Does sunscreen really protect us?

Introduction

Alvy Singer: Sun is bad for you. Everything our parents said was good is bad. Sun, milk, red meat, college. (Annie Hall, 1977[1])

Solar Radiation

The solar radiation has 3 main peaks along the spectrum: Visible light, infrared and ultraviolet light. Of these the ultraviolet light has the most negative effects on our bodies. Ultraviolet light is split into UVA, UVB and UVC. UVC is completely absorbed by the ozone layer and is no danger to our skin. 90% of UVB is absorbed by the ozone layer and levels of UVB vary with time of day, season and the state of the ozone layer. UVB does not penetrate very deeply, glass is sufficient to absorb its radiation and in an exposed person it does not penetrate below the epidermis. UVB is the entity responsible for sunburns. UVA penetrates much deeper than UVB reaching the dermis, it is not affected by the ozone layer, and its intensity is usually constant[2]. UVA and UVB work together to cause skin damage. They both damage DNA in particular mutating the p53 tumour suppressor gene, a gene which normally prevents cancer proliferation[3-4]. UVA and B also reduce the number of Langerhans cells within the epidermis, reducing the skin's natural immune response. UVA penetrates the dermis and breaks down collagen fibres causing sagging and wrinkling of the skin. To protect us from these negative effects sunscreens have been developed over the past 80 years and have become an industry worth € 1.3 billion a year[5].

The History of Sunscreen

The first known example of people applying a topical preparation to prevent sunburn comes from recently translated ancient Egyptian papyri and tombs[6]. The ancient Egyptians saw lighter skin as a sign of status and hence beauty. If you could afford to stay out of the sun, you were doing very well indeed. Some of the everyday ingredients used by the Egyptians are just now being explored as possible sunscreen ingredients in their own right such as jasmine[6].

Bringing the story forward some 2000 years, sunscreen as we now know it was just being concocted. The title of who first invented sunscreen is highly contested and there are 4 claimants. Chronologically Milton Blake, a chemist based in South Australia, was the first to create, albeit unsuccessfully, a sunburn cream in the very early 1930's. Next was Eugene Schueller (the founder of L'Oreal) who marketed his, also ineffective cream, in 1936. Franz Greiter, an Austrian scientist, developed his Glacier Cream after receiving sunburn on the Piz Buin Mountain in 1938. This was the first effective commercially viable sunscreen product. The creation of the first sunblock was credited to Benjamin Green an airman in World War II who invented a heavy unpleasant greasy substance called "red vet pet" (or red veterinary petrolatum) which acted as a physical barrier between skin and sun[7].

Despite the dispute over who first invented sunscreen Franz Greiter was the first to invent the Sun Protection Factor (SPF) rating that is still used today. SPF is essentially a multiplier of the duration of sun exposure until erythema of the skin occurs. So if someone takes 10 minutes to burn in the sun an SPF 6 cream applied to their skin would extend this time to 60 minutes. These early sunscreens were more concerned with preventing sunburn than protecting against radiation so most only

absorbed UVB radiation. In 1992 Boots first developed a new star rating system to measure the amount of UVA protection sunscreens provided and this system has since been adopted by the whole of Europe. However as we shall discuss later, these rating systems are both not standardised and inaccurate when compared to everyday use.

Whilst sunscreens involve mainly using organic compounds that absorb UV radiation and break down dissipating the energy, "sunblocks" are thicker whiter substances that use inorganic molecules which reflect the radiation before it reaches the skin. Whilst these do not undergo photo degeneration and are effective, they are messy and less aesthetically pleasing. For the purpose of this essay both sunscreens and sunblocks will be considered together under the umbrella term sunscreen. The issues surrounding organic and inorganic compounds will be discussed separately. Sunscreen has, over the years, been accused of causing harm and being generally ineffective. This essay will explore the evidence surrounding these claims.

Controversies surrounding sunscreen

"We hit the sunny beaches where we occupy ourselves keeping the sun off our skin, the saltwater off our bodies, and the sand out of our belongings." (Erma Bombeck[8])

<u>Increasing melanoma rate</u>

Sunscreen has been shown to protect against the development of both actinic keratoses[9] and squamous cell carcinomas[10] by preventing UV radiation from damaging DNA. However the incidence of melanoma, the most lethal of cancers, has seen the largest rise in incidence compared with all other major cancers since the 1970s[11]. This is despite the large number of sun protection schemes and the advent of

higher levels of UV protection within sunscreens[12-13]. There are many theories as to why this has occurred. Some studies have questioned as to whether sunscreen itself could have lead to an increase in melanoma[14], however two reviews have shown that sunscreen has had neither a positive or negative effect on the incidence of melanoma[15-16]. One explanation for the association between melanoma and sunscreen use found in those studies is that much lower levels of SPF and UVA protection were found in the sunscreens used in the past[17]. This combined with a higher level of average sun exposure secondary to increasing holiday frequency is one possible explanation for an increasing incidence.

Another explanation for the increase in the incidence of malignant melanoma is the theory of diagnostic drift. Diagnostic drift occurs when lesions are picked up earlier due to increasing screening and/or more benign lesions are included in the diagnostic criteria. This leads to an apparent rise in the incidence of that condition. One study claims that the rising incidence is precisely because of this process[18] and statistics have shown that the majority of the increase has been from more superficial lesions, the natural history of which is unknown[11, 18].

The role of UV radiation on the pathogenesis of melanoma is also uncertain. There are no randomised controlled trials that show a link between UV radiation and melanoma[17]. The closest equivalent is a study which demonstrated sunscreen usage decreased the occurrence of melanocytic naevi[19]. Whilst these lesions are a definite risk factor for malignant melanoma, this is still far from a direct link between sun exposure and melanoma development. However it may be decades before a protective association between the use of modern sunscreens and melanoma can be

confirmed[16]. Interestingly one study has found a slight increase in survival rates from melanoma in those with intermittent sun exposure[20]

Vitamin D insufficiency

One of the other controversial issues surrounding sunscreen is the issue of vitamin D. Vitamin D has long been known to be beneficial to bone health and is synthesised in the skin with the aid of UVB radiation. New studies have shown that vitamin D has antiproliferative and proapoptotic effects[21], and may have a role both in the prevention of major internal cancers and the development of melanoma[20]. Rickets, a condition in which low vitamin D levels leads to inadequate mineralisation of the bone matrix, has recently seen an increase in incidence both within the UK and worldwide[22-23].

The high level of UVB protection afforded by modern sunscreens has been associated with these vitamin D deficient states[24-25]. However one study in Australia showed that subjects who regularly apply sunscreen during summer end up with similar vitamin D levels as a control group[26]. Other authors have noted that it is the seasons, latitude, age and an increasingly indoor lifestyle that has lead to fluctuations in vitamin D levels[17, 23]. Conversely because of the poor application of sunscreen and the increased exposure that most users undergo, the majority of them will probably end up with more vitamin D. Interestingly as sunscreens become more protective, sun protection schemes are encouraged and the public's usage of sunscreen improves, hypovitaminaemia may become a more significant problem. However vitamin D can be easily supplemented via diet, either through fortified dairy products or tablets[17].

Disruptive Organic ingredients

Most sunscreens contain organic molecules that absorb the UV radiation and dissipate the energy when they degrade. There has been considerable concern that these organic molecules or their by-products may be photocarcinogenic. This is understandable given that PABA, a common ingredient in older sunscreens, was found to cause in vitro DNA damage[27]. This ingredient has since been banned from usage in sunscreens. Other organic ingredients in sunscreen over which there is concern include retinyl palmitate and oxybenzone.

Oxybenzone has been shown to cause hormonal dysfunction when absorbed systemically in animal models[28]. Studies have shown that UV filters can penetrate the skin and reach the circulatory system[29-30]. Thus one could postulate that sufficient quantities of oxybenzone could reach the systemic circulation to cause hormonal imbalances especially in those with regular sunscreen usage. However only 0.1-5% of dissolved UV filters within sunscreens actually penetrate the skin[29] and the amount needed to significantly affect rat models was greater than 1.5g/kg/day orally, which would require 30g/kg/day of sunscreen to be applied to a person's skin. One would worry more about the risk of drowning in sunscreen rather than hormonal changes. A recent critical review of the literature has been unable to link UV filters to endocrine disruption in humans[31].

Retinyl palmitate is a very common ingredient in both sunscreens and cosmetics[17]. Of eight in vitro studies looking at the potential photocarcinogenesis of retinyl palmitate, four demonstrated that reactive oxygen species are generated by this substance when it is exposed to UVA radiation[32-35]. Reactive oxygen species are known to cause intracellular DNA damage. Understandably the media has touted this

substance as having cancerous potential and have called into question the safety of sunscreens[17]. On the other hand, retinyl palmitate is pharmacologically identical to retinoids and oral retinoids have been used to prevent skin cancers in patients who are at high risk (e.g. the immunocompromised)[36]. In addition no evidence exists to date to suggest that there is any increased risk of skin cancer in patients on topical or oral retinoids[17].

Toxic Inorganic Chemicals

Titanium dioxide is the only inorganic compound used as a UV reflector within the EU[37]. Although it is highly effective at protecting against UV radiation and has low allergenic potential, it has been shown to induce DNA damage in animal and human cells in vitro[38]. Most recently inorganic compounds have been nanosized to improve the poor cosmetic appearance of inorganic based sunscreens. Concerns have also been raised as to whether this nanosizing would lead to deeper skin penetration of these molecules[17].

A number of studies have looked at the penetration of nanoscale TiO_2 and they concluded that it is limited to the stratum corneum, therefore systemic absorption is limited[39]. Even if systemic absorption did occur a number of other studies have found no cytotoxic or mutagenic potential in nanosized TiO_2[40-41]. Therefore TiO_2 seems to be a fairly safe ingredient for UV protection[17]. Interestingly the DNA damage induced by free radicals from both inorganic and organic sunscreen filters has been shown to be prevented by the addition of antioxidants to the sunscreen[38].

Complex labelling

The SPF rating depends on an even coating of 2mg/cm^2 across the whole body surface area[42]. This recommendation does not fit with the behaviours of the people who use the product. Several studies have shown that in vivo only 0.5-1.5mg/cm^2 is applied to the body and frequently the back of the neck, temples and ears are missed completely[43-44]. This has said to be due to the complexity of the labelling, low cosmetic appearance and the high cost of sunscreen[45]. For a family of four to apply enough sunscreen to provide adequate protection during a beach holiday costs £111 per week[46].

The illusion that this inadequate amount of sunscreen provides enough protection for a whole days sunbathing is perhaps the largest problem with sunscreens. This combined with the habit of having "binges" of sun exposure for 2 weeks every year has been postulated as to why skin cancers rates have increased[16]. Indeed there is some evidence that exposure to small amounts of UV radiation often can lead to melanomas with better survival rates[20].

Conclusion

So is sunscreen in any way harmful? As illustrated above the vast majority of the controversies surrounding sunscreen have little substance to them when the evidence is reviewed. The possibility of DNA damage through the release of free radicals is a worry but there is sufficient evidence that the addition of antioxidants may prevent this damage[38, 47]. The worry about vitamin D deficiency may actually be premature, and as sunscreen usage becomes better there may have to be considerable thought about vitamin D supplementation[17].

The only real harm that sunscreen can really cause is through misuse, poor education and unclear labelling. There should be a change to how SPF is calculated, using a recommended dose of 1mg/cm^2 would be more in keeping with real life usage and the reduction in SPF on the bottles could exact more caution regarding sun exposure[46]. Hopefully the more prevalent sun safety messages will help to teach proper sunscreen usage.

Is sunscreen really of benefit? Whilst there is clear evidence that sunscreen can protect against actinic keratoses and squamous cell carcinoma[9-10], there is little evidence that it prevents the occurrence of both basal cell carcinoma and malignant melanoma[17]. Even as a form of protection against UV radiation, protective clothing has been shown to protect much better then sunscreen, and perhaps we should emphasise covering up over sunscreen usage[48]. However in the future it is doubtless that sunscreens will have even higher, and more accurate, SPF ratings and inorganic based sunscreens will hopefully have a better cosmesis. Finally there will be more evidence as to the effectiveness of modern sunscreens in preventing UV related damage in the coming decades[49].

In conclusion, the topic of sunscreen usage has been the subject of much debate over this past decade and seems particularly polarising in the field of dermatology. After reviewing the literature this author has found that there are very few adverse effects with the use of sunscreen and the majority of media controversies have been based on isolated studies. On the other hand, sunscreen usage is emphasised by both guidelines and health professionals, despite its everyday usage being insufficient and there being a false sense of security in regards to sun protection. Newer health promotions should emphasise the use of sun protective clothes, avoiding periodic

prolonged sun exposure and educating the population on correct sunscreen usage.

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