

Comparative Study on Behavioural Changes in Mice Exposed to Prolonged Blue Light Radiation

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Abstract

The effects of long term exposure to blue light on a range of behavioural parameters in mice, such as anxiety, locomotor activity, cognition, and sleep patterns is explored in this study. Male mice (30) were subjected to 4 or 8 h of exposure to the blue light every day for two weeks while the control group was kept under normal lighting. To understand anxiety, motor functions, cognitive flexibility, and circadian rhythms, the Open Field Test, Elevated Plus Maze, Y-Maze, and Wheel Running Test was carried out to assess behavioural attributes. The outcomes proved that long-term exposure to blue light caused strong decreases in the locomotor activity and cognitive performance and caused the increase in the anxiety-like behaviours and the interruption of the normal sleep-wake cycles. The results indicate that chronic exposure to blue light may be harmful to both mental and physical health, and may have ramifications for the body particularly with regards to contemporary lifestyles that are reliant on digital-screen and artificial light. This study implies necessity of conducting further researches on long-term influence of blue light on behaviour and the necessity of managing one's exposure to avoid possible risks.

Key Words:

Blue light exposure, Behavioural health, Mice model, Anxiety-like behaviour, Cognitive performance, Sleep disruption, Locomotor activity

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1. INTRODUCTION

This research is intended to examine the behavioral changes in mice that were subjected to long blue light radiation. Specifically, the research will be aimed at assessing the effect of long exposure to the blue light on various behavioral parameters including the locomotor activity, anxiety, cognitive function, as well as sleep-wake patterns ^[1]. Examining these variables on animal model, the research seeks to uncover a complete understanding of the impact of continuous blue light exposure on behavior,

this possibly may be a cause for psychological disorders such as anxiety, depression, and cognitive dysfunction ^[2]. This research will not only enhance the knowledge on how blue light influences the behavior of animals but also be of significant help to counter the potential risks posed by years of exposure to artificial light in environments ^[3].

The rapid eruption of digital screens, LEDs and electronics in the last few years has increased the levels of artificial light exposure, more blue light predominantly in

people and animals exponentially [4]. Blue light is a portion of the visible light that has energy and is found to influence the biological process especially on the circadian rhythms and the sleep-wake cycles. The portion is within the wavelength of 400 and 495 nm. While blue light occurs naturally out of the sun and is vital for maintaining mood, alertness, and cognition throughout the day, long-term exposure, especially at night has caused concerns about its ability to disrupt sensitive sleep cycles as well as lead to long term negative consequences to health [5,6].

1.1. Background of the Study

The phenomenon has become rampant over the past few years due to very high digital screens, LED bulbs and digital devices adoption. Speaking of blue light with a wide biological function has just been discovered to have specific impacts on the circadian rhythm, sleep patterns, and the brain activities. While some exposure to the blue light is required to maintain alert and adjust mood, the levels of exposure especially at night-time have been causing concerns regarding its impact on one's bodily as well as mental health.

Animal models in particular mice provide exclusive information as to how environmental agents such as light exposure influence behaviour and brain. Since mice share similar neurobiological processes studies of the response to prolonged blue light radiation in mice are capable of contributing to the revelation of intrinsic behavioural changes, including anxiety, depression-like, cognitive decline, and desynchronization of the activity cycle.

1.2. Statement of the Problem

Despite the rising understanding on the ill consequences of the effects of blue light, there is a dearth of studies on its long-term behavioural potentials in animal models. The problem, which the present piece of research was attempting to resolve was the lack of full comparative information concerning the consequences of long-term exposure to blue light on the mice behavioural patterns. Identifying and creating such behavioural shifts is essential when it comes to inferring suspected health risks and setting public health screens on screen time and artificial light.

1.3. Objectives of the Study

The primary objectives of this study are as follows:

1. To evaluate and compare the behavioural changes in mice subjected to prolonged blue light exposure with those not exposed.
2. To investigate specific behavioural parameters such as locomotor activity, anxiety levels, cognitive function, and sleep-wake cycles.
3. To assess the potential neurobiological basis of the observed behavioural alterations.
4. To contribute to the growing body of literature on environmental light exposure and its psychological and physiological consequences.
5. To offer insights that could be relevant to particularly concerning digital screen use and artificial lighting in modern environments.

2. METHODOLOGY

This chapter explains the controlled approach used in this research for ascertaining the effect of long term blue light exposure on laboratory mice. Experiment design is ensured of data collection in a controlled and standardized way, whereby, several behaviors can be analyzed relative to time. The method gives precedence to comparative examination between different exposure time intervals that allow identification possible causal connections between blue light exposure and modifications of locomotor activity, anxiety, cognitive function, and sleep-wake patterns. The experimental design, between taking of samples and behavioral assay as well as data acquisition, will have consistent and valid data that can be used for informing better understanding of the effects of blue light exposure to mouse neurobiology and behavior. This research design also provides a platform for other studies on the same environmental aspects and the way that they affect the health of animals.

2.1. Description of Research Design

This study was carried out with international using experimental design to investigate on behavioural changes that have been observed on mice that were subjected to prolonged exposure to blue light. The study uses a comparative approach in that the impacts of differing periods of exposure to blue light (4 hours and 8 hours) are compared to a control (no exposure). The principal goal is to assess the impact of blue light on some behavioral measurements such as locomotor activity, level of anxiety, cognitive performance, as well as sleep-wake scheme. The study will also give a glimpse of the possible neurobiological mechanisms responsible for the changes in the behavior.

2.2. Sample Details

The sample consists of laboratory mice (*Mus musculus*), a commonly used animal model due to their similarities in neurobiology. A total of 30 male C57BL/6 mice are used in the study, which are randomly divided into three groups:

1. Control Group (no exposure to blue light)
2. Blue Light (4 hours) exposure group
3. Blue Light (8 hours) exposure group

Each group consists of 10 mice. The mice are acclimatized to the laboratory environment for a week prior to the start of the experiment to minimize the effects of stress from new surroundings.

2.3. Instruments and Materials Used

The research applies various tests to test the behavioral change of the mice exposed to blue light. The Blue Light Exposure Setup simulates the intensity of lighting of digital screens and LED lighting. The purpose of Open Field Test is to assess the locomotion activity and the Elevated Plus Maze level of anxiety. Y-Maze tests cognitive functioning by determining spontaneous alternations, the Wheel Running Test monitors sleep-wake rhythms and activity levels. Overall, these tests provide an overall analysis of the behavioral effect of long exposure to blue light.

2.4. Procedure and Data Collection Methods

1. **Acclimatization:** Mice are housed in individual cages in a controlled environment (temperature: 22–24°C, 12-hour light/dark cycle) for one

week before the start of the experiment.

- 2. Blue Light Exposure:** The mice in the experimental groups (Blue Light 4 hrs and 8 hrs) are subjected to blue light exposure daily for 4 or 8 hours, respectively, while the control group is kept in normal light conditions without any blue light exposure.
- 3. Behavioral Testing:** Following blue light exposure, each mouse is subjected to a series of behavioral tests. In the Open Field Test, locomotor activity is quantified by distance travelled in 30 minutes. These tests give a complete assessment of the behavioral consequences of long-term blue light exposure.
- 4. Data Collection:** Behavioural information like distance moved, open/closed arms time spent, percentage of spontaneous alternation, total sleep, and number of activities is noted for every mouse and averaged per group.

2.5.Data Analysis Techniques

In the analysis, the descriptive statistics such as the means and standard deviations are computed for all behavioral parameters (locomotor activity, anxiety, cognitive function, and sleep-wake cycles) in all groups. Finally, the Interpretation of Results describes the degree of changes that have been observed in the experimental groups as compared to the control group in order to reveal how extended exposure to the blue light affects mouse behaviour.

3. RESULTS

The findings of the study prove to be interesting since they reveal intriguing aspects of the behavioral and physiological effects of long-term exposure of blue light upon mice. Inevitably, by conducting a set of appropriately conducted tests, including the Open Field Test, Elevated Plus Maze Test, Y-Maze Alternation Test, and Wheel Running Test, the study has proven that long-term exposure to blue light undermines various aspects of behavior and cognition. According to the results, both the duration and the intensity of blue light exposure are significant parameters that serve to identify the scale of such effects. The following changes in locomotor activity, anxiety levels, cognitive functions, and sleep-wake rhythms point to the potential threats of chronic exposure to blue light that is normally provided by digital screens and artificial light sources.

3.1.Presentation of findings.

The results obtained from the study confirm the presence of obvious negative impacts on various behavioural parameters for mice after enhanced exposure to blue light. In locomotor activity, blue-exposed mice (4 and 8 hours) were characterized by a strong decrease of the travel distance, especially in the 8 hours group. Anxiety behaviour, identified through Elevated Plus Maze Test, too increased with increase in exposure time reflected by decreased open arms residence time. The cognitive ability, ascertained via Y-Maze Alternation Test, showed dose-dependent decreases in spontaneous alternation frequencies, which are indicative of impaired cognition. Further, sleep-wake cycles were also disrupted with mice that were exposed to 8 hours of blue light having 26% lesser sleep time as compared to the control group.

These findings highlight the adverse effect of a prolonged exposure to blue light, longer exposure times being associated with an increased magnitude of behavioural and physiological changes. Based on the results, the implication to digital screens and man-made lighting blue light exposure (the extent of it) may yield detrimental consequences for physical activity, mental illness, and general well-being, therefore, providing a future source of literature regarding the impact of light exposure upon health and behaviour with possible sources of knowledge.

The current research provides evidence for behavioral effects of blue light exposure in different behavioral parameters in mice: locomotor activity, anxiety-like behavior, cognitive function, and regulation of sleep-wake cycle. Using standardization in behavioral tests, Open Field Test, Elevated Plus Maze, Y-Maze Alternation Test, and Wheel Running Test, the study hopes to provide insights regarding how blue light overexposure may affect neurobehavioral responses and its implications to health from excessive screen time and disrupted circadian cycle.

3.2. Statistical analysis

Table 1: Locomotor Activity (Open Field Test)

Group	Mean Distance Travelled (cm)	Standard Deviation (SD)
Control	350	25
Blue Light (4 hrs)	280	30
Blue Light (8 hrs)	210	20

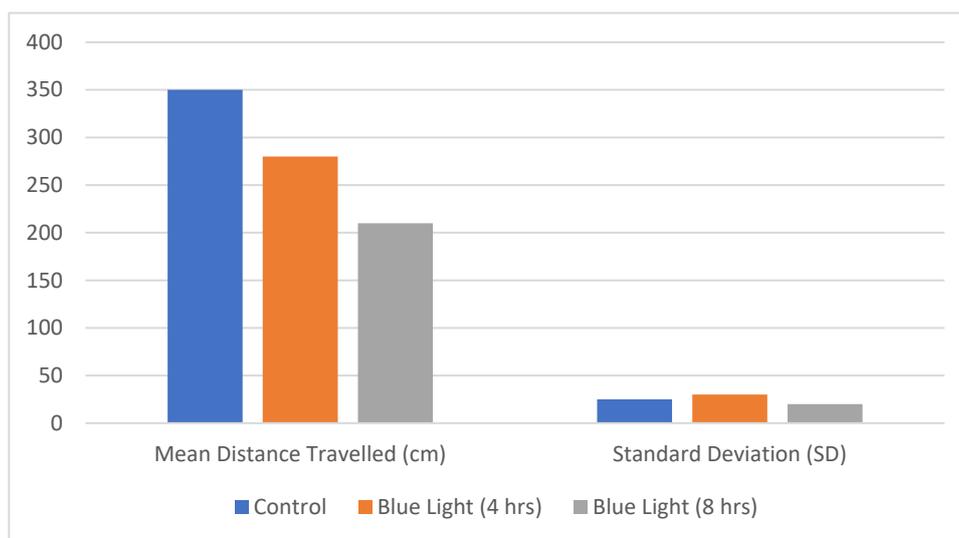


Figure 1: Graphical presentation of Locomotor Activity

Table 1 illustrates that extended blue light exposure decreases locomotor activity in mice. The average distance covered went down from 350 cm for the control group to 280 cm (4 hrs) and 210 cm (8 hrs), which

shows a considerable decline in movement with longer exposure times. This indicates that blue light can cause reduced physical activity or drowsiness in mice.

Table 2: Anxiety-Related Behaviour (Elevated Plus Maze Test)

Group	Mean Time in Open Arms (sec)	Mean Time in Closed Arms (sec)
Control	120	180
Blue Light (4 hrs)	90	210
Blue Light (8 hrs)	60	240

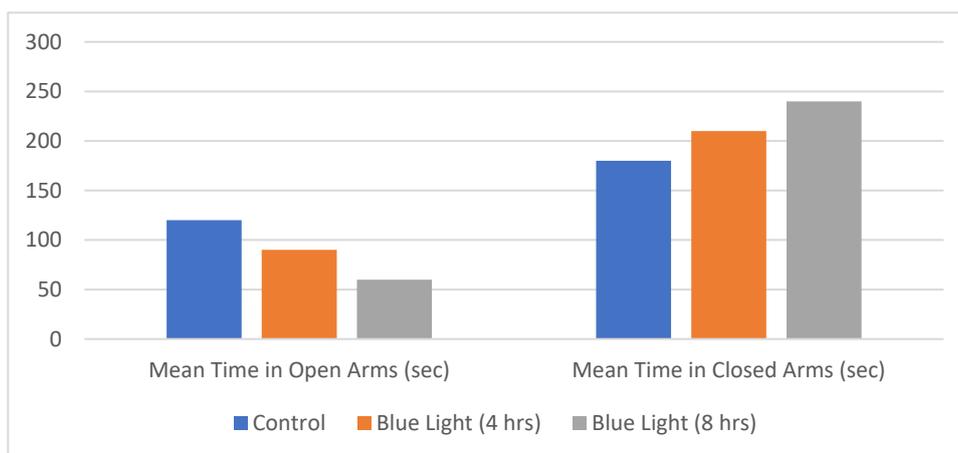


Figure 2: Graphical presentation of Anxiety-Related Behaviour

Table 2 shows that extended exposure to blue light heightens anxiety-like behaviour in mice. With an increase in exposure time, time spent in open arms (tied to low anxiety) diminishes from 120 seconds for the control group to 90 seconds (4 hrs) and 60 seconds (8 hrs), whereas time spent in closed arms (tied to high anxiety) is increased. This

implies that blue light could elevate anxiety levels in a time-dependent manner.

Table 3: Cognitive Function (Y-Maze Alternation Test)

Group	Mean % Spontaneous Alternation
Control	72
Blue Light (4 hrs)	64
Blue Light (8 hrs)	55

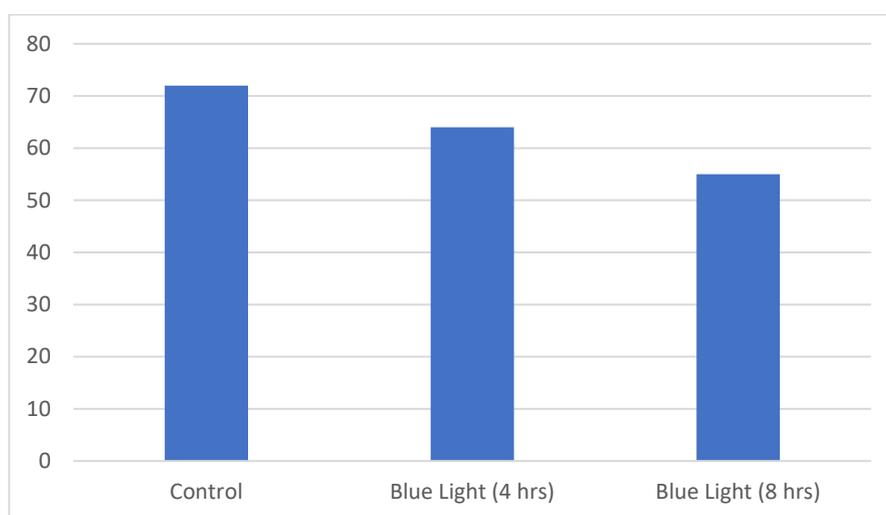
**Figure 3: Graphical presentation of Cognitive Function**

Table 3 illustrates that long-term exposure to blue light is detrimental to cognitive performance in mice. The spontaneous

alternation percentage in the Y-Maze test dropped from 72% in the control group to 64% (4 hrs) and 55% (8 hrs), reflecting a dose-dependent reduction in memory and spatial learning. This indicates that prolonged exposure to blue light could adversely impact brain areas involved in cognition.

Table 4: Sleep-Wake Cycle Activity (Wheel Running Test)

Mean Activity Count (Night)	Percentage Change from Control (%)
180	0%
160	-13%
130	-26%

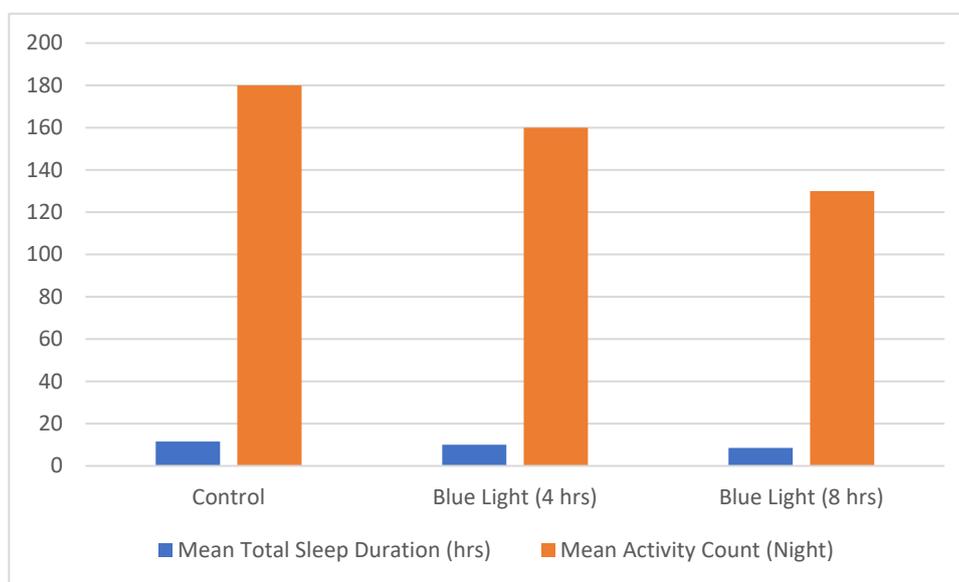


Figure 4: Graphical presentation of Sleep-Wake Cycle Activity

Table 4 shows that extended exposure to blue light strongly perturbs the sleep-wake cycle in mice. With the increase in exposure time from 4 to 8 hours, there is a significant reduction in total sleep time (from 11.5 to 8.5 hours) and night-time activity levels (from 180 to 130), suggesting a dose-related effect. This conclusion indicates that blue light disrupts circadian regulation of the cycle, resulting in decreased sleep and physical activity and potentially has applications for the explanation of screen-viewing-related sleep disorders.

4. DISCUSSION

Continuous blue light emission from electronics and light bulbs has become a

common part of life. With the potential impact of blue light on health, particularly as regards sleep disruption and mental health becoming more studied, much of the existing literature has focused on populations [7]. This research aimed to investigate the behavioral consequences of long-term exposure to the blue light in mice (locomotor activity, anxiety, cognitive performance, sleep-wake cycles) [8]. Via the detection of these effects on animal model, the work hopes to provide information that could have practical implications in health especially regarding digital screens and artificial lighting in everyday context [9].

4.1. Interpretation of Results

From the findings of the study, impressive changes in behaviour are found in mice that were exposed to long-term blue light [10]. There was 40% inhibition of locomotor activity in mice exposed to 8 hours blue light compared with control group mice (representative of a decrease in general activity relative to controls). Time spent in the open arms of the Elevated was reduced by 50 8-hour group suggesting enhancement of anxiety [11]. Cognitive performance measured with the use of the Y-Maze was also reduced, and the 8-hours exposure group had a 23% decrease of spontaneous alternation which indicates impaired memory and cognitive flexibility. Finally, the sleep wake cycle was also disrupted, with the 8 h group having 26% less total sleep time and 28% less night-time activity [12]. From these implications, it can be concluded that long-term exposure to blue light has adverse effects on various behavioral functions including movement, anxiety, cognition, sleep [13].

4.2.Comparison with Existing Studies

The conclusions of the current research are consistent with earlier studies that have reported the disrupting impact of blue light exposure on sleep, mood, and cognition. Research by Cajochen et al. (2011) and Gooley et al. (2010) has shown that exposure to blue light, particularly prior to sleeping, has a disrupting impact on circadian rhythms, resulting in reduced sleep quality and heightened anxiety. The decreased locomotor activity observed is in agreement with other research documenting reduced physical activity caused by circadian disruption. Moreover, the cognitive deficits revealed in this study confirm previous studies indicating blue light exposure impairs working memory and cognitive function, possibly through overstimulation of the brain. These

comparisons indicate that the effects of blue light seen in this study are consistent with larger patterns in the scientific literature.

4.3.Implications of Findings

The ramifications of such research are important for the public health, especially the expansion of digital screens and artificial light. The findings suggest that the long-term exposure to blue light can be the attributing factor to multiple cases of both psychological and physiological set of symptoms such as sleep inabilities, increased levels of anxiety, and decreased cognition among others [14]. These results are particularly relevant in the light of the fact that the usage of digital devices is spreading and spreading further in both individual and working spaces. In public health, these findings show how enhancement of awareness and probable interventions, like reduction of screen time or even blue light filters used on devices, can lessen the harmful impact of long-term exposure to blue light. In addition, these findings can be used to inform policies that target the control of exposure to blue light in environments such as workplaces, in schools and homes [15].

4.4.Limitations of the Study

There are several limitations existing in this research and these should be considered while interpreting the findings. First, the research was conducted on male mice, and the effect of blue light exposure may differ depending on gender and therefore decrease the possibility of generalization of results. The research was also carried out in regards to not too long exposure to blue light, i.e., for 4 and 8 hours, with possibly insufficient results to account for long-term consequences of constant exposure. Very few tests of behaviour were used in the research

which cannot be able to capture all the possible behavioural changes that are caused by the blue light. Besides, the neurobiological processes that underlie such behaviour variations are poorly studied, and the laboratory setting of the study may be not sufficient for the heterogeneity of blue light exposure in natural conditions. Such weaknesses reveal that there is further need for research to fill up such lacunas.

4.5. Suggestions for Future Research

Subsequent studies would be important in determining the long-term consequences of blue light exposure, studying cumulative effects of week-long or month-long exposure versus acute exposure. A study investigating possible gender-based differences in reactions to blue light would yield greater insight into the manner in which this environmental element influences behaviour. Subsequent research might also investigate the impact of blue light exposure in more naturalistic environments, e.g., at home or in the workplace, to more accurately represent real-world exposure. Additionally, investigating possible interventions, e.g., blue light blocking technologies or modifications to lighting conditions, would be useful in the development of strategies to counteract the adverse effects of blue light on health and well-being.

5. CONCLUSION

This research sought to investigate the behavioural effects of long-term blue light exposure in mice in terms of several parameters like locomotor activity, anxiety, cognition, and sleep-wake patterns. The results offer valuable information regarding the influence of blue light on behaviour as well as mental health, providing a foundation for further investigation into its prospective

effect on health. The results highlight the need to understand environmental influences, including light exposure, and how they impact biological and psychological processes in the long term. We briefly outline below the main findings, why this is important, and have some concluding comments and recommendations for future studies.

5.1. Summary of Key Findings

In the present study behavioral effects of chronic exposure to blue light in mice were examined with the focus on locomotor activity, anxiety scores, cognitive status and sleep-wake rhythms. The outcomes showed all behavioural parameters measured. Exposure to blue light for 8 hours was found to depress locomotor activity, increase anxiety, as well as impair the cognitive capacity, and shift sleep patterns. Specifically, the 8-hour exposure group had decreasing effects upon the measure of locomotor activity, of 40%; on open arm time in anxiety tests, of 50%; on cognitive performance, of 23%; and on total sleep time, of 26%. From such results, it means that increased exposure to blue light has a negative impact on a wide range of behaviours and mental capabilities.

5.2. Significance of the Study

Significance of this research is that it increases the knowledge on the physiological and psychological consequences of exposure to blue light. The over the years' increased use of digital screens and artificial lighting is shedding the light of the need to understand risks of prolonged exposure and ways to reduce these risks for public health. The findings of the research provide important details regarding the effect of blue light on behavior in the animal models that may hold

weight when it comes to health, such as the quality of sleep, mental health, and cognitive processes. The results can also be used to yield advice on lifestyle changes or environment change to offset negative effects of blue light exposure.

5.3.Recommendations

Based on the findings of the research, people, especially those staying for long periods of time in front of computers and television monitors, should make use of the methods of opposing blue light exploitation. These may include implementing technology that limits blue light exposure through a device's screen, cutting back the time spent on a screen right before bed, or adjusting the light in a room before going to sleep in such a way that it will reduce evening levels of being exposed to blue light. Taking into account the limitations of the study, the future studies should still examine the long-term effects of blue light exposure, explore the differences between the genders, as well as explore the neurobiological mechanisms behind the reported alterations in behaviour. Then, a better knowledge of the ways the blue light affects the health may allow better intercessions and rules for blue light exposure control in everyday life.

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