



## ASSOCIATION BETWEEN SMARTPHONE ADDICTION AND OCULAR SYMPTOMS WITH AND WITHOUT PROTECTIVE SPECTACLE LENSES

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### Background-

Overuse of smartphones has shown frequent ocular problems, which exponentially increased during previous years due to the adaptation of online classes, meetings, assignments, videos, free time social media addiction, etc. Nowadays plenty of blue-rich light is present in all technological display gadgets. Blue Violet light (380 to 490 nm) is mentioned to as "near Ultra Violet spectrum" or HEV (high energy visible) light due to the high photon energy- which makes it skilled to induce photochemical damage. Constant, continuous & excessive usage of devices can create harmful effects on the Eye and general health. They contribute to the development of Reactive Oxygen Species (ROS) and could lead to degenerative changes in human eyes.

**Material & method-** This cross-sectional time-framed study was conducted from January 2019 to January 2020 at the Department of Optometry, Uttar Pradesh University of Medical Sciences, Saifai, Etawah, Uttar Pradesh. Subjects were selected based on convenience sampling from the campus of the University (students, professionals, staff, and volunteer OPD patients). The complete eye examination was done with Optometric instruments.

**Results-** Of all 600 participants, 571 completed all procedures. Of 571, 97.75% used smartphones of different companies and 84.64% were smartphone addictive. 65.16% of participants were using smartphones for watching videos and surfing on social media most of the time. Of all participants, 65.7% suffered headaches frequently, 33.3% had ocular and peri-ocular pain and 45.32% continuously felt ocular dryness. Ocular fatigue and convergence insufficiency were common in nearly 63% of participants. In all participants, DES symptoms significantly increase as the hours of digital screening increase. Those participants had very less and incomplete blinks; they have the most severe ocular problems with dryness. The strong correlation between very less incomplete blink and exposure dryness is very significant. Along with the ocular problems, other ergonomic problems raised exponentially. The data shows ocular symptoms are significantly less in spectacle users ( $14.4 \pm 2.9$ ) in comparison to non-spectacle users ( $18.29 \pm 6.49$ ). And blue block lens users ( $11.14 \pm 3.175$ ) are significantly less symptomatic in comparison to the non-spectacle users ( $18.29 \pm 6.49$ ) ( $p < 0.05$ ).

**Conclusion-** This study's result reveals that smartphone-addicted participants (whoever uses a smartphone for a long time continuously- Constant, continuous & excessive use) got more frequent

ocular symptoms like dryness, fatigue and headache. There is a significant difference between with and without the spectacle. Using spectacle reduces the symptoms significantly. But there is a significant difference in ocular symptoms and conjunctival injection between anti-reflective and blue light-blocking lenses. Blue protective lenses reduced few symptoms more significantly than ARC lenses.

**Keywords** - *Compact Fluorescent Light (CFL), Light Emitting Diodes (LED), Computer Vision Syndrome (CVS), Digital Eye Strain/ Syndrome (DES), High Energy Visible light (HEVL), Nomophobia, and Blue light protective lenses.*

## **Introduction**

Mobile phone is also known as cell phone, cellular phone, hand-phone and now smart-phone. It was a portable electronic device that was used for making and receiving telephone calls over a radio link while moving around the whole world in the last decades. The first hand-held mobile phone was demonstrated by John. F. Michel and Dr. Martin Cooper of Motorola in 1983, the DYNATEC 8000X was the first to be commonly and commercially available. Add to the new technology, modern mobile phones, converted into smartphone have a wide variety of other functions such as messaging, multimedia messaging service, emails, internet access short-range wireless communication, business applications, gaming, photography and videography etc. (almost similar to portable and handy Laptop with almost all features (additional good quality front and back camera).

Two significant developments in the last decade that have contributed to excessive high-energy blue light exposure are light-emitting diode (LED) lamps and the most recent digital AMOLED (Active Matrix Organic Light Emitting Diode) screen. These drastic measures were taken in response to incandescent bulbs' poor energy efficiency and the anticipated overall energy savings from using more modern CFL and LED lamps, but they neglected to account for the manufacturing process, carbon footprint and in particular, the recycling of the latter.

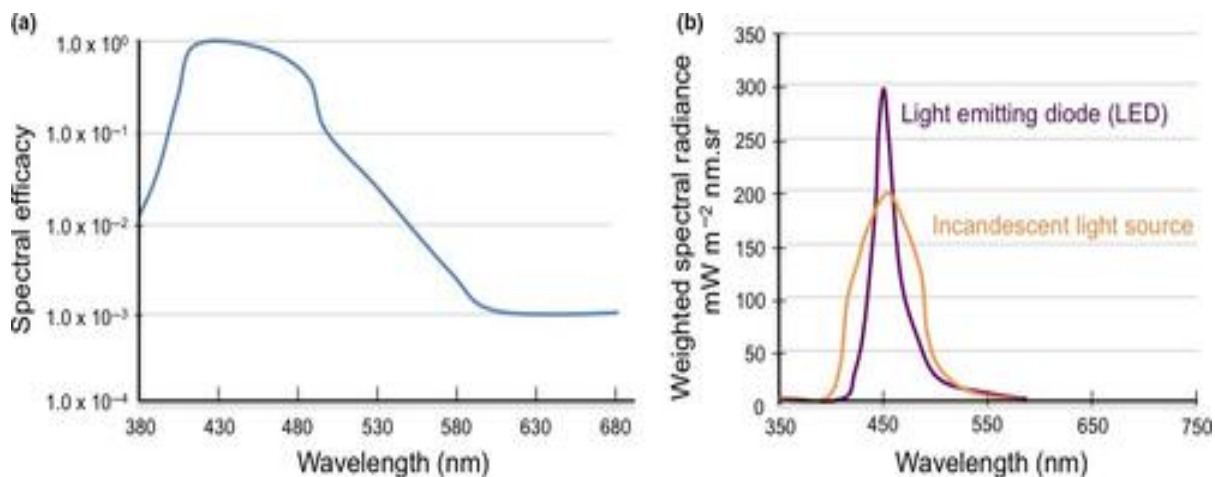
If we talk about digital screen gadgets- Television may be watched at a safer distance, but screens on computers and laptops are closer than that and tablets and smartphones are closest among all digital screen devices, which are used especially by young people, usually for hours and hours each day (average 7 hours every day).

The amount of HEV blue light digital screens emit primarily depends on the technology being used means illumination technique of digital display screen. These electronic portable display devices give off harmful radiation in two forms. First, Radio waves help these devices to catch the network without wire and second, visible Violet Blue light (near Ultra Violet rays), shows similar effects to UV radiation. Which can contribute to many harmful diseases, disorders and degenerative changes directly or indirectly, such as Eye related problems, headaches, Brain tumours, male infertility and Ear hearing impairment, effects on the foetus, Alzheimer's disease, Parkinson's disease, Asthma, Heart trouble, Insomnia, High blood pressure, Leukaemia, Birth defects, Immune system and Rheumatoid arthritis<sup>1</sup>. Cell phones especially smartphones have an addictive quality which can gradually lead to a mental disorder like Nomo-phobia. The person might lose interest in other functions and can feel alone or anxious when that person cannot receive or send a message instantly. According to researchers, women and adolescents are more prone to this type of mood disorder<sup>2</sup>.

Smartphones have become a part of daily life. Overuse of smartphones has shown frequent ocular problems, which exponentially increased during the Covid-19 pandemic due the online classes, meetings, assignments, videos, free time social media addiction etc. Nowadays plenty of blue-rich light is present in all technological gadgets. Blue- Turquoise (470-490nm) is towards other visible wavelengths making it very less harmful. Blue Violet light (380 to 470 nm) is mentioned as "near UV" or HEV (high energy visible) due to the high photon energy- which makes it skilled to induce

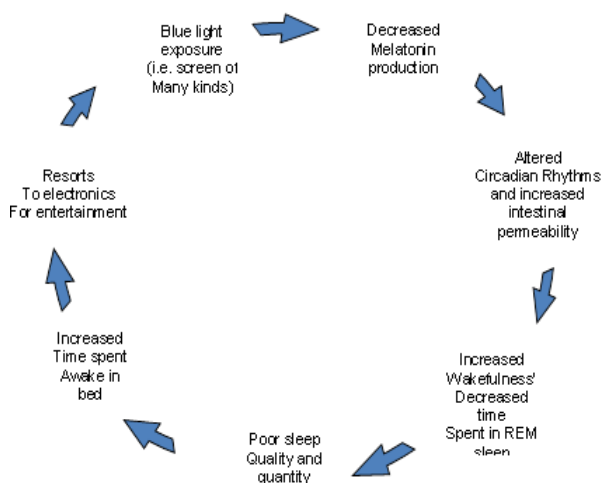
photochemical damage. Constant, continuous & excessive usage of devices created harmful effects on the Eye and general health. They contribute to the development of Reactive Oxygen Species (ROS) and could lead to degenerative changes. Ocular problems like Dryness, Itching, Irritation, Eye strain, Ocular pain, Periocular pain, degenerative changes etc. General health-related problems like headache, neck-ache, insomnia, laziness and other ergonomic problems. Disruptions to the circadian rhythm lead to a greater risk of diabetes, heart disease or obesity and an increased risk of depression. May cause permanent eye damage; may contribute to age-related macular degeneration which can lead to vision loss. And Digital eyestrain syndrome: blurry vision, difficulty focusing, dry and irritated eyes, headache, neck and back pain, etc.

According to research, subjects watching educational tasks blink at a rate of 12.55 blinks/ minute. The mean blink rate, 18.4, was always higher than theirs (measured while the subjects were talking). According to York et al., the blink rate decreased from 15 blinks/ minute to 4 blinks per minute when the visual task changed from watching a regular movie on television to interestingly reading a page of text or watching an engaging video. They observed (during the VDU task), the blink rate was similar to 3.6. Reflex blinking can happen when something touches the cornea, stimulating the corneal nerves. During waking hours, we occasionally blink without being consciously (involuntarily) aware of it. The rate of blinking is thought to be influenced by the difficulty of the visual task and a mechanism in the basal ganglia and reticular formation. Therefore, the reason why the blink rate is so low when using a VDU could be due to concentration, focus and the challenging nature of the task.

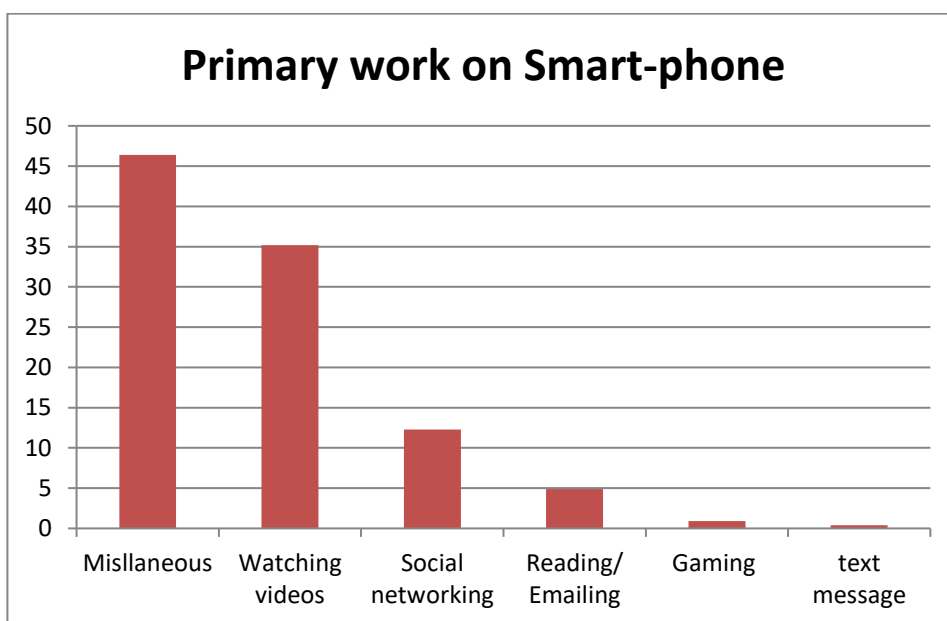


- (a) Diagram of the blue light hazard function, which plots the relative effectiveness of optical radiation to produce damage as a function of wavelength.
- (b) Blue light weighted spectral radiance from incandescent (orange plot) and light emitting diode (purple plot) light sources, after applying the blue light hazard weighting.

### Effect on Circadian Rhythm



Smartphone addiction is also connected to the rise in fatigue and sleep disorder in users. Family relationships and friendships can suffer as a result of the overuse of social media on mobile phones. It can lead to poor communication, rigid boundaries, dishonesty in a relationship, high level of conflict and social isolation<sup>2</sup>. Mobile phones and message services have become integrated aspects of society. Mobile phones most likely have become a primary means of communication. Smartphone users may encounter stress, sleep disturbances and symptoms of depression, especially young adults. Under the age of 25 experienced, people feel anxiety or even irritation when they were not able to access their phone whenever they wanted. According to Twente and her colleagues, smartphones were on the rise, and there was also an increase seen in depressive symptoms and even suicides among adolescents in 2010.



**Graph-1** shows the types of contents seen by the participants (571)

For the 10 different branded lenses studied, the transmission of wavelengths below 460nm varies from 48% to 69% for wavelengths between 460nm to 500nm from 33% to 55%. Between lenses, there was a measurable difference of over 20%. The percentage of light transmitted varies from approximately 71% to 83%, if the transmission range of wavelength is changed to 480nm and 500nm, giving a difference of about 12% between all lenses. Not all lenses transmitted blue light in

the same way, and different manufacturers have different thoughts about how much blue light should be reflected or transmitted<sup>5</sup>.

The chief executive of the French lighting agency is not afraid to speak out against international marketing practices, said that "The market is corrupted by opportunistic procedures, selling lighting products of very low quality". Because the businessman less concern about the quality of digital display lighting.

### **Study design and Duration**

This cross-sectional, time-framed study was conducted from January 2019 to January 2020 at the Department of Optometry, Uttar Pradesh University of Medical Sciences, Saifai, Etawah, Uttar Pradesh. Subjects were selected based on inclusion and exclusion criteria (Convenience sampling) from the campus of the University (students, professionals, staff, and OPD patients).

### **Material & method**

The complete eye examination was done with Optometric instruments, after filling out the informed consent form, reading the information sheet of the study and fixing, validated questions were asked. Responses to symptoms-related questions and smartphone addiction questionnaires were noted. Demographic data, history, symptoms (frequency and severity), signs and clinical findings were noted down for documentation purposes. Enrolled participants are usually new smartphone users and never suffered similar ocular problems before smartphone use. The participants used the spectacle lenses of different brands and companies of National and International brands like Titan, Essilor, Zeiss, Prime, Vision Rx, GKB, HOYA etc.

### **Data analysis**

The data was analyzed by software SPSS of Uttar Pradesh University of Medical Sciences from Biostatistics department. The data was filled in a single excel sheet and then separated in other sheets as per requirements.

### **Results**

Of all 600 participants, 571 completed all procedures. Of 571, 97.75% using smartphones from different companies and 84.64% were smartphone addictive. 65.16% of participants were using smartphones for watching videos and surfing on social media most of the time. Of all participants, 65.7% suffered Headaches frequently, 33.3% ocular and peri-ocular pain and 45.32% continuously felt ocular dryness. ocular fatigue and convergence insufficiency were common in nearly 63% of participants. Along with the ocular problems like eye strain, Periocular pain, tiredness of the eye, burning sensation, watering, redness, slow focusing from distance to near, slow focusing from near to distance, blurred vision at distance, colored haloes, floaters, flashes of light, photophobia, intermittent diplopia, neck pain, shoulder pain and other ergonomic problems raised exponentially as more screen time increases. The data shows ocular symptoms are significantly less in spectacle users in comparison to non-spectacle users. And blue block lens users are significant in comparison to non-spectacle users.

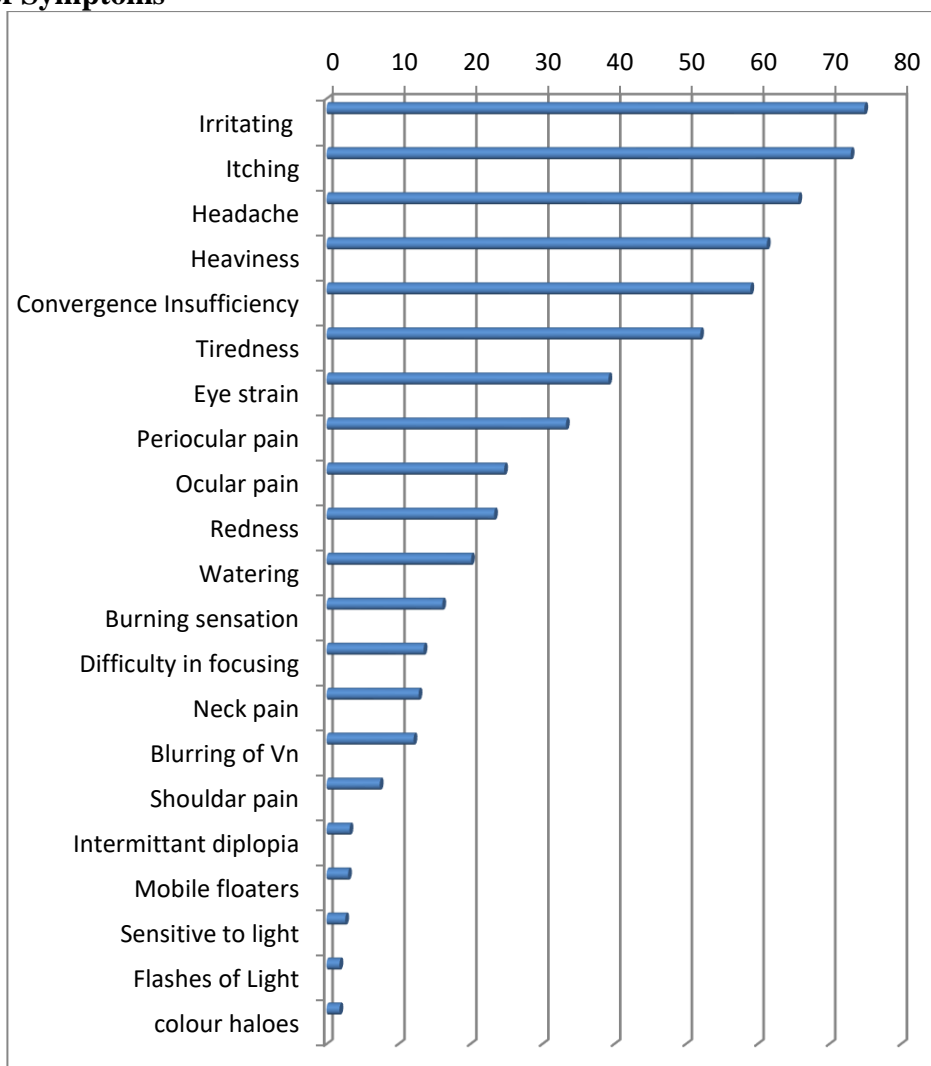
In this study, non-invasive methods were used to measure the blink rate and tear stability of VDU use in normal, healthy subjects. The results showed that the blink rate decreased by an average of five times while using a VDU, and tear film stability influence that time but stability appeared unaffected after use. It was discovered that there was a significant relationship between blinks while using a VDU due to a decrease in blink rate significantly.

**Table-1** Characteristics of study participants

|                                 | Without lenses | With lenses | Total       |
|---------------------------------|----------------|-------------|-------------|
| Age                             | 21.83±3.02     | 24.64±4.48  | 22.84±3.85  |
| Gender- Male                    | 142 (38.8%)    | 107(52.2%)  | 249 (43.6%) |
| Female                          | 224 (61.2%)    | 98 (47.8%)  | 317 (56.4%) |
| BCVA (20/20)                    | 366 (100%)     | 200 (97.9%) | 566 (99.1%) |
| (20/30)                         | 0 (0%)         | (2.1%)      | (0.9%)      |
| IOP, mmHg ± SD                  | 14.6± 2.7      | 14.4±2.9    | 14.5±2.8    |
| Subjective symptoms             | 18.29±6.49     | 13.72±5.91  | 16.65±6.66  |
| Convergence (RAF ruler in cm)   | 8.65±2.28      | 9.59±2.55   | 8.99±2.42   |
| Ocular adnexa (Conj. injection) | 52 (9.11%)     | 22 (3.85%)  | 74 (8.23%)  |
| Tear Prism (in mm)              | 0.35±0.08      | 0.32±0.07   | 0.34±0.078  |
| Average Blink Rate (per minute) | 6.28±0.992     | 5.48±0.96   | 5.99±1.05   |
| TFBUT ±SD                       | 14.93±2.98     | 14.±3.19    | 14.60±3.09  |
| Ocular Surface Disease Index    |                |             |             |
| Total index                     | 15.17±5.19     | 12.73±5.13  | 13.61±5.28  |
| Vision- related function        | 4.70±2.13      | 4.34±2.39   | 4.47±2.31   |
| Ocular Symptoms                 | 6.56±2.91      | 5.07±3.04   | 5.60±3.08   |
| Environmental triggers          | 3.91±2.12      | 3.32±2.17   | 3.53±2.31   |

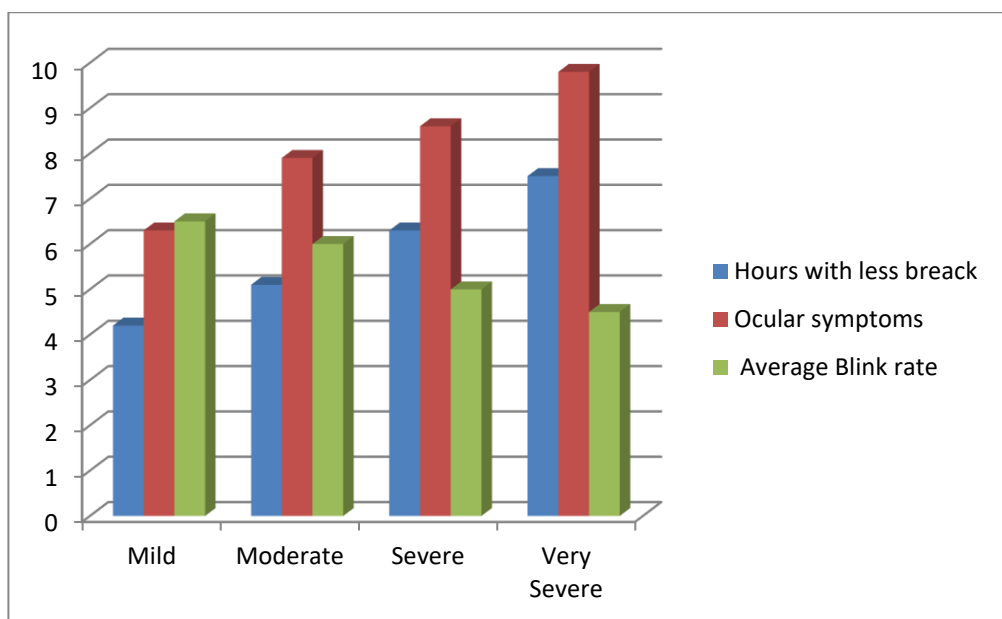
p< 0.005 usually

**Frequency of Symptoms**



**Graph-2** shows the prevalence of ocular symptoms of DES in total participants (571)

**Correlation among continuous digital screen time, ocular symptoms, and less blink rate-**



**Graph-3** shows the correlation among number of hours spent on digital device without break, ocular symptoms, and reduced blink rate

**Table-2** Characteristics of study participants

|                                        | ARC lenses  | Blue protect lenses | All participants |
|----------------------------------------|-------------|---------------------|------------------|
| <i>Subjective symptoms</i>             | 16.52±6.776 | 11.14±3.175         | 16.65±6.66       |
| <i>Convergence (RAF ruler in cm)</i>   | 8.65±2.28   | 9.59±2.55           | 8.99±2.42        |
| <i>Ocular adnexa (Conj. injection)</i> | 52 (9.11%)  | 22 (3.85%)          | 74 (8.23%)       |
| <i>Tear Prism (in mm)</i>              | 0.35±0.08   | 0.32±0.07           | 0.34±0.078       |
| <i>Average Blink Rate (per minute)</i> | 5.48±0.914  | 5.53±0.993          | 5.99±1.05        |
| <i>TFBUT ±SD</i>                       | 14.21±3.658 | 13.93±2.695         | 14.60±3.09       |

**Discussion**

The constant, regular and continuous (without break for long hours) use of smartphone causes more symptoms related to the eye mainly due to incomplete and reduced blink rate, incomplete blink, the heating effect of high energy visible light and the influence of circadian rhythm. Disturbance in sleep and wake-up time influence the whole body and create various health-related issues.

A few previous studies show that HEV light cannot create the ocular problem but now enough evidence is present that showed that intense visible light can exaggerate and can create ocular damage like Macular damage after post-cataract surgery. Previously conventional LCD and/ or LED screens now replaced by OLED or AMOLED (Active Matrix Organic Light Emitting Diode) screens (for making smartphones lighter and thinner) produce their light, directly visible to the user. These are known as emissive in contrast with LCD/ LED screens are known as transmissive. The HEV light emitted is directly collected by the ocular structures and retina at a very short distance. The hazard/ danger come not from the total amount of light emitted (luminous flux) but from the twofold risk of proximity (closeness from a digital screen) and duration of exposure. Watching videos/ movies on a smartphone with an AMOLED screen can therefore be dangerous. Physical (ocular), mental and social aspects are the important components of general health. In the modern

century, mobile phones have brought such a revolution in which most students and youngsters are altered towards mobile. Mobile phones have a great effect on students as well as on youngsters' daily routines, education level, physical and mental health, social activism and economic conditions.

We have enough evidence from studies that the main producer of HEV light is capable to damage macular active cells in vitro. Previously there is Sun only, now there are both, artificial lights and Sun. We also know that we cannot stop using fluorescent HEV light but we can reduce the time duration and take regular breaks in between the digital screen use like following the 20-20-20 rule to reduce the ocular symptoms. As we know that "Precaution and Prevention is always better than Cure". So precaution against digital screens that have high emission of HEV light: avoid close, long-time continuous overexposure with high levels of brightness. The cumulative effect over time is dangerous and harmful for all sophisticated ocular structures. Precaution and prevention should be taken early and long-term. Mainly to children, young adults and after early-age cataract surgery, whose ocular media allow these HEV lights to pass in large volumes and are prone to overexposure effects of the Sun, digital screens and artificial white fluorescent light. There is now sufficient evidence present to demonstrate that the aphakic retina is affected earlier than the pseudophakic.

Recently, a young woman and a girl, who had watched their smartphone in the dark for an extended period, have temporary unilateral blindness and bilateral mild photo-chemosis, respectively published in the national newspaper. And the studies also indicate the female are more symptomatic than male. Not all portions of blue light should be avoided. The wavelengths over 480 nm are beneficial for colour vision and directly involved in the synchronization of the circadian clock which influences the sleep-wake cycle.

Different symptoms associated with the different causes like ocular pain usually associated with convergence insufficiency and refractive error, dryness usually associated with metabolic changes, decrease blink-rate and incomplete blink and radiation heating effect, and frontal headache usually associated with uncorrected and or residual refractive error and influenced circadian rhythm. The radiation effect usually depends on time (duration), strength/ intensity of radiation light, area of exposure and angle of incidence of radiation.

Protection means with the spectacle the ocular symptoms reduce but it does not mean that the total ocular symptoms will vanish by the spectacle lenses. Preventive measures like protective spectacle lenses only reduce the symptoms related to the radiational effect of blue light like irritation, grittiness, dryness and redness etc. But the patient needs to do preventive measures for other symptoms which are not related to the radiational effect of blue light like muscular fatigue, convergence insufficiency etc.

Community health professionals should enhance social interaction among students and spread awareness, and educate them about radiation, which will help to improve professional standards and create a better image in society. Teaching programmes can be given to students, their parents and teachers using various channels of communication regarding reducing the effects of smartphones on mental and social aspects of health.

## **Conclusion**

This study's results reveal that smartphone-addicted participants (overexposure from a very short distance) got more frequent ocular symptoms like exposure to dry eye, conjunctival injection, DES etc. (female > male). HEVB light has potential ocular risks and shows ocular symptoms, which are generated by a significant incomplete and reduced blink rate. There is a significant difference between with and without the spectacle. Using spectacle reduces the ocular symptoms and



conjunctival injection and the significant difference between anti-reflective and blue light-protecting lenses. Blue protective lenses reduced few symptoms more significantly than ARC lenses.

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## **Acknowledgments**

Thank Dr. Satya Vrat Tripathi, Smt. Anarkali Tripathi, Smt. Rajni Tripathi and Dr. Deepak Gupta for their blessings and love. I would like to thank participants for providing information and cooperation.

## **Funding information**

This research received no any grant from any funding agency in public, commercial or not-for-profit sectors (totally self-funded).

## **Data availability**

The data in addition to the ones provided in this article that support the findings of the study are available from the corresponding author, Aditya T; upon reasonable request.

## **Interest of conflict**

None

## **Author's information**

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