Considerations in the Prescription and Use of Photoprotective Eyewear

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ABSTRACT

The human eye is subject to oxidative changes and vision loss as a result of exposure to electromagnetic radiation emitted from the sun and other natural and man-made sources. In particular, cataracts and macular degeneration are associated with such exposures, as are skin cancers of the eyelids and surrounding tissues. Until recently, emphasis on protecting the eyes from solar radiation centered on blocking the transmittance of ultraviolet radiation to the eye with UV-blocking sunglasses, eyeglass lenses and contact lenses. Recent research suggests high-energy visible (HEV) light also may be damaging to the eye and the retina in particular. This paper summarizes some of the most important research in this area and provides eye care professionals a scientific rationale for prescribing and dispensing HEV-filtering eyeglasses and sunglasses to prolong the visual health of their patients.

Despite a significant body of research demonstrating the damage sunlight can afflict to ocular tissues, most consumers remain unaware of the potential harmful effects of sunlight on their eyes.

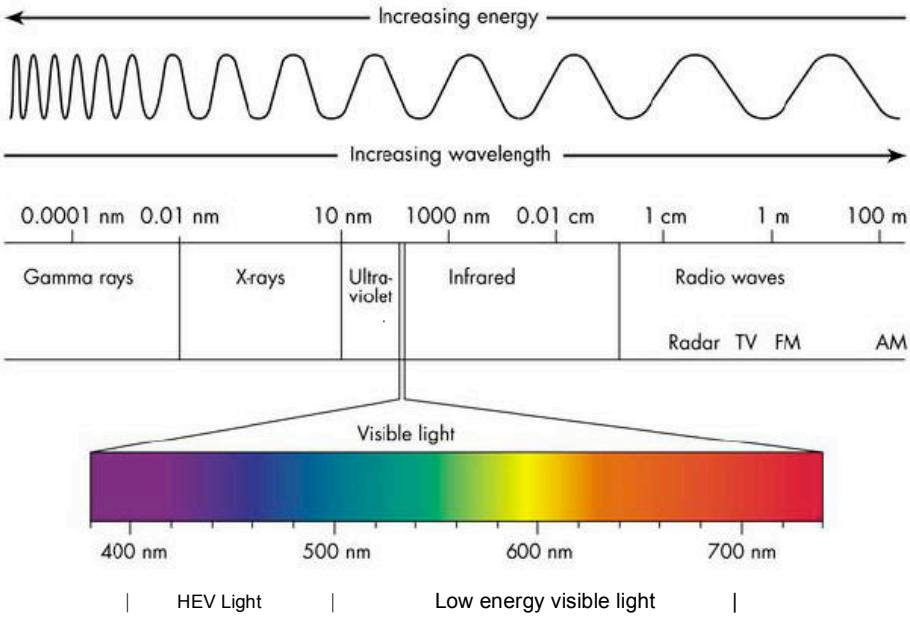
In a recent consumer survey conducted by a leading manufacturer of photochromic lenses, while 82 percent of respondents said they know extended exposure to sunlight can cause skin cancer, only 9 percent were aware that sunlight can harm the eyes.[1]

While most studies in the past concentrated on the harmful effects of ultraviolet radiation (UVR) on the eyes, a growing body of evidence suggests high-energy visible (HEV) light from sunlight also may pose a significant threat to ocular tissues, particularly the retina.

This paper summarizes some of the most important research concerning the effects of HEV radiation on the eye. Eye care providers should be aware of this research, as it suggests eyewear that shields the eyes from HEV light as well as UVR may be essential to safeguard the eye from oxidative and other adverse changes that can result in preventable vision loss.

Introduction: Solar Radiation, UV and HEV Light

UVA, UVB AND HEV (VIOLET TO BLUE OF THE VISIBLE SPECTRUM)



The human eye responds to only a small portion of the entire electromagnetic energy spectrum the portion described as the visible light spectrum.

Visible light falls between invisible ultraviolet rays comprising higher energy, shorter wavelength radiation, and invisible infrared rays that have lower energy and longer wavelengths.

Visible light contains a spectrum of monochromatic radiation, ranging from high energy/ short wavelength light rays to lower energy/longer wavelength rays. High-energy visible radiation (also called HEV or blue light), is violet to blue in color and ranges in wavelength from approximately 400 to 500 nanometers (nm).

Lower energy visible light ranges from 500 to 700 nanometers in wavelength, and includes green, yellow, orange and red light. Lower-energy infrared rays have wavelengths greater than 700 nm.

Ultraviolet radiation emitted by the sun is classified as UVA (320 to 380 nm), UVB (280 to 320 nm) and UVC (100 to 280 nm).[2]

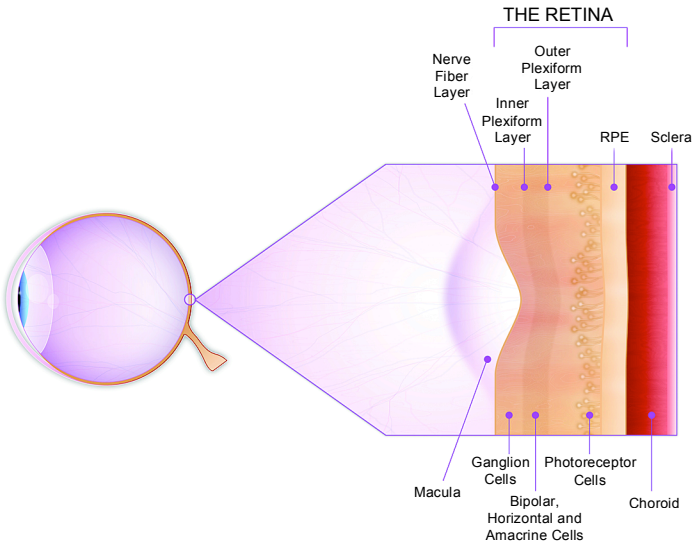
The ozone layer of the atmosphere blocks all UVC rays and most UVB rays from reaching the Earth's surface. According to the Skin Cancer Foundation, UVA rays account for up to 95 percent of the UV radiation reaching the Earth’s surface, and

although they are less intense than UVB, UVA rays are 30 to 50 times more prevalent and can penetrate clouds and glass.[3]

Though the higher energy UVB rays are more damaging to the skin than UVA rays, the human lens blocks UVB rays and most UVA rays that enter the eye.[4] Some UVA rays and virtually all HEV light, however, can penetrate the lens and reach the light-sensitive retina at the back of the eye.

Also, though the human lens takes on a yellowish tint with age that which helps to filter UVA and blue light, children and young adults tend to spend significantly more time in the sun than older adults, and researchers say that nearly 23 percent of a person's lifetime exposure to solar radiation occurs by age 18.[5]

HEV Light and Macular Degeneration



Age-related macular degeneration (AMD) is the leading cause of progressive blindness in American seniors and elderly throughout the world, and to date there is no efficient cure for the disease.

One cause of AMD appears to be damage to the retinal pigment epithelium (RPE), a layer of cells underlying the light-sensitive photoreceptor cells in the retina that are responsible for vision.

The function of the RPE is to nourish the photoreceptors, and when this function is compromised, photoreceptors in the macula die, causing loss of central vision.

Though the pathogenesis of AMD is not completely understood, a growing body of research suggests HEV or "blue light" may play a significant role in RPE cell changes and in the long term may lead to macular damage.

Here is a sampling of recent research concerning the effect of HEV light on the retina and RPE:

Studies Suggesting HEV Light Causes Eye Damage

A2E and blue light in the retina: the paradigm of age-related macular degeneration.
Biological Chemistry. March/April 2002.
In this review of scientific literature, researchers at the Institute of Biochemistry, Swiss Federal Institute of Technology (Zurich, Switzerland) conclude that photoreceptors in the retina are susceptible to light, particularly HEV light. The mechanism of the eye damage appears related to oxidative changes within the retina that are facilitated by exposure to blue light.

Blue light irradiation inhibits the production of HGF by human retinal pigment epithelium cells in vitro.
Photochemistry and Photobiology. September 2006.
In this study, human RPE cells were exposed to blue light (460 nm) and red light (640 nm) for up to 48 hours, and non-irradiated RPE cells were used as controls. After the exposure period, the RPE cell viability was evaluated by expression of hepatocyte growth factor (HGF) in the cellular media. (HGF is a substance found in healthy RPE cells that stimulates growth of various ocular cells and promotes the survival of RPE cells and retinal neurons.) The researchers found that the blue light exposure significantly inhibited the growth of RPE cells and production of HGF, whereas red light exposure did not cause similar effects.

Do blue light filters confer protection against age-related macular degeneration?
Progress in Retinal and Eye Research. September 2004.
After a review of the scientific literature on the topic, researchers in the United Kingdom and the United States conclude that though the current research does not definitively prove that HEV light is a risk factor for age-related macular degeneration, evidence from animal studies "confirms' blue light's damaging potential" and studies of human macular pigment density and the risk of AMD progression following cataract surgery "lend further weight to the hypothesis that blue light exposure has a role in the pathogenesis of AMD."

Mitochondria-derived reactive oxygen species mediate blue light-induced death of retinal pigment epithelial cells.
Photochemistry and Photobiology. May 2004.
In this study, researchers induced RPE cell death with exposure to HEV light (405 to 445 nm) and concluded that mitochondria-derived reactive oxygen species (ROS) created by the light exposure played a critical role in the RPE damage. The study authors also said the results of the study may indicate new approaches for treating AMD using mitochondria-targeted antioxidants.

Muller cell response to blue light injury of the rat retina.
Investigative Ophthalmology & Visual Science. August 2008.
potassium and water regulation in the retinas of rats that appear to be associated with degenerative changes in the inner retina.

The influence of sublethal blue light exposure on human RPE cells.
Molecular Vision. September 21, 2009
Researchers in Germany found that human RPE cells, when irradiated with a non-lethal dose of HEV light (405 nm), activate a host of defense mechanisms while simultaneously triggering cellular stress responses that may be involved in RPE disease development. The study authors concluded that continuous HEV light exposure can detrimentally affect metabolically stressed RPE cells, and this may have implications for pathogenesis of age-related macular degeneration.

Studies Suggesting Blue Filtering Lenses May Protect Vision

AcrySof Natural filter decreases blue light-induced apoptosis in human retinal pigment epithelium.
Graefe's Archive for Clinical and Experimental Ophthalmology. May 2008.
Researchers exposed human RPE cells that were protected with either a filter that blocked only UV or a filter that blocked both UV and HEV light to blue light (430 to 450 nm) for 10 days. They found that blue light exposure caused significant RPE cell death, and the lens that blocked both UV and HEV light significantly reduced RPE cell apoptosis (death) caused by blue light exposure.

Augmentation of macular pigment following implantation of blue light-filtering intraocular lenses at the time of cataract surgery.
Investigative Ophthalmology and Visual Science. October 2009.
Researchers in Ireland found that the retinas of eyes implanted with intraocular lenses that blocked HEV light showed higher levels of the macular pigments lutein and zeaxanthin, which are believed to be protective against AMD.

Protection of retinal pigment epithelium cells from photooxidative stress using a blue light-filtering intraocular lens.
Clinical and Surgical Ophthalmology. January 2005.
In this study, cultured retinal pigment epithelium (RPE) cells were stressed by exposure to blue light of sufficient intensity to trigger cell apoptosis (death) after an exposure of four hours. When RPE cells undergoing the same blue light exposure were shielded with an IOL that blocked HEV light, there was a 50 to 60 percent reduction in cells undergoing apoptosis. The researchers concluded that HEV light-filtering lenses "may provide a means of prophylaxis against biochemical events which trigger the onset of clinical age-related macular degeneration."

Implications for the Prescription and Use of Photoprotective Eyewear

Given that a growing body of scientific research suggests exposure to HEV light from sunlight may be associated with oxidative stress and damage to the human retinal pigment epithelium, eye care professionals have a science-based rationale for prescribing HEV-blocking eyewear for children and adults.

The following are the light-absorbing characteristics of several popular brands of eyeglass and sunglass lenses:

Product	Polarizing Efficiency	HEV Transmittance %
Coppertone Gray	>99%	5.60
KBCO Gray	>99%	7.86
Airwear Gray	>99%	14.40
Polaroid Gray	>99%	15.01
NuPolar Gray	>99%	15.95

Product	Polarizing Efficiency	HEV Transmittance %
Coppertone Brown	>97%	2.90
Polaroid Brown	>99%	3.31
Airwear Brown	>99%	3.68
NuPolar Brown	>99%	5.00
KBCO Brown	>99%	5.73
NuPolar Copper	>99%	7.38

HEVWP1010

*The lower the transmittance value the higher the filtering capability. Results based on internal testing. Data on file at Vision-Ease Lens.

Based on these data, it appears the lenses that offer the best photoprotection from the potentially harmful effects of both UV radiation and HEV light are Coppertone® Polarized Prescription Sun Lenses (Vision-Ease Lens, Ramsey, Minn.).

Also, given the apparent cumulative dose effect of solar radiation on ocular tissues and the increased exposure to solar radiation among young people, it may be wise to suggest the use of HEV filtering eyewear for children and young adults as a preventative measure to reduce the risk of vision disorders later in life.

References

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3. www.skincancer.org/understanding-uva-and-uvb.html
4. Violet and blue light blocking intraocular lenses: photoprotection versus photoreception. *British Journal of Ophthalmology*. June 2006.
5. www.skincancer.org/skin-cancer-facts

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