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Blue-light-blocking Lenses in Eyeglasses: A Question of Timing

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The circadian clock governs many aspects of life, and many studies have now shown that disruption of this important biological system has severe consequences for human health. Disruption of the circadian system is a cofactor in the development of type 2 diabetes, cardiovascular disease, cancer, sleep disorders, and cognitive dysfunctions.[1] Circadian disruption can be caused by a genetic mutation in one of the clock genes or, as is happening more frequently today, by exposure to light at unusual times of the day or night (e.g., during the night shift at a factory) or at different times on different days of the week (i.e., social jet lag).

Light is the most powerful signal used by our bodies for synchronizing our internal circadian clocks with the external environment. Studies over the last 20 years have shown that a complex photoreceptive system in the eye called the non-image–forming visual system conveys environmental light information to the master circadian clock located in the hypothalamus via a neuronal pathway called the retinohypothalamic tract. Although classical (i.e., rods and cones) photoreceptors contribute to the entrainment of the circadian system, a newly discovered class of photoreceptors within the retina, the intrinsically photosensitive retinal ganglion cells (ipRGCs), is also an essential component of the non-image–forming visual system. The ipRGCs contain the photopigment OPN4 (melanopsin), which is maximally photosensitive in the blue range (460 to 480 nm) of the visible light spectrum.[2] Studies in rodents have shown that ipRGCs are not only involved in the regulation of circadian rhythms but they are also involved in the modulation of visual function, mood, learning, and body temperature.[2] Finally, it worth mentioning that ipRGCs also regulate the pupillary light reflex in rodents and in humans and non-human primates.[2]

Melatonin, the hormone of darkness, is synthesized by the pineal gland during the night and acts as a chronobiotic to entrain the circadian system and time the onset of sleep at night.[3] Indeed, melatonin and melatonergic drugs are the only available treatments for synchronizing the external light:dark cycle with blind people who lack circadian photoreception. Early studies have demonstrated that exposure to light during the night suppressed melatonin levels and that blue light (range 460 to 480 nm) was very effective in suppressing melatonin levels.[4] Thus, exposure to blue light, even for a limited time, in the evening and/or at night may indeed affect the synchronization of the circadian rhythm, as well as the timing of sleep. Emerging experimental evidence has shown that blue light is more effective than green light in shifting the human circadian clock, can stimulate alertness,

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and can promote cognitive functions during the daytime.[5] Genomic studies have also indicated that polymorphisms in the gene coding for *OPN4* may augment the susceptibility to developing seasonal affective disorders and that exposure to light sources rich in blue light may help to treat patients suffering from seasonal affective disorders. Finally, it is worth mentioning that exposure to blue light, such as that emitted by electronic devices (e.g., tablets and smartphones), in the evening may negatively affect the quality of sleep and the circadian rhythm.[6] Besides affecting sleep timing and the circadian rhythm, melatonin signaling dysfunctions have also been implicated as cofactors in the development of insulin resistance, type 2 diabetes, immune responses, cancer, and disorders of blood pressure. Hence, melatonin suppression at night may lead to other negative health outcomes that may not be directly connected with the circadian rhythm and sleep.[5]

Therefore, it is important to recognize that the time (i.e., morning vs. evening) at which individuals expose themselves to blue light needs to be considered because exposure during the daytime has positive effects whereas exposure during the early evening or night may negatively affect the circadian system and sleep. In this context, it is worth mentioning that there is a significant effort to develop intelligent artificial lighting systems[5] in which the presence of blue light in the range of 460 to 480 nm can be changed according to the time of the day.

Many manufacturers of lenses and ophthalmologists are now proposing and/or recommending the use of a lens in which blue light is completely removed or significantly reduced. The scientific premises for the use of a lens that blocks blue light is based on some experimental evidence suggesting that exposure to blue light may be a risk for the development of age-related macular degeneration (AMD). Indeed, earlier epidemiological studies suggested that the amount of blue light received during life may be a cofactor in the development of AMD.[7] Because of this evidence, an intraocular lens (IOL) that blocks blue light was developed in the early 1990s by a few companies, and ophthalmologists began to replace lenses damaged due to cataracts with these new IOLs. However, it is now apparent that the use of these blue-light–blocking IOLs did not provide any significant protection against the development of AMD.[7] Also, the use of these IOLs has raised several concerns about the negative effect that the removal of blue light may have on the regulation of circadian rhythms, sleep, and cognitive functions.[8] Thus, the practice of inserting IOLs that block blue light during cataract surgery has been discontinued.

Over the last 20 years, we have been part of a technological revolution that has transformed how artificial light sources emit light. In just a few years, we have moved from incandescent light sources (which emit light across the visible spectrum, but with a higher proportion of long wavelength yellow/red light) to light-emitting diodes (LEDs, which emit across the entire visible spectrum, but with higher proportion in the short wavelength blue region) for general illumination.[5] Also, the use of electronic devices containing LEDs has exploded; these devices are now used by the majority of the population, including children of a very young age. The effects that these changes may produce on the health of the eye are still unknown,[5] but some researchers have suggested that blocking blue light from the screens of tablets, smartphones, and other electronic devices may help with ocular health and may alleviate digital eye strain.[9] Hence eyeglass lenses manufactures have developed and then promoted the use of lenses that can filter out wavelengths of light in the blue range. Although this is an appealing idea, recent studies do not support any positive effects of lenses that block blue light, such as relieving digital eye strain.

It is also worthwhile to mention that experimental evidence in several animal models - including humans - indicates that the light:dark cycle and the spectral composition of the light may affect eye growth.[10] Hence it seems ill-advised for children to be wearing blue-blocking glasses all day long before the effects of blue-blocking glasses on eye growth has been fully evaluated.

In conclusion it seems that the evidence supporting a beneficial effect of lenses that reduce or completely block blue light transmission to the retina is not very strong, whereas the evidence supporting the negative effects of blue light reduction during the daytime is supported by many studies. Hence, the use of a lens that may attenuate or eliminate the amount of blue light during the daytime should be discouraged, and the use of lenses reducing the amount of blue light in the evening hours (to prevent melatonin suppression) is certainly a welcome addition and should be encouraged by ophthalmologists as a new way of improving the regulation of circadian rhythms and sleep.

In modern life we exist in an artificially lighted environment (e.g., offices and factories) with a reduced level of light, especially blue light, during the daytime and we overexpose ourselves to light during the evening and nighttime. Overwhelming experimental evidence indicates that the amount and spectral composition of the light that is perceived by our eyes plays an important role in human health (from our physical metabolism to our mental health) and that an alteration in this complex system may lead to undesired consequences.[5] Thus, the use of devices that may affect this complex light-perceiving system should be fully evaluated before the devices are provided to the general public.

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REFERENCES

1. Sletten TL, Cappuccio FP, Davidson AJ, et al. Health Consequences of Circadian Disruption. Sleep 2020;43:zsz194. [PubMed: 31930347]
2. Schmidt TM, Chen SK, Hattar S. Intrinsically Photosensitive Retinal Ganglion Cells: Many Subtypes, Diverse Functions. Trends Neurosci 2011;34:572–80. [PubMed: 21816493]
3. Zisapel N New Perspectives on the Role of Melatonin in Human Sleep, Circadian Rhythms and their Regulation. Br J Pharmacol 2018;175:3190–9. [PubMed: 29318587]
4. Brainard GC, Hanifin JP, Greeson JM, et al. Action Spectrum for Melatonin Regulation in Humans: Evidence for a Novel Circadian Photoreceptor. J Neurosci 2001;21:6405–12. [PubMed: 11487664]
5. Tosini G, Ferguson I, Tsubota K. Effects of Blue Light on the Circadian System and Eye Physiology. Mol Vis 2016;22:61–72. [PubMed: 26900325]
6. Chang AM, Aeschbach D, Duffy JF, Czeisler CA. Evening Use of Light-Emitting eReaders Negatively Affects Sleep, Circadian Timing, and Next-Morning Alertness. Proc Natl Acad Sci U S A 2015;112:1232–7. [PubMed: 25535358]
7. Algvere PV, Marshall J, Seregard S. Age-related Maculopathy and the Impact of Blue Light Hazard. Acta Ophthalmol Scand 2006;84:4–15. [PubMed: 16445433]

8. Brøndsted AE, Haargaard B, Sander B, et al. The Effect of Blue-blocking and Neutral Intraocular Lenses on Circadian Photoentrainment and Sleep One Year after Cataract Surgery. Acta Ophthalmol 2017;95:344–51. [PubMed: 27966269]

9. Rosenfield M, Li RT, Kirsch NT. A Double-blind Test of Blue-blocking Filters on Symptoms of Digital Eye Strain. Work 2020;65:343–8. [PubMed: 32007978]

10. Chakraborty R, Ostrin LA, Nickla DL, et al. Circadian Rhythms, Refractive Development, and Myopia. Ophthalmic Physiol Opt 2018;38:217–45. [PubMed: 29691928]