



Balancing Benefits and Risks: A Mini Review of The Complex Relationship between the Blue Light Exposure and Sleep Health

Omnia Magdy¹, Sara Ibrahim¹, Rana Osama¹, Sama S. ElSherefy², Asmaa Mohamed³, Noha N. Lasheen^{4,5}

1: Undergraduate Students in Faculty of Medicine, Galala University, Suez, Egypt

2: Undergraduate Student in Faculty of Medicine, Ain Shams University, Cairo, Egypt

3: Undergraduate Student in Faculty of Medicine, Cairo University, Cairo, Egypt

4: Associate Professor of Physiology, Faculty of Medicine, Galala University, Suez, Egypt

5: Associate Professor of Physiology, Faculty of Medicine, Ain Shams University, Cairo, Egypt

Submit Date : 12 June 2025

Accept Date : 24 July 2025

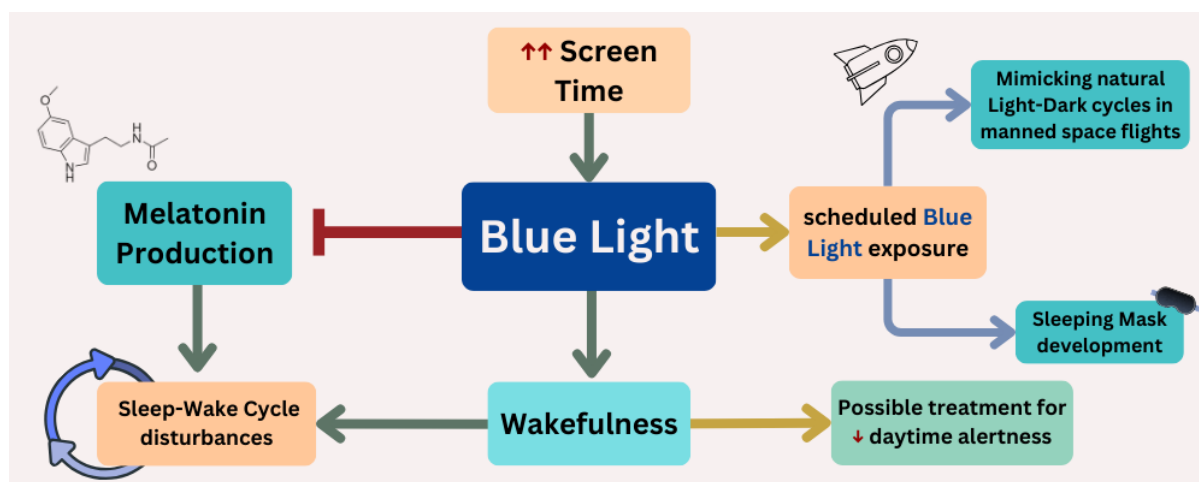
Keywords

- Blue Light
- Healthy Technology
- Post-Traumatic Stress Disorder
- Social Media
- Sleep Disorders

Abstract

Over the past decade, growing scientific concern has focused on the influence of technology, in particular social media engagement and exposure to blue light, on sleep patterns. This review aimed to synthesize current evidence investigating the relationship between blue light and melatonin secretion as well as the duration of sleep, focusing on the adverse and potential positive impacts on human health and wellbeing. This review focuses on the effect of blue light exposure on circadian rhythms, melatonin suppression, and cognitive function. Blue light emissions from electronic devices have been linked with sleep-wake cycle disruptions and lower melatonin level. In opposition, controlled exposure to blue light has been shown promise to be effective in specific medical conditions, such as seasonal affective disorder and circadian rhythm disorders and post traumatic stress disorder. The review also discusses the possible benefits of blue-light filtering lenses and light-based interventions to improve sleep outcomes. This review emphasizes the need for the establishment of healthy technology usage habits to reduce the negative implications on sleep. Researchers and medical professionals can better customise therapies to improve general health and sleep quality by knowing the subtle effects of blue light for clinical practice.

Graphical Abstract:



Introduction

As technology advances, it becomes more increasingly apparent how blue monochromatic light affects our sleep cycles. The wavelength range for blue monochromatic light produced by mobile phones is 435–440 nm. Light-emitting diodes (LEDs), which are used to illuminate smart gadgets like phones, tablets, and laptop computers, emit light at this wavelength. Social media additionally contributes to the problematic overuse of blue-light-emitting devices, which feeds the vicious cycle of blue light exposure and disturbed sleep (1).

In a study conducted on medical students, it was found that the screen time immediately before sleep is around one hour per night (1). Such exposure on a daily basis may lead to a disrupted circadian rhythm or the sleep-wake cycle, by adding difficulty in falling and maintaining sleep (2). This problem is exacerbated by social media, which provides a culture of constant connectivity and the fear of missing out, causing cognitive and mental arousal (3).

In addition, blue monochromatic light exposure may affect sleep that goes beyond simple psychological arousal. It was found that blue light

exposure, particularly throughout the night, can inhibit melatonin production. The effects of blue light on brain function have garnered significant attention in recent research. A notable study by **Alkozei et al.** (4) explored the impact of blue wavelength light exposure on brain connectivity, specifically between the amygdala and the dorsolateral prefrontal cortex (DLPFC), revealing increased bidirectional connectivity between these regions. This suggests that blue light can influence neural mechanisms linked to emotional regulation and alertness, which may indirectly affect sleep and mood depending on the timing and duration of exposure (4).

Apart from its suppression of melatonin, blue monochromatic light's direct impact on the length of sleep has also been studied. In several clinical trials, blue light exposure prior to bedtime shortened total sleep time and increased wake after sleep onset (5). Such sleep disturbances could impact several aspects of health and well-being, including the immune system and emotional regulation.

It is crucial to note that, even though blue light has a detrimental impact on sleep, certain potential

arguments have been rising to use it as an intervention for some diseases.

This review article tries to provide a comprehensive overview to investigate how social media and exposure to blue monochromatic light affect sleep. We seek to shed light on the significance of forming healthy technology usage habits in an increasingly digital world.

Methodology:

Search Strategy

A comprehensive search of relevant literature was conducted using electronic databases such as PubMed, SCOPUS, and PsycINFO. A combination of keywords and MeSH terms were used including keywords like "blue light exposure", "health effects", "sleep quality", "cognitive performance", "circadian rhythm", "melatonin suppression", and "blue light filtering".

Inclusion Criteria:

Studies were included if they involved human subjects of all age groups (children, adolescents, adults, and older adults) and examined the impact of blue light exposure from electronic devices or other sources on health and sleep. Both positive and negative impacts were considered—benefits on mood, cognitive performance, alertness, and sleep-related symptoms in certain diseases, as well as adverse effects such as sleep disturbances, melatonin suppression, circadian rhythm disruption, and long-term health consequences. Only peer-reviewed articles in English published between 2014 and 2024 were included. Population:

Exclusion Criteria:

Excluded were animal studies, non-peer-reviewed works, and studies not specifically addressing blue light exposure or lacking empirical sleep-related data.

Data Extraction and Synthesis

Data was extracted on study characteristics (author, year, study design, sample size, population), interventions/exposures, outcomes measured, main findings, and conclusions, and findings were summarized qualitatively to highlight both positive and negative impacts of blue light exposure on health and sleep.

Results and Discussion:

I. Blue Light Exposure and Melatonin Suppression

The impact of evening exposure to LED-backlit computer screens on circadian physiology and cognitive performance has been a topic of interest in recent research. The relationship between light exposure and human circadian rhythms has been extensively studied, with significant findings summarized in a systematic review by Tähkämö, Partonen, and Pesonen (6). This review synthesizes evidence from various studies on how different light exposures influence circadian rhythms, which are crucial for regulating sleep-wake cycles, hormone release, and other physiological processes. In summary, they reported that short-wavelength blue light plays a central role in entraining the circadian system, with exposure during evening hours delaying circadian phase and disrupting sleep (6).

Tähkämö et al. (6) also emphasized that timing, intensity, and duration of light exposure are critical factors that determine its impact on the circadian rhythm. Morning exposure advances the circadian phase, promoting earlier sleep onset and

wake times, while evening blue light exposure delays it, leading to difficulties falling asleep and waking up early. This highlights the importance of managing artificial light exposure, particularly in modern environments with pervasive LED lighting (6). Furthermore, the review linked circadian disruption to adverse health outcomes such as mood disturbances, metabolic issues, and chronic sleep deprivation, reinforcing the need for practical guidelines on light exposure in both workplace and personal settings (6).

In addition, **Downie** (7) raises the question of whether the use of blue-light filtering lenses could mitigate the negative effects of their exposure on circadian rhythms and cognitive performance, though study did not directly investigate the impact of evening exposure to LED-backlit screens. In adolescents, **Touitou et al.** (8) that nighttime light exposure leads to disturbed circadian rhythms, sleep loss, and increased risk behaviours, often intensified by the cycle of nighttime media use. Similarly, **Arrona-Palacios et al.** (9) examined older adults and found that uncontrolled lighting environments delayed melatonin onset and increased the phase angle between melatonin onset and sleep onset, potentially disrupting sleep patterns and affect overall sleep quality, highlighting the importance of managing light exposure to maintain healthy sleep-wake cycles in older adults.

Chellappa et al. (10) provided further insight through showing the non-visual effects of light on melatonin, alertness, and cognitive performance, indicating that blue-enriched light can help keep person alert. Their finding suggested that the spectral composition of light can influence melatonin levels and circadian physiology, thereby contributing to the understanding of the impact of different light spectra on melatonin suppression.

II. Sleep Duration and Screen Time:

Numerous studies have investigated the association between screen use and sleep duration, particularly in children, adolescents, and young adults. The majority of these studies have consistently reported a negative association, indicating that increased screen time is associated with shorter sleep duration. The stimulating effects of electronic devices, such as smartphones, tablets, and computers, have been suggested to disrupt sleep patterns, delay sleep onset, and reduce total sleep time (11).

The blue light emitted by screens, especially in the evening hours, can suppress production of some neurotransmitters, which may lead to difficulties falling asleep and disrupted sleep quality. Additionally, engaging in stimulating activities, such as playing video games or using social media, can enhance cognitive arousal, making it harder to wind down and transition into sleep.

The included studies specifically examined the impact screen time may have on sleep duration. For example, **Hysing et al.** (12) assessed use of new electronic devices and its effects on sleep onset latency (SOL) between adolescents at age of 17 years. They found that the associations between electronic media use and sleep were robust across the included sleep parameters, including SOL, sleep deficit and sleep duration. The Daytime screen use showed a total screen time after school hours for more than 4 hours was related to long SOL. When analyses were conducted separately for each electronic device, all daytime screen use over 2 hours was significantly associated with long SOL. Daytime screen use showed a similar pattern. Total screen time above 4 hours was associated with an increased risk of less than 5 hours of sleep.

Similarly, in the study of **Echevarria et al.** (13), the median screen time was 4.5 hours per day. The mean sleep daily duration was 7.6 hours. They found an inverse relationship between screen time and sleep duration. Adolescents with more than 9 hours of screen time were 60% more likely to have bad sleep quality.

Overall, the literature reviewed, including studies 15, 16, and 17 suggest a negative association between screen use and sleep duration, particularly in children, adolescents, and young adults. The stimulating effects of screens, along with the suppression of melatonin production, appear to disrupt sleep patterns and reduce total sleep time.

III. Positive usages of Blue Light:

A method of scheduling darkness and bright light, specifically short peak wavelength (= 469 nm) blue light exposure, was tested by several studies and eventually suggested as a possible promising treatment for decreased daytime alertness, increased daytime sleepiness, and reduced nocturnal sleep tendency, especially in older individuals by influencing the amplitude and/or phase of circadian rhythm timing, possibly through the utilisation of blue light's suppression of melatonin production (14,15). It was suggested to use the shorter wave-length blue light by many studies which revealed that short-wavelength blue light between 446 and 477 nm could be more effective (almost more than 3 times) in melatonin suppression than long-wavelength above 530 nm of equal photon density (16, 17). In addition, there was a decline in the number of nighttime awakenings and time of awakening, and higher subjective sleep quality accompanied by a forward shift in sleep-wake phase when blue light glasses

are used to treat delayed sleep-wake phase disorder (17). Moreover, scheduling bright light and darkness exposure was proposed to be an adaptation method prior to launching manned space flights to limit the anticipated negative effects of circadian rhythm disruption on the spacecraft crews, especially nervous system manifestations, which may be short-term in the form of impaired alertness, or long-term effects, which may be irreversible or disabling in later years. Also, it was mentioned that white, fluorescent light of relatively high illumination use may be used as a prelaunch countermeasure (18).

Furthermore, NASA has proposed some technical procedures to maintain design and utilisation of a blue-red light system in spacecraft lighting to simulate the circadian rhythm physiological processes similar to the natural light-dark cycles. They mentioned that the red-light portion of the system in the evening to activates melatonin production, meanwhile the blue-light one may induce wakefulness. As 24-hour day is not followed by space missions, and promoting a comfortable healthy rhythm for the crew may not be preserved, more attention is directed to the different degrees of illumination required for many tasks in the spaceship to mitigate performing such tasks on earth and achieving optimal results (18).

Recent studies have explored the effects of blue light therapy (BLT) on post-traumatic stress disorder (PTSD) symptoms, particularly sleep disturbances and emotional regulation, as shown in Table 1.

Table 1. Summary of randomized controlled trials on light therapy for PTSD Treatment.

Study	Sample Size	Intervention / Exposure	Summary of Findings
Killgore et al. [19]	84	6 weeks of daily 30-minute morning blue light (469 nm) vs. placebo amber light (578 nm)	Blue light therapy significantly improved total sleep time, sleep quantity, and circadian bedtime shift compared to amber light. PTSD symptoms declined more in the blue light group, with better retention of extinction memories and reduced neural fear responses.
Killgore et al. [20]	76	Blue light therapy (BLT; 469 nm) vs. Amber light therapy (ALT; 578 nm)	BLT led to increased total sleep time and left amygdala volume compared to ALT. Improvements in sleep quality and nightmare severity were linked to increases in amygdala volume. ALT improved wake after sleep onset and sleep efficiency.
Vanuk et al. [21]	82	Participants underwent a fear conditioning/extinction protocol followed by a 6-week light therapy intervention either to morning blue light therapy (BLT) or placebo amber light therapy (ALT) daily for 30 minutes	BLT group retained extinction memory better than the placebo group. Daily morning blue light was linked to improved extinction learning, better sleep, and decreased PTSD symptoms compared to amber light.
Youngstedt et al. [22]	69	4 weeks of daily morning bright light treatment (10,000 lux for 30 min/day) vs. control (inactivated negative ion generator)	Bright light significantly improved PTSD symptoms compared to control. No significant effects were found for anxiety, depression, or sleep disturbance. These results suggest short-term efficacy of bright light treatment for veterans with chronic PTSD.
Jecmen et al. [23]	41	Daily morning BLT vs. ALT for 6 weeks	Morning BLT may improve PTSD symptoms by regulating circadian rhythm and enhancing sleep quality. ALT also reduced PTSD symptom severity, but changes may involve other mechanisms. Morning BLT shows potential to enhance current PTSD treatments.
Zalta et al. [24]	15	Wearable light device (Re-timer®) for 1 hour each morning for 4 weeks vs. dimmed device (placebo)	The wearable light device was well-tolerated with moderate adherence. The active group was more likely to achieve significant reductions in PTSD and depression symptoms compared to placebo. The study suggests potential efficacy for morning light treatment in improving PTSD symptoms. However, a larger trial is needed.

Similarly, a sleeping mask using a similar technology was developed using red light exposure to promote sleepiness, and conversely, scheduled and gradually increasing blue light emission as an alarm, over the years this technology has been continuously improved by the manufacturing company while also paying more attention to fine details like making the mask more lightweight and flexible (25).

Lastly, In the study conducted by **Mastrullo et al.** (26), the authors explored the role of pericytes' circadian rhythms in regulating endothelial cell synchronization and angiogenesis within a 3D

tissue-engineered scaffold. This research is pivotal as it sheds light on the intersection of circadian biology and vascular physiology. The study utilized advanced tissue engineering techniques to recreate a dynamic microenvironment where the influence of pericytes' circadian clocks on endothelial cell behavior could be precisely observed. Their findings suggest that pericyte circadian rhythms play a significant role in coordinating endothelial cell activities, which is crucial for effective angiogenesis and tissue repair processes.

The investigation revealed that disruptions in the circadian clocks of pericytes lead to impaired

synchronization among endothelial cells, subsequently affecting the formation and functionality of blood vessels within the engineered scaffolds. This disruption underscores the importance of maintaining circadian rhythm integrity for optimizing angiogenic responses. The study's use of a 3D scaffold model provided a more realistic representation of tissue architecture compared to traditional 2D cultures, enhancing the relevance of the findings to in vivo conditions. This approach highlights the potential of integrating circadian considerations into tissue engineering strategies for improved therapeutic outcomes.

Furthermore, **Mastrullo et al.** (26) demonstrated that the synchronization of endothelial cells is not merely a passive phenomenon but is actively regulated by pericytes' internal clocks. This discovery opens new avenues for research into how circadian rhythm manipulation could be employed to enhance tissue regeneration and vascular health. The study's results have significant implications for developing targeted therapies and engineering solutions that account for circadian influences, ultimately advancing the field of regenerative medicine and improving patient outcomes in vascular and tissue repair contexts.

Conclusion

Blue light emitted from screens is proved to have positive effects on health only in certain cases, such thing does not overlook the negative impacts of blue light on the circadian rhythm and melatonin production. Screen use has to be used in moderation and avoided around nighttime to prevent shifts of the circadian rhythm.

Additionally, further generalizable research is needed to explore integrating blue light as treatment regimen for chronic PTSD.

Declarations

- Ethical Approval: Not applicable
- Consent for Publication: Not applicable
- Funding: No funding was received for this minireview
- Availability of data and materials: upon request from the corresponding author
- Competing interests: The authors declare no conflict of interest in this study.
- Authors' contributions: All authors(O.M., S.I., R.O., S.S.E., A.M., N.N. L) shared in idea, design and writing the draft. They all approved the final version of this manuscript.

References:

1. **Jniene, A., Errguig, L., El Hangouche, A. J., Rkain, H., Abouddrar, S., El Ftouh, M., &Dakka, T. (2019).** Perception of Sleep Disturbances due to Bedtime Use of Blue Light-Emitting Devices and Its Impact on Habits and Sleep Quality among Young Medical Students. *BioMed research international*, 2019, 7012350. <https://doi.org/10.1155/2019/7012350>
2. **Tosini, G., Ferguson, I., & Tsubota, K. (2016).** Effects of blue light on the circadian system and eye physiology. *Molecular vision*, 22, 61–72.
3. **Demirci K, Akgönül M, Akpınar A.** Relationship of smartphone use severity with sleep quality, depression, and anxiety

- in university students. *J Behav Addict.* 2015 Jun;4(2):85-92. doi: 10.1556/2006.4.2015.010. PMID: 26132913; PMCID: PMC4500888.
4. **Alkozei, A., Dailey, N. S., Bajaj, S., Vanuk, J. R., Raikes, A. C., & Killgore, W. D. S. (2021).** Exposure to Blue Wavelength Light Is Associated With Increases in Bidirectional Amygdala-DLPFC Connectivity at Rest. *Frontiers in neurology*, 12, 625443. <https://doi.org/10.3389/fneur.2021.625443>
 5. **Silvani, M. I., Werder, R., & Perret, C. (2022).** The influence of blue light on sleep, performance and wellbeing in young adults: A systematic review. *Frontiers in physiology*, 13, 943108. <https://doi.org/10.3389/fphys.2022.943108>
 6. **Tähkämö, L., Partonen, T., & Pesonen, A. K. (2019).** Systematic review of light exposure impact on human circadian rhythm. *Chronobiology international*, 36(2), 151–170. <https://doi.org/10.1080/07420528.2018.1527773>
 7. **Cajochen, C.. (2015).** Light: An underestimated environmental factor in sleep medicine. *Sleep and Biological Rhythms*, 13, 111. <http://doi.org/10.1111/SBR.12120>
 8. **Downie, L.. (2017).** Blue-light filtering ophthalmic lenses: to prescribe, or not to prescribe?. *Ophthalmic and Physiological Optics*, 37, 640 - 643. <http://doi.org/10.1111/opo.12414>
 9. **Arrona-Palacios, A., Lee, J. H., Czeisler, C. A., & Duffy, J. F. (2023).** The Timing of the Melatonin Onset and Phase Angle to Sleep Onset in Older Adults after Uncontrolled vs. Controlled Lighting Conditions. *Clocks & sleep*, 5(3), 350–357. <https://doi.org/10.3390/clockssleep5030026>
 10. **Touitou, Y., Touitou, D., & Reinberg, A..(2016).** Disruption of adolescents' circadian clock: The vicious circle of media use, exposure to light at night, sleep loss and risk behaviors. *Journal of Physiology-Paris*, 110, 467-479. <http://doi.org/10.1016/j.jphysparis.2017.05.001>
 11. **Smith, M. T., McCrae, C. S., Cheung, J., Martin, J. L., Harrod, C. G., Heald, J. L., & Carden, K. A. (2018).** Use of Actigraphy for the Evaluation of Sleep Disorders and Circadian Rhythm Sleep-Wake Disorders: An American Academy of Sleep Medicine Clinical Practice Guideline. *Journal of clinical sleep medicine : JCSM : official publication of the American Academy of Sleep Medicine*, 14(7), 1231–1237. <https://doi.org/10.5664/jcsm.7230>
 12. **Hysing M, Pallesen S, Stormark KM, Jakobsen R, Lundervold AJ, Sivertsen B.** Sleep and use of electronic devices in adolescence: results from a large

- population-based study. *BMJ Open* [Internet]. 2015 Feb 2;5(1):e006748. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4316480/>
13. **Echevarria P, Del-Ponte B, Tovo-Rodrigues L, Matijasevich A, Halal CS, Santos IS.** Screen use and sleep duration and quality at 15 years old: Cohort study. *Sleep Medicine X* [Internet]. 2023 Dec 1;5:100073. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10251069/>
 14. **Brautsch LAs, Lund L, Andersen MM, Jennum PJ, Folker AP, Andersen S.** Digital media use and sleep in late adolescence and young adulthood: A systematic review. *Sleep Medicine Reviews* [Internet]. 2023 Apr 1;68:101742. Available from: <https://www.sciencedirect.com/science/article/pii/S1087079222001551?via%3Dihub#bib38>
 15. **Pavlova M. (2017).** Circadian Rhythm Sleep-Wake Disorders. *Continuum* (Minneapolis, Minn.), 23(4, Sleep Neurology), 1051–1063. <https://doi.org/10.1212/CON.0000000000000499>
 16. **St Hilaire, M. A., Ámundadóttir, M. L., Rahman, S. A., Rajaratnam, S. M. W., Rüger, M., Brainard, G. C., Czeisler, C. A., Andersen, M., Gooley, J. J., & Lockley, S. W. (2022).** The spectral sensitivity of human circadian phase resetting and melatonin suppression to light changes dynamically with light duration. *Proceedings of the National Academy of Sciences of the United States of America*, 119(51), e2205301119. <https://doi.org/10.1073/pnas.2205301119>
 17. **Liu D, Fang P, Liu H, Chen L, Fu Y, Liu J, et al.** The Clinical Effect of Blue Light Therapy on Patients with Delayed Sleep-Wake Phase Disorder. *Nature and Science of Sleep* [Internet]. 2022 Jan 1;Volume 14:75–82. Available from: <https://doi.org/10.2147/nss.s344616>
 18. [Internet]. [cited 2024 Apr 4]. Available from: https://www.nasa.gov/sites/default/files/atoms/files/lighting_design_technical_brief_ochmo.pdf
 19. **Killgore, W., Pace-Schott, E., Grandner, M., Vanuk, J., Reign, D., & Dailey, N. (2022).** Using blue light therapy to facilitate recovery of sleep and psychological functioning in PTSD. *Sleep*, 45(A103-A104). <https://doi.org/10.1093/sleep/zsac079.226>
 20. **Killgore, W. D. S., Pace-Schott, E. F., Grandner, M. A., Vanuk, J., Reign, D., & Dailey, N. S. (2022).** Using blue light therapy to facilitate recovery of sleep and psychological functioning in PTSD. *Frontiers in Behavioral Neuroscience*, 16, Article 910239. <https://doi.org/10.3389/fnbeh.2022.910239>
 21. **Vanuk, J., Pace-Schott, E. F., Grandner, M. A., Killgore, W. D. S., Reign, D., &**

- Dailey, N. S. (2022).** Disrupted sleep and extinction memory in PTSD: Effects of morning blue light therapy. *Frontiers in Behavioral Neuroscience*, 16, Article 886816.
<https://doi.org/10.3389/fnbeh.2022.886816>
22. **Youngstedt SD, Kline CE, Reynolds AM, Crowley SK, Burch JB, Khan N, Han S.** Bright Light Treatment of Combat-related PTSD: A Randomized Controlled Trial. *Mil Med.* 2022 Mar 28;187(3-4):e435-e444. doi: 10.1093/milmed/usab014. PMID: 33511988.
23. **D Jecmen, R King, J Gould, J Mitchell, K Ralston, A I Burns, A Bullock, M A Grandner, A Alkozei, W D Killgore, 0038** The Effects of Morning Blue Light Therapy on Insomnia Severity and PTSD Symptoms in a Clinical Sample, *Sleep*, Volume 43, Issue Supplement_1, April 2020, Pages A15–A16,
<https://doi.org/10.1093/sleep/zsaa056.037>
24. **Zalta AK, Bravo K, Valdespino-Hayden Z, Pollack MH, Burgess HJ.** A placebo-controlled pilot study of a wearable morning bright light treatment for probable PTSD. *Depress Anxiety.* 2019; 36: 617–624.
<https://doi.org/10.1002/da.22897>
25. **Light research aids slumber [Internet]. NASA;** [cited 2024 Apr 4]. Available from:
https://spinoff.nasa.gov/Spinoff2019/cg_8.html
26. **Mastrullo, V., van der Veen, D. R., Gupta, P., Matos, R. S., Johnston, J. D., McVey, J. H., Madeddu, P., Velliou, E. G., & Campagnolo, P. (2022).** Pericytes' Circadian Clock Affects Endothelial Cells' Synchronization and Angiogenesis in a 3D Tissue Engineered Scaffold. *Frontiers in pharmacology*, 13, 867070.
<https://doi.org/10.3389/fphar.2022.867070>