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Effect of Blue Light on Human Eye: Advances to counter its impact (A Review)

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Abstract:
Background*: Light is fundamental for human vision. Abundance of light is useful for sustaining comfortable human life. Good blue light (blue-turquoise part) is essential for overall well being. However in modern time, due to various causes like pollution, modern gadgets like smart phone etc. existence of harmful light like blue-violet light has increased. Blue-violet light is harmful to retinal cells. Blue-violet light causes long term damage to our eyes as it can accelerate onset of AMD (Age related Macular Degeneration). To protect or shield human eye against blue-violet light wearing of lenses with blue-violet light protection is suggested.*
Materials and Methods*: Papers related to effect of blue light were reviewed to find the present status in the research related to effect of blue light.*
Results*: The present paper reviews the effect of blue light blocking spectacle lenses on visual performance, macular health and the sleep wake cycle and recent advances in the field.*
Conclusion: *Review of literature shows that much work is done on blocking blue light and minimizing the harm. However much of work is scattered and more wider work on subject is required.*
Key Word*: blue light, photopollution, blue block spectacles, Digital eyestrain*

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I. Introduction

Environment pollution is of different kinds and photopollution or pollution of light is important. Thus Pollution is not limited to environmental factors. The visual display terminals like mobile screens and LCD emit blue light which causes harmful effects to eyes. Tablets, smart phones and other digital displays are not only change the light spectrum we are exposed to but they also change the visual behaviour. It's important to recognize that we are spending far more time looking at things "close up" than we did before. That's often because the background brightness is too low. This is even a problem among children: "school myopia" refers to the increasing propensity of children to suffer from shortsightedness once they start school. If we fail to spend enough time looking into the distance, then our eyes don't get as much opportunity to relax, and we essentially "unlearn" the ability to focus quickly for various distances. That causes digital eye strain. In addition, we naturally blink less when we're staring at digital displays, so our cornea is moistened less frequently by tear fluid. This can lead to tired, strained eyes, and in the worst case it can even impair our vision[1]. Sunlight is the main source of blue light, and being outdoors during daylight is where most of us get most of our exposure to it. But there are also many man-made, indoor sources of blue light, including fluorescent and LED lighting and flat-screen televisions.

Most notably, the display screens of computers, electronic notebooks, smartphones and other digital devices emit significant amounts of blue light. The amount of HEV light these devices emit is only a fraction of that emitted by the sun. But the amount of time people spend using these devices and the proximity of these screens to the user's face have many eye doctors and other health care professionals concerned about possible long-term effects of blue light on eye health.

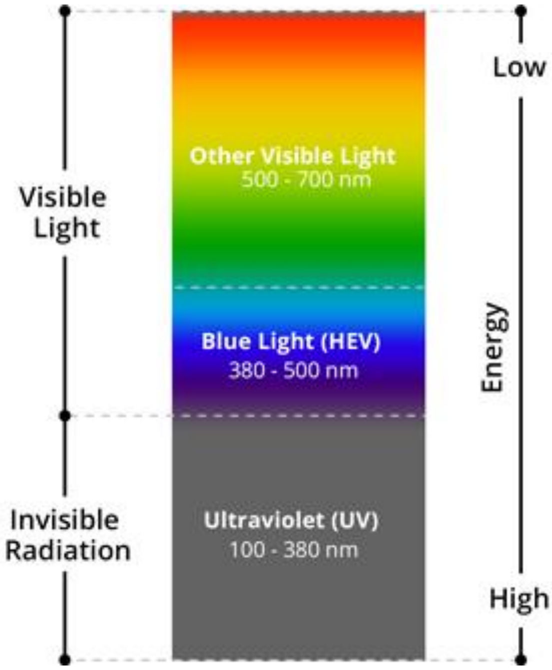

Figure 1 Spectrum of light

Blue light is defined as visible light ranging from 380 to 500 nm. Blue light sometimes is further broken down into blue-violet light (roughly 380 to 450 nm) and blue-turquoise light (roughly 450 to 500 nm) as shown in figure 1.

Approximately one-third of all visible light is considered high-energy visible (HEV) or "blue" light.

When you stare at a screen for hours at a time, whether it is a computer, TV, phone or tablet, you are exposed to blue light from the device. But there is no scientific evidence that blue light from digital devices causes damage to your eye.

The discomfort which people have after looking at screens is termed as digital eyestrain. As while looking at screens blink-rate is decreased causing eye strain and dry eyes Blue light does affect the body's circadian rhythm, our natural wake and sleep cycle. During the day, blue light wakes us up and stimulates us. But too much blue light exposure late at night from your phone, tablet or computer can make it harder to get to sleep

Shorter wavelengths were associated with more intense cellular damage, initially at the level of the RPE, with a peak of the action spectrum occurring at around 440 nm in the normal (phakic) eye. There have been developed International standards based on these empirical studies, which define exposure limits, below which adverse effects are unlikely to occur. However, driven by requirements for brighter and lower energy lighting, the last 10 years has seen significant changes in light sources for both commercial and domestic applications, with an increased use of compact fluorescent lamps (CFL) and high intensity light-emitting diodes (LEDs). Moreover, white-light LEDs (the most common type of LED) have become ubiquitous in backlit displays in smartphones and tablet computers. Although the light emitted by these LEDs appears white, their emission spectra show peak emissions at wavelengths corresponding to the peak of the blue light hazard function. It has been shown that exposure of cultured RPE cells to light equivalent to that emitted from mobile display devices causes increased free radical production and reduced cell viability. This has raised concerns that the cumulative exposure to blue light from such sources may induce retinal toxicity and potentially increase the risk of age-related macular degeneration[2].

II. Material And Methods

Papers related to effect of blue light were reviewed to find the present status in the research related to effect of blue light.

Study Design: Review of papers

Procedure methodology: papers related to effects of blue light mainly on ocular health were reviewed.

III. Result

The present paper reviews the effect of blue light blocking spectacle lenses on visual performance, macular health and the sleep wake cycle and recent advances in the field. Various Studies suggested that photopollution has been increased due to increase in use of visual display terminals (VDT) and blue light is an integral part of emission from VDT. According to studies blue light along with shorter wavelength light from the spectrum has found to cause harmful effects in eye starting from dry eye to age related macular degeneration. Newer advances have shown various methods for protection against blue light.

IV. Discussion

In modern society, computers and other digital electronic devices are ubiquitous in both the workplace and domestic environments and given the high number of hours per day that most individuals spend viewing small text on electronic devices at short working distances, it is not surprising that up to 90% of users periodically experience asthenopic symptoms including, eyestrain, headaches, ocular discomfort, dry eye, diplopia and blurred vision. However, what is now termed computer (or digital) vision syndrome is a multifactorial condition with several potential contributory causes, such as uncorrected refractive error, oculomotor disorders, tear film abnormalities and/or musculoskeletal problems. Therefore, the role played by blue light in these symptoms is difficult to extricate.

To investigate whether suppression of blue light can improve visual function in patients with short tear break up time dry eye[3].

Protecting the eyes from short-wavelength blue light may help to ameliorate visual impairment associated with tear instability in patients with Dry eye. This finding represents a new concept, which is that the blue light exposure might be harmful to visual function in patients with short tearfilm breakup time and dry eye.

Blue light has high photochemical energy which induces cell apoptosis in retinal pigment epithelial cells. The phototoxicityand retinal hazard by blue light stimulation has been well demonstrated using high intensity lightsources. However, it has not been studied whether blue light in the displays, emitting low intensity light, such as those used in today's smartphones, monitors, and TVs, also causes apoptosis in retinal pigment epithelial cells. It was examined the blue light effect on human adult retinal epithelial cells using display devices with different blue light wavelength ranges, the peaks of which specifically appear at 449 nm, 458 nm, and 470 nm. . These results show that even at the low intensity utilized in the display devices, blue light can produce reactive oxygen species and induce apoptosis in retinal cells. Our results also suggest that the blue light hazard of display devices might be highly reduced if the display devices contain less short wavelength blue light[3].

The Age-related maculopathy (ARM) is the most common cause of visual loss after the age of 60 years, is indeed a complicated scenario that involves a variety of hereditary and environmental factors. The pathological cellular and molecular events underlying retinal photochemical light damage, including photoreceptor apoptosis, have been analysed in experimental animal models. Studiesof age-related alterations of the retina and photoreceptors shows that there is accumulation of lipofuscin in retinal pigment epithelium (RPE) cells, and the formation of drusens. A new concept of an inflammatory response to drusen has emerged, suggesting immunogenic and systemic reactions in Bruch's membrane and the subretinal space. Oxidative stress and free radical damage also impact on the photoreceptors and RPE cells in the ageing eye. Based on the photoelectric effect, a fundamental concept in quantum physics, the consequences of high-energy irradiation have been analysed in animal models and cell culture. Short-wavelength radiation (rhodopsin spectrum), and the blue light hazard (excitation peak 440 nm), have a major impact on photoreceptor and RPE function, inducing photochemical damage and apoptotic cell death. After cataract surgery, there is a severe change in ocular transmittance,in aphakic or pseudophakic eyes (with clear intraocular lenses), high-energy (blue) and ultraviolet-A radiation strikes the retina. Epidemiological data indicate a significantly increased 5-year incidence of late ARM in non-phakic eyes compared with phakic eyes[4]. Studies reveal that Blue light suppresses the melatonin production.

The Shorter wavelength that affects level of melatonin more than any other wavelength. Normally ,pineal gland in the brain begins to release melatonin couple of hours before bedtime, and melatonin reaches its peak in middle of night .

When people read on blue light emitting deviceit takes longer time to fall asleep and wakeup feeling sleepier even after eight hours of closed eye condition[7]. Eyewear is available with lenses featuring digital eye strain-reducing capabilities

1) Spectacle lenses: Blue-light filtering spectacle lenses can partially filter high-energy short-wavelength light without substantially degrading visual performance and sleep quality. These lenses may serve as a supplementary option for protecting the retina from potential blue-light hazard[5]. The advanced technology provides the most effective UV protection possible, and filters out harmful blue-violet light.Some companies rank filtering capacity of lens according to Eye Sun Protection Factor (E-SPF*) to be sure that eyes are protected. BlueProtect reflects parts of the blue-violet light emitted by these sources, preventing light from entering the eye. Some coating reduces the transmission in the spectrum of 380–455 nm (blue light hazard) to a BPI 15 while keeping the high transmission level above 460 nm.

Our exposure to blue-violet light may not always be the same.
However, we must always enjoy comfortable vision.
Blue-violet light is everywhere, although its intensity varies greatly.

While a typical LCD computer monitor produces a brightness of 250 cd/m^2, a clear blue sky at midday is 32 times as bright. Direct sunlight can be thousands of times as bright[6].

2)Intraocular lenses: The IOLs with UV-filter were introduced in the 1980s. Ultraviolet filter IOLs are supposed to confer protection against radiation below 400 nm; for longer wavelengths the transmittance increases substantially compared with that of the normal ageing crystalline lens. However, it was recently reported that a number of traditional IOLs actually transmit more than 10% of UVA radiation between 350 nm and 400 nm (Laube et al. 2004); these high-energyphotons have the capacity to induce deleterious cellular effects. New types of 'yellow' IOLs have been introduced, which have a filtering effect that mimics that of the ageing human lens by attenuating light from wavelengths between 400 nm and 500 nm . The yellow IOLs provide a better degree of protection against UV radiation and blue light than traditional IOLs that have only UV filtering capabilities[5].

The yellow IOL gives a yellowish hue to the ocular image which, generally, does not seem to be a problem. The yellow IOLs induce a reduction of the scotopic sensitivity (Mainster 2005 & Sparrow 2003). This moderate loss of scotopic vision was found to be of the same magnitude as that of a 53-yearold human lens. Patients with the blue light-blocking IOL exhibit a significant threshold elevation at 410 nm (violet light) and at 450 nm (blue light). However, no significant differences in visual performance were found at 500 nm or 560 nm (green light) between patients implanted with the yellow IOL and those implanted with the clear IOL (Jackson 2005). The yellow IOLs reduce the optical chromatic aberration by blocking blue light. Infact the yellow IOLs proved to enhance contrast sensitivity and a reduce glare[5].

3) others: The Vision Council recommends individuals and their children visit a local eyecare provider to discuss their digital habits and what eyewear solutions are available to relieve the symptoms of digital eye strain.

In addition to eyewear solutions, other ways to relieve digital eye strain include: shown in figure 2

- Take frequent breaks from using digital devices (20-20-20 rule)
- Reducing overhead lighting to eliminate screen glare
- Positioning yourself at arm's distance away from the screen for proper viewing distance when at a computer
- Increasing the size of text on devices
- Reducing exposure to sunlight using different types of shades (umbrella, hat etc.) in day time.
- Protective eyeware for outdoors: Sunglass, polarised glass would be helpful from protecting against blue rays from sun.
- Reduce glare by Adjusting the brightness of the screen, changing background (from bright white to cool grey) may be helpful.
- Recently Several international optical manufacturing for Glare reducing filters are also available.
- Dust free screen may aid in reducing glare
- Avoid using device in direct sunlight.
- Selection of yellow LED lamps for domestic use may reduce significant amount of blue light exposure.
- Several international optical manufacturing and protection standards that quantify UV and Blue light filtering performaning exists.
- RPF Retina Protection factor: is a light blocking and device protection scale developed based upon digital light research. Reference [1] & [2]

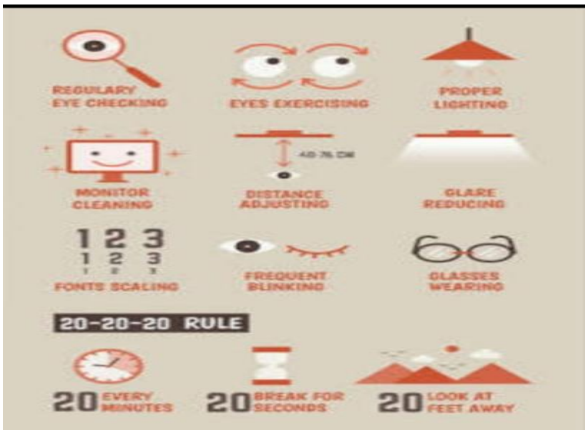

Figure 2 Management of digital eyestrain

Zhi-chun Zhao et.al In their study " Research progress about the effect and prevention of blue light on eyes" summarized that, a certain extent blue light can promote human eye refractive development like prevent occurance of myopia and regulate circardian rhythm, but harmful blue light- induced effects on human eyes should not be ignored.[8]

V. Conclusion

Review of literature shows that much work is done on blocking blue light and minimizing the harm. However much of work is scattered and more wider work on subject is required. Personal Eyecare starts from individual thus everyone should take care of a very important organ Human eye. Further advancement is necessary for the future generation. It is desirous that we should have some wavelength measurement process or marking/star for available artificial lightings. Authorities/ Governments may help in the matter. We need to take care of digital light safety measures to prevent exposure. Now different devices have blue light controlling display but we need in all available displays. Now different devices have blue light controlling display but we need in all available displays.

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