

UNDERSTANDING BLUE LIGHT

Exposure to certain wavelengths of blue light carries potential blinding effects and a link to AMD.

BY ARON SHAPIRO



Age-related macular degeneration (AMD) affects more than 8 million Americans and is projected to increase in prevalence by more than 50% by 2020.¹ It is the leading cause of irreversible blindness in individuals older than 50 years. In many cases, damage to retinal pigment epithelium (RPE) cells and the chronic aberrant inflammatory response

to this damage leads to large areas of retinal atrophy, the expression of angiogenic cytokines such as VEGF, or both.¹ In the wet form of AMD, choroidal neovascularization (CNV) develops, accompanied by increased vascular permeability and fragility, which can lead to subretinal hemorrhage, fluid exudation, lipid deposition, detachment of the RPE from the choroid, and, eventually, blindness.¹

Risk factors for AMD include age, tobacco use, genetic factors, and an antioxidant-deficient diet. Because of its impact on lipofuscin accumulation and A2E-mediated phototoxic effects, exposure to blue light has been recognized as another potential risk factor.² This column describes the effects of blue light on the eye and its connection to AMD.

FACTS ABOUT BLUE LIGHT

Blue light is part of the visible light spectrum, with wavelengths of about 415 nm to 495 nm. Blue light can be divided into two bands: blue-violet light (415-455 nm) and blue-turquoise light (465-495 nm).³ When light in the blue-violet range hits the eye, a process unique to this band of wavelength occurs. During the visual cycle, when opsin starts the process of phototransduction, certain intermediate products are produced that can also bind opsin and accept more photons within this range of wavelength, resulting in photoreversal that occurs faster than the normal visual cycle. This photoreversal enables the eye to absorb more blue light than any other kind of light.⁴

Photons of light are small units of energy, too much of which can result in uncoupling of cellular oxidative phosphorylation, which produces reactive oxygen species (ROS) that disrupt membranous structures of the photoreceptor outer segments and consequently damage delicate RPE cells.

This damage causes incomplete phagocytosis and digestion of oxidized outer segments in the RPE, which leads to an accumulation of the waste product lipofuscin (the so-called *age pigment*) in RPE cell granules. Composed of lipids, proteins, and a number of chromophores, lipofuscin is highly susceptible to photochemical changes that can produce permanent cellular damage. Lipofuscin phototoxicity is perpetuated by A2E (N-retinylidene-N-retinylethanolamine), a key fluorophore that is excited by blue light. The photosensitization of A2E leads to the formation of ROS.⁵⁻⁸ Excessive oxidative stress can cause dysfunction in the RPE cells and, eventually, apoptotic cell death.^{2,9,10}

Not all blue light is harmful; in fact the two bands of blue light mentioned above, blue-violet and blue-turquoise, exhibit vastly different effects on the eyes. Besides helping with visual acuity, contrast acuity, and color vision, blue-turquoise light is essential for our pupillary reflex and for synchronization of our circadian rhythms, which in turn help to maintain and regulate memory, mood, and hormonal balance. Light of this wavelength plays a vital role in



AT A GLANCE

- Exposure to blue light is recognized as a potential risk factor for AMD because of its impact on lipofuscin accumulation and A2E-mediated phototoxic effects.
- Sources of harmful blue light include sunlight, modern lighting, televisions, laptops, smartphones, and tablets.
- Nutritional supplements with pharmacologic doses of antioxidants and zinc have been shown to lower the risk of developing advanced AMD; also, blue-blocking lens technologies are offered by several companies.

maintaining general health.³ Blue-violet light, on the other hand, is harmful to the retina and over time causes retinal cell death.

LIGHT HURTS

Epidemiologic studies have found evidence of a relationship between chronic sunlight exposure and AMD. The Beaver Dam Eye Study found that levels of sun exposure in teen and early adult years were strongly associated with a higher risk of developing RPE abnormalities and early AMD.^{11,12} In the Chesapeake Bay Waterman Study, a group of individuals with advanced AMD reported having high levels of blue light exposure over the preceding 20 years.^{13,14} Recently, the EUREYE Study reported a significant association between lifetime blue light exposure and AMD in individuals with low dietary levels of antioxidants (including vitamins C and E, zeaxanthin, and dietary zinc).^{2,3,15}

Studying narrow bands of wavelengths, researchers with Essilor and the Paris Vision Institute found that blue-violet light was the most harmful to porcine RPE cells, as it caused the most cell death.² In humans, the amount of exposure to blue light varies with time of day, location, and season. During the day, 25% to 30% of sunlight is composed of blue light. But there are many other sources of blue-violet light. Modern lighting, including LED lights and compact fluorescent lamps (CFLs), although bright and energy-efficient, can be a strong source of harmful blue light. Thirty-five percent of LED light and 25% of light from CFLs consists of harmful blue light. The “cooler” or whiter the light source, the higher the proportion of blue light emitted.³

Other sources of harmful blue light include televisions, laptops, smartphones, tablets, and other such electronic devices. The popularity and necessity of these devices ensures our constant exposure to high-intensity blue light. Unfortunately, the cumulative effect over time could potentially cause damage to retinal cells, slowly leading to retinal cell death and potentially to AMD.³ This is why protecting eyes from exposure to harmful blue light is of paramount importance.

PREVENTIVE MEASURES

It may be beneficial to prescribe nutritional supplements with pharmacologic doses of antioxidants and zinc to patients with AMD, as doing so was shown to lower the risk of developing advanced AMD by 25%.³ A high-dose combination of vitamin C, vitamin E, beta-carotene, and zinc has also been recommended to mitigate ROS damage caused by excessive blue light.³ Patients would be smart to cut back on their exposure to electronic devices and bright lights. Additionally, physicians should advise patients on how to protect themselves against both ultraviolet (UV) and blue-violet light.

The research pipeline is rich with selective photofiltration

technologies to make spectacle lenses that reduce levels of exposure to the harmful blue-violet portion of the spectrum while permitting the rest of the visible spectrum to enter the eye at normal levels. These technologies would allow the eye’s necessary visual and nonvisual functions to be maintained while exposure to hazardous wavelengths would be reduced.

Optical companies that currently offer blue-blocking technologies include Nikon (SeeCoat Blue), Essilor (Crizal Prevencia), PFO Global (iBlu coat), Hoya (Recharge), VSP (Unity BluTech), and Spy Optic (Happy Lens).³ However, many of the existing blue-blocking lenses distort colors, and the lenses themselves appear yellowish. In addition, several intraocular lens manufacturers include blue-blocking pigments in certain lenses in addition to universal inclusion of UV-blocking.

CONCLUSION

With modern lighting and the use of electronic gadgets on the rise, it is time we take exposure to blue light as seriously as we have for decades been treating exposure to UV light. Properly protecting the eyes during teenage years and early adulthood could go a long way in reducing the risk of AMD and irreversible permanent blindness in older age. Educating patients to this effect and advising them to be conscious of their exposure to sources of harmful blue light has become necessary. ■

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- financial interest: no financial interest in any companies mentioned