requires that the SPF be determined after applying 2 mg/cm² of the product, a very thick layer. At 2 mg/cm², a 4-ounce container provides only 2-4 whole body applications for an adult. Studies have shown that consumers usually apply 0.5-1.0 mg/cm² or less. Applied in these amounts, sunscreens (SPF 30-100) provide an actual SPF that is about 25% of the labeled SPF.8 Nevertheless, studies have found that long-term daily sunscreen use combined with other sun-protective measures can reduce the risk of non-melanoma skin cancer and can reduce other adverse effects of UV exposure such as photoaging.8-11

**Prevention of Melanoma** – Fair skin, use of tanning beds, and a history of sunburn are associated with increased melanoma risk.4 In a recently published population-based, case-control study in 603 Australian adults 18-39 years old with a first primary cutaneous melanoma diagnosis and 1088 controls 18-44 years old, regular sunscreen use was associated with a reduced risk of cutaneous melanoma.12 In a prospective trial, 1621 Australians 25-75 years old were randomized to use an SPF 16 sunscreen either daily or in a discretionary manner (generally 0-2 times weekly) for 4 years. Compared with discretionary users, daily sunscreen use had half as many new primary melanomas (11 vs 22) and a 73% reduction in invasive melanomas (3 vs 11) 14 years after randomization.13

**SAFETY** – All organic sunscreens, especially oxybenzone, can cause contact allergic and photoallergic reactions, but these reactions are uncommon.14 Estrogen-like activity has been reported in vitro and in some animal studies. These agents can penetrate the epidermis and small amounts can be absorbed systemically; detectable levels have been reported in human plasma, urine, breast milk, amniotic fluid, and fetal and cord blood.15-17 Whether such exposure could result in hormonal alterations or other adverse effects in humans is unclear.18,19

An Australian government review of the safety of titanium dioxide and zinc oxide nanoparticles concluded that these microfine particles do not penetrate or minimally penetrate the stratum corneum and underlying layers of skin, suggesting that systemic absorption and toxicity are unlikely.20

**Environmental Safety** – In Hawaii, legislation was recently passed banning the sale of sunscreens that contain oxybenzone and/or octinoxate because they can cause coral bleaching.21 Detectable concentrations of sunscreens have been observed in some fish species and adverse reproductive effects have been reported.22

**USE IN INFANTS AND CHILDREN** – Sunscreen use is generally recommended for children >6 months old during any sun exposure that might burn unprotected skin. Inorganic sunscreens are less likely than organic sunscreens to cause irritation and sensitization.23

**VITAMIN D AND SUNSCREENS** – Most people require only 2-8 minutes of unprotected exposure to summer sun to maximize synthesis of vitamin D₃. Whether sunscreen use could lead to vitamin D₃ deficiency is unclear.

**APPLICATION** – For maximum efficacy, sunscreen should be applied about 15-30 minutes before sun exposure and reapplied at least every two hours and after swimming or sweating. Water-resistant sunscreens remain effective for 40 or 80 minutes while swimming or sweating; no sunscreens are waterproof. For maximum effect, approximately one teaspoon of sunscreen should be applied to the face and neck and one to each arm; two teaspoons should be applied to the torso and two to each leg.24

When using both a sunscreen and an insect repellent, the sunscreen should be applied first. Applying the insect repellent N,N-diethyl-m-toluamide (DEET) after sunscreen has been shown to reduce the SPF of the sunscreen, but applying sunscreen second may increase absorption of DEET. The CDC does not recommend use of products that combine a sunscreen with an insect repellent because the sunscreen may need to be reapplied more often and in greater amounts than the repellent.25
PROTECTIVE CLOTHING — Clothing can block UV exposure. Factors that affect the level of UV protection from clothing include fabric color, fabric type, and tightness of the weave. The ultraviolet protection factor (UPF) is a measure of how effective a fabric is at blocking UV radiation; a rating of 15-24 indicates good protection, 25-39 very good protection, and 40-50 excellent protection. Washing clothes with RIT Sun Guard can confer a UPF of 30.

CONCLUSION — Routine application of adequate amounts of a broad-spectrum sunscreen with an SPF ≥15 protects against sunburn, photoaging, non-melanoma skin cancer, and probably melanoma as well. Whether systemic absorption of small amounts of sunscreen ingredients could be harmful remains to be determined, but currently available data suggest that the benefits far outweigh the risks.


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