Ocular Hazards of Ultraviolet (UV) and Blue Light Exposure

NOTE

This paper supersedes 19HUPBL06 – Ocular Hazards of UV Exposure

INTRODUCTION

The range of wavelengths of visible light is from approximately 400 nanometres (nm) to 700nm. The wavelength of UV radiation is below that of visible light, ranging from 100nm to 400 nm. Since UV radiation has more energy than visible light, it may cause damage to the ocular lens of the eye causing cataracts. Blue light may play a role in the pathophysiology of macular degeneration depending on exposure intensity and time.

Ultraviolet radiation is divided into 3 major component bands: UV-A 315-400nm, UV-B 280-315nm, and UV-C 100-280nm.

- UV-A radiation comprises longer wavelength radiation, close to blue in the visible spectrum. It is usually responsible for skin tanning and premature aging of the skin with prolonged exposure.
- UV-B radiation comprises shorter wavelength radiation. It can cause blistering sunburn and is believed to be associated with skin cancer.
- UV-C radiation is absorbed by the atmosphere and is neither detected at sea level nor at typical flight levels.

If adequate eye protection is not worn; excessive exposure to intense sunlight and/or to any artificial source of light, such as welding torches and sun lamps, can lead to burning of the delicate tissue in the eye. The highest risk comes from direct exposure to sunlight, light reflected from snow and snow-covered surfaces, or when flying above clouds with light reflected from cloud surfaces.

The retina is mostly spared the harmful effects of UV because this part of the Electromagnetic (EM) spectrum is absorbed by the front part of the eye. However, the high energy violet and blue parts of the sunlight spectrum reach retina and are considered harmful to the retina at high doses.

UV EXPOSURE IN THE COCKPIT

The results of the measurements of UV radiation in the cockpit have been somewhat varied, controversial, and conflicting. UVB and UVC radiation is blocked by cockpit windows. However, some studies show significant UVA pilot exposure, whereas recent studies show very little, if any, pilot UV exposure. UV radiation intensity increases with flight altitude, but the cockpit windows absorb UV radiation depending on the windshield. Currently, it seems that most of the UV exposure that pilots are facing is a result of sun exposure on ground, either on a layover or at home while engaging in outdoor activities.

CATARACT

A cataract is a clouding of the lens in the eye. They develop slowly and may form within one or both eyes. There are several risk factors attributed to cataract formation: smoking, family history of cataracts, poor diet, diabetes, use of steroid medication, infrared and sunlight exposure. UV exposure is one of the risk factors for cataract formation, proven by epidemiological studies.

Typically, cataract surgery is a common procedure in the elderly population. During the procedure, the lens with the opacification(s) is removed and replaced by an artificial lens, restoring clear vision. However, accommodation may be lost unless accommodative intraocular lenses are utilized during cataract surgery. As the new lens is fully transparent, it does not absorb as much light as the original yellowish cataract lens. This could possibly accelerate Age Related Macular Disease (AMD).

The results of the incidence of cataract in pilots compared to general population have been controversial. Some studies indicate higher incidence whereas others do not. The reasons for the varying results may be the diagnostic criteria for cataracts and whether the diagnosis is made by an ophthalmologist or aviation medical examiner.

EYELID MALIGNANCIES

Basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) are the two common malignant tumours of the eyelid. Both epidemiological and molecular studies support the association of these skin cancers with exposure to UV radiation. It is thought that UV-B radiation plays a bigger role than UV-A radiation.

The pathophysiology is, however, also believed to be multifactorial including the following: fair skin (less melanin), gender (males > females), age (> 50 years old with regard to the development of SCC), a history of sunburn and or fragile skin (people with rare genetic predisposition), the use of certain immunosuppressive medications, weakened immune systems, and a history of skin cancer.

MACULAR DEGENERATION
(Age-related Damage in the Central Vision Area)

Macular degeneration is a medical condition which may result in blurred vision or no vision in the centre of the visual field. Early symptoms are few or mild, but over time there might be a gradual degeneration of vision that may affect one or both eyes.

Macular degeneration does not result in total blindness; however, loss of central vision can make it difficult to recognize faces, drive, read, or perform other daily activities.

Age-related Macular Degeneration was previously thought to be linked to UV radiation exposure, but currently the association is not clear-cut, and the research results have been controversial. Violet and blue light from the visible light spectrum have been suspected to play a role in the development of macular degeneration, but the research results have been inconclusive.

The anterior parts of the eye absorb UV radiation, protecting the retina due to absorption prior to reaching the retina. Other risk factors for macular degeneration include age, smoking, lack of regular endurance exercise, and genetic background.

Medication exists to slow the development of macular degeneration, however, currently no means exist to restore any associated loss of vision. In addition, a diet rich in lutein and zeaxanthin (natural blue-light filtering retinal pigments), and antioxidants (vitamins C, E, zinc, etc.), could contribute to the prevention of ocular photochemical damage.

Though the cause(s) of macular degeneration remain unclear, protection of eyes from sunlight is recommended because of known harmful effects of exposure.

PHOTOKERATITIS
(Snow Blindness)

Photokeratitis requires strong UV exposure, often from bright sunlight with reflection from water or snow or from an activity engaging bright light for long periods, for example, welding (welder's flash).

In this instance, acute UV-B and UV-C exposure damages the surface layer of the cornea, resulting in sunburn-like damage to the cornea. The eye becomes red, watery, irritated, sometimes painful (the feeling of sand in the eyes), and sensitive to light exposure.

Pilots should seek medical advice if they develop these symptoms. Treatment is to avoid UV-radiation, use eye drops, and avoid rubbing the eyes. Symptoms usually resolve in a couple of days.

Typically, UV exposure during flying is not so strong that it will cause photokeratitis.

PROTECTION OF THE EYES

Pilots should wear sunglasses when there is potential exposure to sunlight. Protection is recommended in flight, and in the cockpit sun visors may be useful.

Pilots should choose sunglasses that include protection against UV-A and -B radiation. Typically, a 100% UV absorption label on protective eyewear means that all UV-A radiation and wavelength up to 400nm of UV-B is absorbed.

Although “blue-blocking” lenses are marketed widely for eye protection, there is no evidence at present of an effect of blue blocking lenses for the prevention of eye diseases. Future high-quality, randomised trials are required to define the effects of blue-light filtering lenses more clearly on visual performance, macular health, and sleep in adult populations.

The sunglasses that pilots use should be of good optic quality, there should not be any reduction in the visual acuity and no colour distortion.

If a pilot has prescription glasses, their sunglasses should have the same correction as their prescription glasses. The use of polarized or photochromic sunglasses is not recommended when flying.

SOURCES

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