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A Study on the Effect and Prevention of Blue Light on Eyes

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Abstract: ***In recent years, large number of people complaining about rteh effects of light pollution on their eyes. Blue light with the wavelength range between 415nm and 455nm is much nearly related with eye damage in the visible range. High energy blue light damages the hormonal balance and negatively impacts sleep quality by passing from the cornea to retina. Here it led to many types of disease such as cataract, age related degeneration and dry eye. It also stimulates the brain, inhibits melatonin secretion, and increases the production of adrenocortical hormones. Consequently, the impact of Blu-rays on the eye is growing in significance going forward. The effects of blue light on ocular tissues are highlighted in this study, along with a summary of the studies on eye injuries, physical preventative measures, and medical care.***
Keywords: ***blue light, ocular injury, prevention.***

I. INTRODUCTION

From the past 15 to 20 years, sources of technology have undergone a revolution. Lighting sources and technology have historically been reluctant to advance, particularly in case of non- commercial or industrial illumination [7]. Edison sockets and incandescent bulbs are commonplace in most households. The adoption of other technologies, including compact fluorescent lamps (CFLs), to replace incandescent sources has increased significantly during the past ten years. However, government has frequently been the driving force behind this transformation, emphasising energy-efficient alternatives over customer demand for a variety of light sources. The average user instantly noticed the difference in CFL source quality, though perhaps not in the precise details of its power spectrum. High brightness light-emitting diodes (LEDs) have simultaneously made enormous strides in development and performance [22]. By fusing a blue light LED with phosphor, a white light LED has been initially created. Solid-state lighting is the term used to describe this solid-state fluorescent analogue (SSL). Due to its numerous inherent and potential advantages over existing technologies, this strategy is now regarded as the next generation of illumination.

LEDs swiftly replaced incandescent bulbs for general lighting in mobile devices like smart phones [26]. LEDs are perfect for these applications because of their tiny size and constrained screen size. It didn't take long to realise that laptop computers might employ backlit liquid crystal panels (LCDs). The fragility of the microfluorescent lighting utilised for illumination and consumer demand for thinner screens were the driving forces behind this move. Large LCD television sets and backlit tablet screens like iPads and e-readers now predominately use LED technology. As a result, blue light currently predominates in RGB and SSL illumination systems, which weren't around ten years ago. A white light LED source is basically a bichromatic source that generally combines the entire emission from a blue light LED with yellow phosphor. It is also one of the most common types of LED. The absorption characteristics of the phosphor have a significant impact on the particular pump wavelength of the phosphor in the 450–470 nm range. Although the white-light LED can be viewed as the fluorescent source's SSL analogue, its power spectrum differs significantly from that of conventional, fluorescent, or incandescent white light sources [16].

A. Light exposure and age-related macular degeneration in humans

Studies in numerous animal models have demonstrated that blue light exposure may increase the likelihood of developing AMD or other retinal diseases [4]. Since light therapy has only recently been used by a small number of people, it is impossible to determine the true risk associated with exposure to artificial light (white or blue) in humans. The evaluation of the danger mainly posed by continuous exposure to blue light in the genesis of AMD, which is quite challenging due to the wide individual variation in susceptibility to blue light damage. Chronic exposure to visible and blue light may play a role in AMD development, according to previous epidemiological research. [5] did not discover any correlating evidence between blue light and the onset of AMD. As evaluated by [19] that the danger from blue light arised from variety of sources of light. Therefore, it is evident that a variety of variables have a role in the pathogenesis of AMD. This discovery makes it challenging to forecast the relationship between blue light exposure and the onset of AMD, in addition to the inadequate data in terms of subject count or period of treatment.

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At the end, UV light is the risk factor related to age degeneration. UV light is the only visible light whioch can enter into eye and reach to retina and led to many eye disease. As per the theory of [17], using an animal model, the retina can be shielded from UV and blue light by using materials for intraocular lenses that are yellow in colour (400–450 nm). Therefore, limiting the amount of blue light in the 400–450 nm region that reaches the retina may also be crucial for retinal protection.

B. Effects of Blue Light on Cornea

The cornea, which is found at the front of the eyeball, is the first structure light comes into contact with when it passes through the eye. It has been shown that exposure to blue light increases the production of reactive oxygen species (ROS) in corneal epithelial cells and activates the ROS-nucleotide-binding domain, leucine-rich containing family, pyrin-domain containing-3 (NLRP3)-IL-1 signalling pathway, which in turn causes inflammation in human corneal epithelial cells (HCECs) brought on by hyperosmotic pressure.

The survival rate of cornea has been demonstrated in few researches. Therefore, mediated oxidative damage and apoptosis cause additional ocular irritation and the development of xerophthalmia. [30]. Further evidence that blue light contributes to the development of dry eye came from studies that demonstrated how effective antioxidant extracts associated with free radical elimination could reduce the oxidative damage brought on by blue light, enhancing the medical symptoms of the eye surface in dry eye mouse model [11].

Antioxidants applied topically can therefore be utilised as a medication alternative for blue light-induced dry eyes. Using an in vitro cell culture experiment, [18] recognized phototoxicity of blue light on corneal epithelial cells. The findings indicate that blue light in the near UV area may have dose- and time-dependent effects on the corneal epithelial cells' mitotic phase. Dry eyes develop when the microvilli on the corneal epithelium's epithelial layer stop supporting and stabilising the tear film. However, corneal epithelial cells are not the only ones that are impacted by blue light.

The amount and duration of blue light exposure also have a strong inhibitory effect on the activity of corneal stromal cells. According to research, the inhibitory effects of blue light may be caused by how it affects the autophagy of corneal stromal cells. Blu-ray irradiation is also used to treat bacterial keratitis.

Future treatments for refractory corneal ulcers are anticipated to use blue light at a wavelength of 440 nanometers in combination with riboflavin corneal cross-linking for the treatment of bacterial keratitis. Further research is required to determine the efficacy and safety [14].

C. Effects of Blue Light on Lens

Because of lens opacity, cataracts are one of the main causes of blindness in the world. People began to recognise that the lens may efficiently filter short light waves to lessen the likelihood of retinal light damage as early as the 1980s, in addition to providing the primary optical power (measured in diopters). Short wave light is absorbed by structural proteins, enzymes, and protein metabolites found in the lens. The lens eventually darkens and turns yellow as a result of the addition of these chemicals and their derivatives to the protein of the lens. Blue light is substantially more effectively absorbed by the lens, preventing any retinal damage from blue light. However, the lens must experience a loss of transparency or a change in colour when it exerts its protective action on the retina, which causes cataract development. As everyone is aware, exposure to sunlight is thought to increase the chance of developing cataracts. According to studies, blue light can cause lens epithelial cells (hLECs) to produce ROS in their mitochondria, which may cause cataracts to form [2]. Recent research suggested that oxidative stress plays a significant role in the aetiology of age-related cataracts. Several studies disclosed that an increase in antioxidant enxzyme in hLEC straightforward release free radicals to lessen effects of H_2O_2. The lens can remain clear and the development of cataracts can be slowed down by apoptosis and ROS accumulation. The only carotenoids found in the lens of the eye, lutein (L) and zeaxanthin (Z), are powerful antioxidants. They exhibit the traits of substances that absorb blue light with short wavelengths [Bernstein]. According to research, L or Z can prevent oxidative damage to the lens's proteins, lipids, and DNA. The redox status of these antioxidants can be enhanced during oxidative stress, protecting the lens [9].

D. Effects of Blue Light on Retina

The retina is where vision first develops and where many eye illnesses that might cause blindness cause their lesions. It is critical in preventing blindness. Blue light can injure the retina by passing past the lens and entering the tissue there. Studies on how blue light affects the retina are pretty common at the moment, but they are still up for debate.

E. Oxidative Stress Injury of the Retina

The remains of the rod- and cone-shaped, phagocytic retinal pigment epithelial cells are known as lipofuscin. Retinal pigment epithelium's second enzyme has been generally observed to rise with advancing age. The core fluorescent group of lipofuscin is currently N-yellowy-N-retinoid-ethanolamine (N-retinyl-N-retinylidene ethanolamine, A2E). Through retinal pigment epithelial cells that have undergone oxidative stress-mediated apoptosis and necrosis, it exhibits significant absorption of blue light in non-degradable pigments [13]. The primary sites of oxygen free radicals related with blue light are mitochondria. Since single cell photo-oxidative stress is what initiates the mechanism of blue light damage to the retina, Ishii and Rohrer dubbed it the "bystander effect." Blue light induces local oxidative stress and an active ROS-induced signal in individual retinal pigment epithelial cells. While the Ca^{2+} signal was slowly and unevenly relayed to nearby cells, the radiation quickly travelled to the periphery and changed the potential of the mitochondria. Finally, the high baseline Ca2+ levels' metabolic properties caused localised cell injury in the retinal pigment epithelial cells. The outcomes of the experiment also shown that blue light could cause the pigments in the retina to degrade [12].

F. Effects of Blue Light on Refractive Development

However, there is no clear connection between the lower myopia incidence and the amount of time spent working close-up and the intensity of outdoor activities, according to epidemiological evidence [24]. A new study examined the effects of screen reading on schoolchildren's visual acuity. The findings demonstrate that screen reading can cause impaired eyesight in kids to appear and develop, and a correlation has been found between an increase in screen reading time and a higher prevalence of nearsightedness. Compared to most artificial illuminants, sunshine's is substantially richer in short-wavelength light., according to study of [25], which in turn causes the eye length to shorten via the production of retinal dopamine. The study also suggested that for the reduction of astigmatism, the importance of blue light increased at the time of growing stage. According to animal research, monochromatic short-wave blue light prevented the ocular axis and glass cavity from developing normally in guinea pigs, which led to a relative hyperopia. Furthermore, it was demonstrated that exposure to blue light may quickly cause the development of hyperopia rather than myopia, which may contribute to the understanding of how blue light might influence and affect reverse myopia and growth of refraction. Additionally, the study demonstrated that short wave blue light influences the guinea pig's development of their refractive system by increasing the density and expression of their retinal cones, however the precise source and effect are unclear. Additional research will be required [31].

G. Effects of Blue Light on Circadian Rhythm

As per the several studies and researches, blue light sources can easily regulate teh clock of body and improve memory, attentiveness and cognition related problems. The primary function is that blue light excite the pineal gland to release melatonin, which regulates human circadian rhythm [15] and can either increase or reduce cortisol expression relying on the time of day. Researchers who looked into how well seniors slept following cataract surgery discovered that they slept better overall because transparent artificial crystals allowed more blue light to enter the eye, confirming that blue light can control the circadian rhythm. Several disorders related to sleep looks like to be strongly related to visual impairment, which is also responsible for hypothesis of many researchers that quality of sleep is mainly related to eye diseases. Dry eyes can be brought on by sleep disturbances because they increase the synthesis of corticosteroids, which can decrease parasympathetic nerve excitability and tear secretion. When eyes are awake for a longer period of time, tear evaporation increases and causes dry eye symptoms. Disorders of blue light reduce the quantity of time that the eyes close at the same time. Lack of sleep can also lower the body's testosterone levels, according to certain research [23]. Numerous studies have demonstrated that a lack of androgens can cause the eyelid glands to malfunctionc[27].

II. OBJECTIVE OF THE STUDY

The main aim of the research paper is to research about the consequences seen by blue light on tissues of eyes, and also its proper treatment and prevention.

III. LITERATURE REVIEW

According to [28], The dangers of blue light exposure to human health are receiving more attention from researchers. Blue light's comparatively high energy level has the potential to permanently photochemically harm eye tissue. The development of dry eye disease, glaucoma, and keratitis are frequently brought on by excessive exposure of the eye to blue light, which frequently results in a number of alterations, including oxidative stress, mitochondrial apoptosis, inflammatory apoptosis, mitochondrial apoptosis, and DNA damage.

Therefore, the therapeutic management of blue light hazard makes extensive use of physical shielding, chemical and medicinal preventive measures, gene therapy, and other techniques. We evaluated the treatment strategies for addressing the risk posed by blue light by reviewing the studies on potential signalling pathways and mechanisms in the eye caused by blue light.

As per [29], by examining the biomechanical and microstructural alterations. The average user instantly noticed the difference in CFL source quality, though perhaps not in the precise details of its power spectrum. High brightness light-emitting diodes (LEDs) have simultaneously made enormous strides in development and performance [22]. By fusing a blue light LED with phosphor, a white light LED has been initially created. Solid-state lighting is the term used to describe this solid-state fluorescent analogue.

According to [1], High-density lipoproteins transport lutein through the blood (HDL). AMD is predisposed by genes regulating SR-B1 and HDL levels, supporting the role of cholesterol/lutein transport pathways. Recent research demonstrates that lutein intake can influence immunological responses and inflammation in addition to having positive impacts on a variety of visual function assessments. Lutein inhibits NF kappa-B activation as well as the expression of iNOS and COX-2, according to in vitro research. Since AMD has characteristics of a chronic low-grade systemic inflammatory response, focus has switched from lutein's local effect in the eye to its precise role in this illness.

As per [10], A synthetic lens known as an intraocular lens (IOL) is surgically inserted inside the eye during cataract surgery after the crystalline lens is removed. Modern IOLs all lower the transmission of UV light, but some IOLs, known as blue-blocking or blue-light filtering IOLs, also lessen the transmission of short-wavelength visible light. Short-wavelength visible light may cause retinal photoxicity, according to cell culture and animal studies, which are the main sources of support for blue-light filtering IOLs. IOLs that filter blue light have been proposed to provide retinal protection and maybe halt the progression of age-related macular degeneration (AMD). We looked into the research supporting these alleged advantages of blue-light-filtering IOLs and took into account any possible negative effects.

According to [8], Blue light-blocking intraocular lenses (IOLs) are frequently utilised and have been incorporated into the arsenal of the contemporary cataract surgeon. Their proponents contend that they may slow the onset or progression of age-related macular degeneration and offer protection against light-induced retinal damage. With limited clinical data available to date, the majority of the evidence for photoprotection is theoretical or based on findings in cell culture or animal trials. There is currently accumulating clinical data on the use of these IOLs in patients that examines the advantages and potential negative effects, notwithstanding the theoretical nature of the reasoning.

The history of the creation of these IOLs, the proof that limiting short-wavelength light exposure protects retinal cells and function, and any potential drawbacks of IOLs due to their decreased light transmission are all discussed in this article. We put this data into perspective in relation to cataract patients and the environments they live in on a daily basis.

According to [20], employing RNA-seq to examine aberrant signalling pathways and the blue light-exposed mouse eyes' gene expression. Kunming mice were split into two groups: one received blue light exposure as part of the experiment, and the other received only natural light. The mice were put to death after 14 days, and their eyeballs were harvested. Using RNA-seq to reconstruct genetic networks, a whole transcriptome investigation of the gene expression of the eyes was attempted. The associated signalling pathways were discovered using Gene Ontology (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG) analysis. A certain amount of aberrant gene expression and signaling pathways in the eye can be induced by blue light exposure. Antioxidants applied topically can therefore be utilised as a medication alternative for blue light-induced dry eyes. Using an in vitro cell culture experiment, The findings indicate that blue light in the near UV area may have dose- and time-dependent effects on the corneal epithelial cells' mitotic phase. Dry eyes develop when the microvilli on the corneal epithelium's epithelial layer stop supporting and stabilising the tear film. However, corneal epithelial cells are not the only ones that are impacted by blue light. The amount and duration of blue light exposure also have a strong inhibitory effect on the activity of corneal stromal cells.

According to [21], The most typical cancer of the adult eye is uveal melanoma. Despite the fact that it is a tumour that does not occur very frequently, the clinical prognosis is frequently poor due to the high prevalence of aggressive metastatic illness, for which there are few treatment choices. The aetiology of this illness is not well understood, despite the fact that various risk factors have been noted. However, unlike cutaneous melanoma, UV light does not play a significant role in these risk variables. High-energy short-wave (blue) light, a form of visible electromagnetic radiation associated with many types of age-related retinal damage, is the topic of this review. It was previously underappreciated as a risk factor for the onset and progression of uveal melanoma. We conclude by talking about the implications of these findings for modern ocular medicine, specifically the controversy over the filtering power of intraocular lenses used to replace damaged crystalline lenses after cataract surgery.

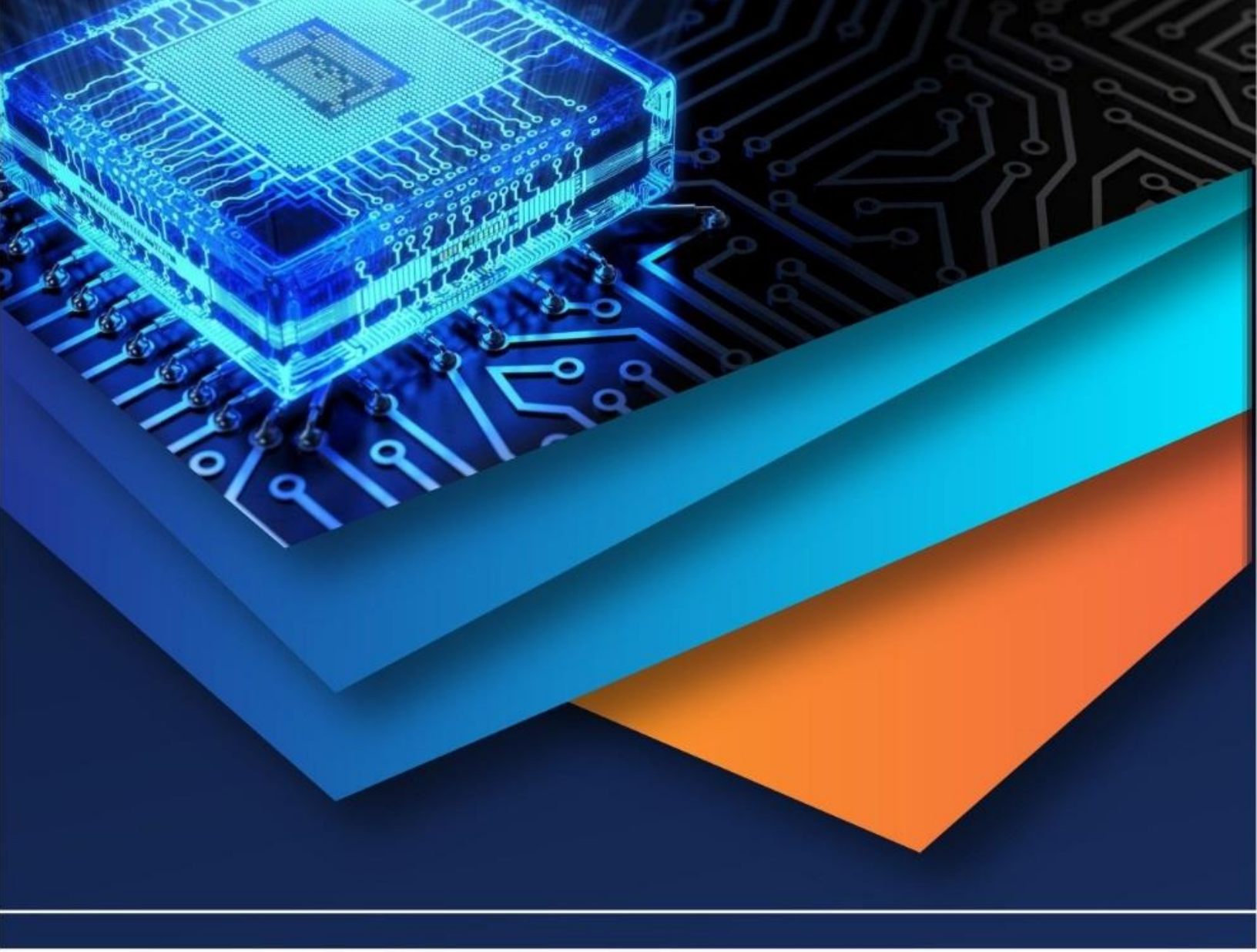
IV. CONCLUSION

In conclusion, while blue light can help humans enhance their eyes' ability to see well and regulate their circadian rhythm to some level, it can also cause varied degrees of damage to the cornea, crystal lens, and retina. Therefore, when utilising blue light-related items, especially at night, it is vital to take the necessary precautions.

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