Ocular phototoxicity in the mountains

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"The eye is born from light and for light" JW von Goethe

Although light is necessary for ocular physiology, notably for phototransduction, acute and chronic exposure can cause lesions to the eyeball.

The harmful effect of light has been suspected from antiquity; Socrates reported eye discomfort after watching eclipses.

The consequences of light exposure on the retinal function were demonstrated experimentally in rats over 40 years ago, including at low intensity and over a long period of exposure. More recently, in vivo and in vitro models have demonstrated more specifically the role of blue light (BL) (380-480nm) in the apoptosis of photoreceptors and of the cells of the retinal pigment epithelium [1]. Light thus leads to photochemical reactions within ocular tissues. These require a chromophore, exposure time and a sufficient dose, releasing the free radicals involved in oxidative stress and the processes of eye ageing.

Ultraviolet rays and blue light which are of particular interest to us, belong to the vast range of electromagnetic waves.

These are made up of photons, which are classified according to their wavelength with its own energy (inversely proportionate to their wavelength). We are familiar with UV rays particularly due to their action on the skin and the cornea (snow blindness) in our particular speciality. The ozone layer filters UV rays up to 290nm, and the eye is therefore exposed to the remaining UVs, from 290 to 400nm (UVB and UVA) and to the spectrum of visible light (which starts with blue light) in the
absence of efficient protection. Intraocular transmission of the rays depends on their wavelength, but in fact UVs are mainly absorbed by the cornea and the crystalline. It is estimated that less than 2% of the initial UV dose reaches the retina in adult eyes, compared with 2 to 8% in children under the age of 10. [7, 2]

Visible light (400 to 800nm) provides us with the coloured sensation of our vision, whilst infrared light has mainly heat related properties. The retina is exposed to the components of visible light due to their wavelengths, whence its potential danger. Sliney et al. estimate at 40% the fraction of blue light transmitted to the retina in adults aged 60 and still more in children, for whom 65% of blue light rays are transmitted [8].

![Electromagnetis spectrum](image)

**Fig. 1: Electromagnetis spectrum.**

Back in 1908, Hess discovered that the dose of cosmic rays increased with altitude during balloon travel. **Thus, the dose of UVs received by the eye increases by 10% in levels of 1000m of altitude, by 20% on water, by 10% on sand and by 80% on snow.** Mountain professionals are therefore a population who are overexposed to light (particularly UV and blue light) due to the combination of these elements.

Several large scale studies have been carried out amongst populations living in sunny plains (POLA, Sète, France [3, 4], Beaver Dam Eye study Wisconsin USA [10], Chesapeake Bay study, Australia [9]); these showed an increase in the prevalence of cataracts, notably cortical and, more controversially, of maculopathies. [3, 4, 9, 10]

To our knowledge, no study has been published on a population living at altitude and thus overexposed. In our department we have carried out an original study on high mountain guides compared with a population living in the plains of the Lyon region (Study registered Eudract 2010-A00647-32, Promoter Essilor International, main investigator Prof. Corinne Dot). This study highlights mainly the effects of the sun's rays at altitude as well as under the more secondary conditions of the combined effects of the wind and low temperatures.

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Study undertaken amongst high mountain guides in Chamonix [6]

Ninety-six high mountain guides (GHM) from the Chamonix valley aged over 50 and 90 control patients from the refraction department at the Desgenettes Hospital in Lyon, of comparable age, took part in this study.

A questionnaire was used to evaluate exposure at altitude (number and altitude of trips) and the means of protection used. Each of the patients was examined under dilatation by means of a clinical examination of the anterior segment (classification LOCS, III, Lens Opacities Classification System III,) together with analysis using a sheimpflug camera (Oculyzer®, Alcon), and then of the posterior segment with retinal photography of the posterior pole. Statistical analyses used Student's T test for the comparison of the 2 groups and a logistic regression to evaluate the risk factors.

The results were as follows:

- **Regarding surface pathologies**, the mountain guides (GHM) presented statistically more dermatochalasis (28.1% compared with 4%, p<0.001), chronic blepharitis (52.1% compared with 10.2%, p<0.001) and abnormalities of the lachrymal points (33.3% compared with 4%, p<0.001). Their Break Up Time (BUT) is also statistically lower (4.55s compared with 7s, p<0.001). We also observed more pterygium (8.9% compared with 0%, p<0.001), pinguecula (58.3% compared with 21.7%, p<0.001) and arcus senilis (27.6% compared with 11.7%, p<0.001).

- **Regarding the crystalline**, the mountain guides had more abnormalities of the crystalline (42.4% compared with 16.2%, p<0.0001). They had mainly cortical opacities (30.8% compared with 10%, p=0.02). The difference is also significant for cataract surgery (5.4% compared with 0%, p=0.02). The maximum average crystalline density measured by Oculyzer® was also greater in the mountain guides (22.5% compared with. 20.2%, p=0.016). We also observed in the peripheral cortex of the guides round punctiform cortical microopacities in a significantly higher proportion (p=0.004) mostly located towards the nose.

- **Regarding the macula**, 30.2% of the mountain guides presented an abnormality of the macula area (including all abnormalities) compared with 18.9% in the control group (p<0.001). These abnormalities are mainly represented by drusen (28.7%) of a variety of sizes and numbers, and mainly seed-like.

- **Significant risk factors** identified are the high altitude (3000m to 5000m) and work in a snowy environment, a separate factor due to the scale of the reflection it generates.

Protections used were photochromic lenses (OR=0.53 for crystalline opacities), the wearing of a visor (OR=0.37 for the crystalline, OR=0.4 for the macula) and the wearing of a ski mask (OR = 0.44 for blepharitis, OR = 0.5 for the crystalline, OR = 0.6 for arcus senilis).
Fig. 2: Comparison of the prevalence of pathologies between the control group and the guides.

Fig. 3: Section showing anterior cortical micro-opacities using a Slit Lamp.

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Discussion

The mountain guides group presents more superficial pathologies, which are not described in literature as being linked to UV exposure, with the exception of pterygium. It is probable that this increase is due to a number of factors, combining UV action with weather conditions (cold and wind).

With regard to the crystalline, our results agree with the French POLA [4] study and with those of the Chesapeake Bay study [9] carried out amongst Australian fishermen and concerning the increased prevalence of crystalline cortical opacities. The crystalline would appear to behave like a real intraocular dosimeter of the UV rays received.

In terms of macular impact, results in literature are controversial. The POLA study does not find any difference in the population living in Sète. On the other hand the relative risk of showing signs of age-related maculopathy is 2.2 in the American Beaver Dam Eye study. The risk of developing AMD is also increased amongst Australian professional fishermen in Chesapeake Bay. In our study we also noted an increase in the prevalence of mainly seed-like drusen, which are a sign of macular ageing.

The low numbers in our population, along with the long-standing use by mountain guides of preventive equipment in the form of the wearing of sunglasses, certainly explains why we did not find more AMD, and underlines the relative efficiency of the means of protection used. However, the results of the questionnaire show that vigilance in terms of protection at medium mountain altitudes is lower, particularly when hiking and climbing. Yet exposure to UV rays is identical, whatever the weather, since UVs are not filtered by the clouds, whence insidious and chronic exposure, even at medium mountain altitudes.

Optimal ocular protection therefore involves the wearing of a visor with protective glasses: either sunglasses or photochromic lenses. This important data for professionals exposed to these rays (mountain and sea), should also be taken into consideration for children whose clear crystalline
allows more rays to pass and for keen mountaineers and fishermen.

This data also underlines the importance of the latest technological progress made in terms of materials. Polycarbonate stops 100% of UVs (cut off at 385nm). For the visible spectrum, class 3 lenses halt 85% of visible rays and therefore allow 15% of rays through, to enable colour vision. An interesting technological advance is the arrival of melamine-coated, class 3 brown sun lenses, which offer the "plus" of cutting out 100% of the start of blue light (cut out up to 425nm, preventing the absorption peak of ganglion cells at 480nm).

![Fig. 5: Effect of a class 3 sun lens on the sun's rays. Under the graph: rays transmitted to the eye despite the wearing of a class 3 lens, i.e. around 15% of blue light.](image)

Our study underlines the protection offered by photochromic lenses. Photochromic lenses also exist mounted on curved frames, transiting from class 2 to class 4 shade, depending on outdoor conditions; these are also a good means of protection in the mountains.

**Conclusion**

Recent data confirms the harmful action of chronic sun exposure without protection. The increase in ocular surface pathologies, impact on the crystalline and impact on the macular, means that extraocular protection optimised by means of the new materials available should be advised, right from the youngest age.

This study on ocular phototoxicity in the mountains was the subject of a thesis for a Medical Doctorate, presented by H. El Chehab on 18th October 2011 in Lyon [5]. Conflicts of interest: Essilor International (promoter of the study)

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