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Review Article

The Impact of Blue Light on Eye Health- A Brief Review

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Abstract

The advent of technology such as digital screens and LED lights has brought about the production of blue light, though it usually comes from the sun. Blue light is a visible light having wavelength ranging between 400-500nm. We have highlighted the positive impacts on blue light including regulation of circadian rhythm, improvement of mood, visual acuity support and improvement of cognitive function. Emphasis have also been placed on the negative impacts of blue light on eye health including computer vision syndrome, retinal damage, long term damage to the eye and alteration of circadian rhythm. In order to reduce these negative impacts of blue light on the eye, several options including the use of blue light filters, wearing of blue light blocking glasses, screen adjustment, proper lighting and behavioral modification have been explored to combat the menace of blue light on the eye. It is worthy to note that, the eye is one of the most useful organs in the body and serious care must be taken to preserve its anatomical and physiological integrity in order to enhance its proper function(s).

Key words: blue light; circadian rhythm; eye; retinal damage; computer vision syndrome

Introduction

We live in a digital world. The advent of digital devices such as smart phones, laptops and television sets (TV) has come with a challenge peculiar to us than those in ancient times. Our generation has the highest number of people in front of screens for longer hours than any other generation. With this increased usage of ICT devices such as computers, TV and mobile phones, exposure to blue light has become an unavoidable aspect of daily life. Blue light, which is a high-energy visible (HEV) light within the 400-500 nanometer range, emanates from numerous sources, including sunlight, LED lighting, and digital screens such as smartphones, tablets, and computers [1]. While natural blue light from the sun plays an essential role in regulating the circadian rhythms and enhancing mood and alertness, the surge in artificial blue light exposure raises significant concerns about its potential impact on eye health [2].

The modern lifestyle, characterized by extended use of digital devices, has led to an unprecedented increase in the duration and intensity of blue light exposure. This change prompts critical questions about the long-term effects on visual health. Notably, blue light penetrates deeper into the eye compared to other visible light, reaching the retina and potentially causing damage [3]. As such, understanding the mechanisms through which blue light affects ocular structures and functions is pivotal to developing effective preventive and mitigative strategies.

Historically, eye health issues related to blue light have been overshadowed by other visual concerns such as myopia and cataracts. However, recent scientific advancements have spotlighted the specific risks associated with HEV light, prompting a re-evaluation of both natural and artificial light exposure. Researchers have identified several potential adverse effects, including digital eye strain, disruption of sleep patterns, and more severe conditions like macular degeneration [4]. Historically, concerns about blue light's impact on eye health have been overshadowed by other issues such as glaucoma, myopia and cataracts [5]. However, recent breakthroughs in scientific research have highlighted the specific risks associated with high-energy visible (HEV) light, leading to a re-assessment of exposure to both natural and artificial light. Researchers have identified several potential adverse effects, including digital eye strain, sleep pattern disruption, and more severe conditions such as macular degeneration [4, 6].

This review aims to explore the multifaceted relationship between blue light exposure and eye health. It probes into the physiological pathways affected by blue light, shed more light on the positive and negative effects of blue light and evaluate the effectiveness of current protective measures. By comprehensively addressing these aspects, we seek to provide a holistic understanding of the impact of blue light on ocular health and offer informed recommendations for minimizing potential harm while maintaining the benefits of blue light in our daily lives.

Summarily, as our reliance on digital technology continues to grow, so also a heightened awareness and proactive management of blue light exposure is needed. This review seeks to provide a panoramic view of the intricate

dynamics between blue light and eye health, thereby empowering individuals to make well informed, educated and necessary adjustments in their daily routines to safeguard their visual health

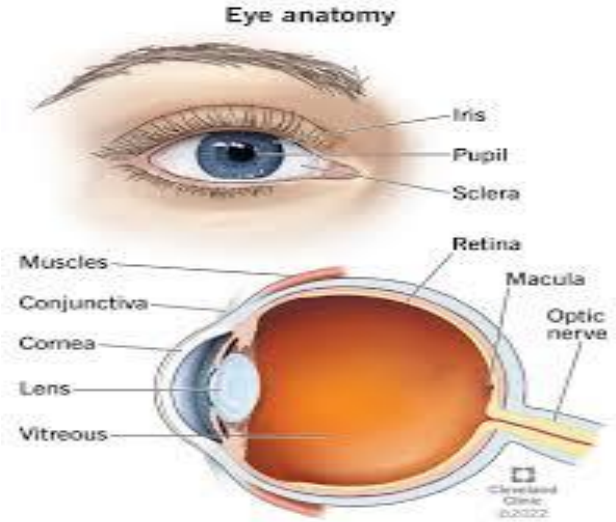

Figure 1: Structure of the Eye (Internal and External)

Sources and Mechanisms of Blue Light

Source: Stanborough, 2024[6]

All the light we see is made up of different wavelengths of light," says Vivienne Sinh Hau, MD, an ophthalmologist at Kaiser Permanente in Riverside, California. "Certain wavelengths show certain colors." About one-third of all visible light is blue light. Blue light is part of the visible light spectrum or electromagnetic spectrum (what the human eye can see). Vibrating within the 380 to 500 nanometer range, it has the shortest wavelength and highest energy. The most natural source is sunlight, but LED TVs, fluorescent lights, smartphones, tablets, and computers emit blue light too [7].

Natural Source of Blue Light

The primary natural source of blue light is sunlight. Blue light constitutes a significant portion of the visible light spectrum emitted by the sun. During daylight hours, blue wavelengths scatter more easily in the atmosphere than other wavelengths, giving the sky its blue color and contributing to the overall brightness and clarity of the environment [8].

Artificial Sources

In modern times, artificial sources of blue light have proliferated due to advancements in technology. These include:

LED Lighting

Light-emitting diodes (LEDs) are widely used in various lighting applications, from household bulbs to streetlights. LEDs are energy-efficient and long-lasting, but they also emit a higher proportion of blue light compared to traditional incandescent bulbs [8].

Digital Screens

Devices such as smartphones, tablets, computers, and televisions use LED backlighting, which emits significant amounts of blue light. Given the increased screen time in contemporary lifestyles, exposure from these sources has surged [9].

Fluorescent Lighting

Common in offices, schools, and other indoor environments, fluorescent lights also emit blue light, although to a lesser extent than LEDs [10].

Compact Fluorescent Lamps (CFLs)

These are energy-saving bulbs that emit blue light.

LED-Based Devices

These are other LED-based gadgets like gaming consoles and LED advertising displays.

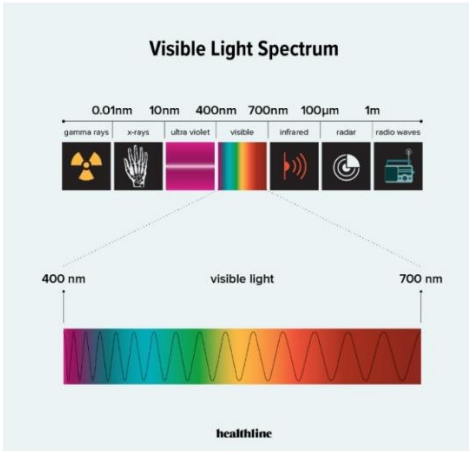

Figure 2: Diagram Showing Visible Light Spectrum

Source: Stanborough 2023[6]

Interaction with Eye Structures

Blue light interacts with various parts of the eye, influencing vision and potentially impacting eye health. Here's how it works:

Cornea and Lens

Blue light first passes through the cornea and lens. Unlike ultraviolet light, which is largely absorbed by the cornea and lens, blue light penetrates these structures and reaches the retina [1].

Retina

The retina, located at the back of the eye, contains photoreceptor cells (rods and cones) that convert light into electrical signals, which are then transmitted to the brain via the optic nerve. Blue light penetrates deeply into the eye, reaching the delicate retinal cells. Prolonged exposure to high-energy blue light can damage these cells over time [1]. Blue light plays a crucial role in regulating circadian rhythms, the body's internal clock that governs sleep-wake cycles. Specialized photoreceptor cells in the retina, known as intrinsically photosensitive retinal ganglion cells (ipRGCs), are particularly sensitive to blue light. When these cells detect blue light, they signal the brain to suppress the production of melatonin, a hormone that induces sleep. While this mechanism helps maintain alertness and wakefulness during the day, excessive blue light exposure, especially in the evening, can disrupt sleep patterns by delaying melatonin production and interfering with natural sleep cycles [9].

Positive Effects of Blue Light

Most times, many people know only about the negative effects of blue light. Blue light also has positive effects. They include:

Boosts/Improves Alertness and Cognitive Function

Exposure to blue light during daylight hours help to increase alertness and improve cognitive function. From early on, alertness has been associated with the time of day. Kleitman, a scientist who has also done research on the impact of blue light on eye health already noticed that the diurnal modulation of alertness shows a close temporal association with the circadian rhythm of core body temperature with its highest values or amounts in the evening and lowest points early in the morning. Blue light stimulates the brain, improves memory function and the overall mood of the individual [11].

Regulates Circadian Rhythms

Blue light plays a vital role in regulating circadian rhythms, the body's internal clock that dictates sleep-wake cycles. Exposure to natural blue light in the morning helps synchronize the circadian rhythm, promoting better sleep patterns and overall well-being [12].

Improves Mood

Blue light exposure, particularly from sunlight, can improve mood and combat feelings of depression. It triggers the release of serotonin, a hormone that stabilizes mood and feelings of well-being [9].

Supports Visual Acuity and Health

Blue light is necessary for good vision. It helps maintain the health of photoreceptor cells in the retina, which are crucial for clear vision [13].

Negative Effects of Blue Light

Computer vision syndrome (CVS) is the combination of eye and visual problems associated with the use of computers. In modern western society, the use of computers for both vocational and avocational activities is almost universal. However, CVS may have a significant impact not only on visual functions but also on professional productivity, since between 64% and 90% of computer users experience visual symptoms. These visual symptoms include digital eye strain, headaches, ocular discomfort, dry eye, diplopia and blurred vision either at near or when looking into the distance after prolonged computer usage [5]. In the preceding discussion, we shall look at the aspects of computer vision syndrome which is consequent mostly on blue light exposure.

Digital Eye Strain

This is a major type or part of computer vision syndrome characterized by eye discomfort, dry eyes, blurred vision, headaches, neck and shoulder pain. It can be caused by several factors such as poor lighting and uncorrected eye defects but it's mainly caused by blue light exposure. Prolonged exposure to blue light from digital screens can lead to digital eye strain, causing symptoms like dry eyes, blurred vision, and headaches. The short wavelength of blue light scatters more within the eye, making it difficult for the eyes to focus [5].

Retinal Damage

Unlike other lights of the electromagnetic spectrum, blue light penetrates the eye more deeply reaching even into the retina. Extended or prolonged exposure to blue light emanating from digital devices can cause potential photochemical damage to the cells of the retina. This in turn could increase the risk for a disorder or disease called age related macular degeneration (AMD) [14]. Blue light has a higher energy level compared to other visible light wavelengths. This high energy enables it to penetrate more deeply into the eye, potentially causing photochemical damage to the retinal cells. Studies suggest that cumulative exposure to blue light could increase the risk of developing age-related macular degeneration (AMD), a leading cause of vision loss in older adults [3].

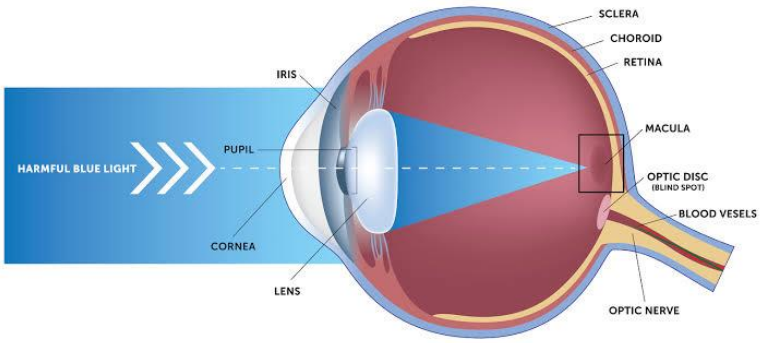

Figure 3: Diagram Showing how Blue Light Penetrate the Eye Structure (Cornea, Lens and Retina)

Source: Source: Stanborough 2023[6]

Disruption of Circadian Rhythm

Recall that when we were discussing the positive effects of blue light, we mentioned regulation of Circadian Rhythm. But this is blue light from natural source (sunlight) and not the blue light that emanates from digital devices. Exposure to blue light, particularly in the evening, disrupts circadian rhythms by inhibiting melatonin production. This creates a false impression of daylight for the eyes and the nervous system thereby making the individual alert for longer periods. This disruption can lead to poor sleep quality and

has been linked to various health issues, including obesity and depression [15].

Potential for Long Term Damage

Chronic exposure to blue light may accelerate retinal aging and contribute to cumulative damage, resulting in permanent vision impairment. This is particularly concerning the increased use of digital devices from a young age [16]. There is no substantiative evidence however that blue light exposure can cause blindness but there are studies indicating it is a primary cause of digital eye strain. There are also postulated theories that it's a high-risk factor for various health issues like obesity and depression as cited above.

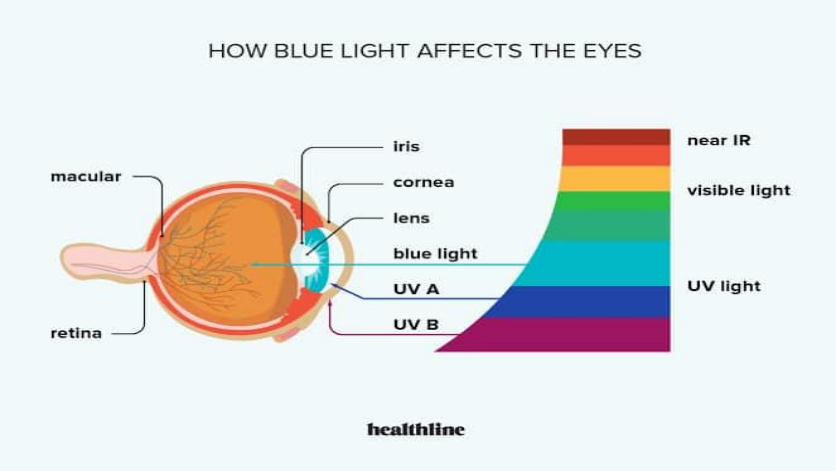

Figure 4: Diagram Showing how Blue Light affects the Eye

Source: Source: Stanborough 2023[6]

Protective Measures against Blue Light Exposure

Seeing as the world keeps technologically advancing and we have increasing need for digital devices, there is great likelihood that we will still spend a good deal of our time around the screen. There has to be therefore protective measures or mitigative strategies that need to be kept in place in order to safeguard our eye health.

These mitigative strategies or protective measures include but are not limited to the following:

Use of Blue Light Filters

Applying blue light filters to digital devices can reduce the amount of blue light emitted. These filters are available as screen protectors or software applications that adjust the color temperature of the display [17].

Wearing Blue Light Blocking Glasses

There are special glasses with lenses that block or filter out blue light. They can be worn to reduce exposure. These glasses are particularly useful for people who spend long hours in front of screens [18].

Adjusting Screen Settings

There are many digital devices these days that come with special settings to reduce the amount of blue light being emitted by them. This is seen especially in the smart phones that are produced recently. Activating night mode or adjusting the screen's color balance to warmer tones or reducing the screen's contrast/brightness can lessen the impact of blue light [19].

Behavioral Modifications

Some adjustments in the way we use our devices will greatly help in combating the negative effects that come with blue light exposure. These adjustments include:

i.Taking Regular Breaks: There's a rule known as the 20-20-20 rule which says that every 20 minutes, take a 20-second break and look at something 20 feet away [5].

ii.Screen Positioning: Keep screens at arm's length (about 25 inches) and slightly below eye level to reduce potentials for digital eye strain [18].

Use of Better / Proper Lighting

Ensuring proper lighting in the workspace or home can reduce glare and strain. Indirect lighting that avoids reflecting off screens is recommended for minimizing the impact of blue light.

i.Workplace: Using indirect lighting to reduce glare on screens. One must avoid working in the dark with only the screen light and balancing ambient lighting with task lighting. That is to say, one must have an additional source of light for the room in the dark when using digital devices and not allowing the screen brightness from the device not be the only source of light.

ii.Home: one must utilize warm, dim lighting in the evening to prepare the body for sleep and installation of adjustable lighting to match the time of day, thereby reducing blue light exposure at night [19].

Conclusion

The effect of blue light on eye health is a multifaceted issue that encompasses both positive and negative impacts as we have discussed so far. While blue light can enhance alertness and mood, regulate circadian rhythms, it can also have negative effects such as computer vision syndrome or digital eye strain, disruption of sleep patterns and can potentially cause long term retinal damage. Also, protective measures such as use of blue light filters and screen protectors, use of blue light blocking glasses and better lighting at home and work amongst other measures are helpful mitigative strategies in combating the negative effects of blue light.

Future Research and Developments

Future research should focus on the long-term impact of blue light exposure from digital devices, especially in younger populations. Advancing technologies for blue light filtration and creating guidelines for safe digital device use are essential. Additionally, exploring genetic factors that influence susceptibility to blue light damage could lead to personalized protective strategies.

Conflicts of Interest

There are no conflicts of interest.

References

1. https://www.eyeyoga.com.au/wp-content/uploads/2020/05/Blue-Light-and-Digital-Eye-Strain-American-Academy-of-Ophthalmology.pdf

2. Thapan K, Arendt J, Skene DJ. (2001). An action spectrum for melatonin suppression: Evidence for a novel non-rod, non-cone photoreceptor system in humans. J. Physio; 531:261-267.
3. Mainster MA. (2006). Violet and blue light blocking intraocular lenses: Photoprotection versus photoreception. Bri J. Ophthalmol; 90(6), 784-792.
4. Tosini G, Ferguson I, Tsubota K. (2016). Effects of blue light on the circadian system and eye physiology. Mol Vis, 22:61-72.
5. Rosenfield M. (2011). Computer vision syndrome: a review of ocular causes and potential treatments. Ophthalmic Physiol Opt; 31(5): 502-515.
6. Stanbrough, RJ. (2024). What is blue light and how does it affect our eyes. Accessible online at www.healthline.com. Retrieved on 23rd september 2024.
7. Lawler S, Janda M, Antrobus J, Horsham C, Meciar S, Hacker E. (2022). Trends in young adults'sunburn and use of sun-safe behaviours in a high UV outdoor festival environment. Popul.Med; 5:1090.
8. American Optometric Association. (2021). Blue light and your eyes. Retrieved from [https://www.aoa.org/healthy-eyes/eye-and-visionhealth/bluelight.
9. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Harvard+Health+Publishing.+%282018%29.+Blue+light+has+a+dark+side.+Retrieved+from+https%3A%2F%2Fwww.health.harvard.edu%2Fstaying-healthy%2Fblue-light-has-a-dark-side%2C+2018&btnG=
10. National Eye Institute. (2024). The nation's leader in vision research. Retrieved from www.nei.nih.gov. Accessed online on 23rd September, 2024.
11. https://www.sciencedirect.com/science/article/pii/S1087079207001001
12. Lockley, SW, Gooley JJ. (2006). Circadian photoreception: spotlight on the brain. Cur Biol; 16(18): R795-R797
13. Everyday Health. (2021). What is blue light. A complete scientific guide. Available online on www. Everydayhealth.com. Retrieved on 22nd September, 2024
14. Algvere PV, John M, Stefan S. (2006). Age-related maculopathy and the impact of blue light hazard. Acta opthalmol Scand; 849(1): 4-15
15. Chang AM, Aeschbach D, Duffy JF, Czeisler CA. (2015). Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. Proceedings of the National Academy of Sciences; 112(4), 1232-1237.
16. Nikita AW, Hameed B. (2022). A review of the current state of research on artificial blue light safety as it applies to digital devices. Heliyon; 8(8):10282
17. Kim J, Lee J, Lee J, Choi A, Kim D. (2016). The effect of blue-light blocking glasses in reducing digital eye strain in general population. J. Kor Ophthalmol Socie; 57(6), 855-861.
18. Sheppard AL, Wolffsohn JS. (2016). Digital eye strain: prevalence, measurement and amelioration. BMJ Open Ophthalmol; 3(1):000146.Van der Lely S, Silvia F, Corrodo G, Anna WJ, Oskar GJ. (2015). Blue light glasses as a countermeasure for alerting effects of evening light-emitting diode screen exposure in male teenagers. J. Adolesc Health; 56(1):113-119