

Blocking Short-Wavelength Component of the Visible Light Emitted by Smartphones' Screens Improves Human Sleep Quality

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ABSTRACT

Background: It has been shown that short-wavelength blue component of the visible light spectrum can alter the circadian rhythm and suppress the level of melatonin hormone. The short-wavelength light emitted by smartphones' screens can affect the sleep quality of the people who use these devices at night through suppression of melatonin.

Objectives: In this study, we examined the effects of covering the screens of smartphones with different filters (changing the effective wavelength of the light) on sleep delay time in 43 healthy students.

Materials and Methods: Volunteer students were asked to go to bed at 23:00 and to use their mobile phones in bed for watching a natural life documentary movie for 60 minutes. No filter was used for one night while amber and blue filters were used for other 2 nights. Photospectrometry method was used to determine the output spectrum of the light passing through the filters used for covering the screens of the mobile phones. The order for utilizing amber or blue filters or using no filter was selected randomly. After 1 hour, the participants were asked to record their sleep delay time measured by a modified form of sleep time record sheet.

Results: The mean sleep delay time for the "no-filter" night was 20.84±9.15 minutes, while the sleep delay times for the nights with amber and blue filters were 15.26±1.04 and 26.33±1.59 minutes, respectively.

Conclusion: The findings obtained in this study support this hypothesis that blue light possibly suppresses the secretion of melatonin more than the longer wavelengths of the visible light spectrum. Using amber filter in this study significantly improved the sleep quality. Altogether, these findings lead us to this conclusion that blocking the short-wavelength component of the light emitted by smartphones' screens improves human sleep.

Keywords

Smartphones, Mobile Phones, Blue Light, Sleep Quality, Display, Screen

Introduction

The retinal light exposure can affect sleep duration and biological parameters such as blood pressure [1]. As output of light-emitting electronic devices such as smartphones, tablets and laptops is mainly in the short wavelength component of the visible light spectrum, using these devices before sleep might cause sleep disorders. Some stud-

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ies show that exposure to bright light at night suppresses melatonin secretion and, it has been revealed that human circadian system is susceptible to short-wavelength component of the visible light spectrum [2, 3]. Some recent studies show that especially short wavelength blue light adversely affects the level of melatonin more than other wavelengths of the visible spectrum. On the other hand, for treatment of some types of mood disorders and sleep problems which are caused by circadian rhythm, blue wavelengths have been effectively used [4]. The disturbances of circadian rhythm are believed to be linked to the increased prevalence of sleep disorders and light therapy through regulation of the circadian system can be used to treat these sleep disorders [5]. The use of blue light in modern societies is rapidly increasing and it is estimated that a large proportion of the population of the world are exposed to artificial light at night [6]. Recent studies reveal that exposure to artificial light at night can be associated with increased risk of breast and prostate cancer [7]. Blue light has some well-known applications in different medical fields such as phototherapy [8, 9] or antibacterial treatment of plaque-induced periodontal pathologies [10]. As exposure to blue light is associated with some risks, it has been suggested to use LEDs with the emission peak of 470–480 nm instead of using LEDs with emission peaks below 450 nm [6]. Over the past several years, our laboratories at the Ionizing and Non-ionizing Radiation Protection Research Center (INIRPRC) have expanded their focus on studying the health effects of exposure to some common and/or occupational sources of electromagnetic fields (EMFs) such as cellular phones [11-19], mobile base stations [20], mobile phone jammers [21-23], laptop computers [24], radars [12], dentistry cavitrans [25], MRI [26, 27], Wi-Fi routers [28] and different coils [29, 30]. This study was aimed at assessing if blocking the short-wavelength component of the light emitted by smartphones' screens could improve the sleep

quality in university students.

Material and Methods

Participants

Forty-three healthy students (15 males and 28 females, mean age: 23.58 ± 8.78 years) participated in this study. Prior to the experiment, an oral explanation was given to all participants.

Ethical Issues

This study was approved by the INIRPRC and was carried out in accordance with the ethical guidelines of Shiraz University of Medical Sciences (SUMS). All participants were provided with written informed consent.

Exposure to Light

All participants were requested to go to bed at 23:00 under dim light conditions. They were asked to use their mobile phones in bed for 60 minutes (to watch a life documentary movie). No filter was used on one night, while amber and blue filters were used on other 2 nights. The brightness of the screens was the same on these three nights. The output spectrum of the light passing through the filters used to cover the screens of the mobile phones was determined by spectrometric methods (Figure 1). The order for using amber or blue filters or using no filter was selected randomly. After 1 hour, the participants were asked to record their sleep delay time measured by a modified form of sleep time sheet. Furthermore, all participants were asked to complete a previously validated questionnaire about their routine exposures to different electromagnetic fields. Participants were instructed to keep the bedroom temperature at about 25°C and were ordered to maintain their regular sleep/wake up schedule (e.g. 24:00 to 08:00).

Results

The mean age of the participants was 23.6 ± 8.8 years. The frequency of male participants

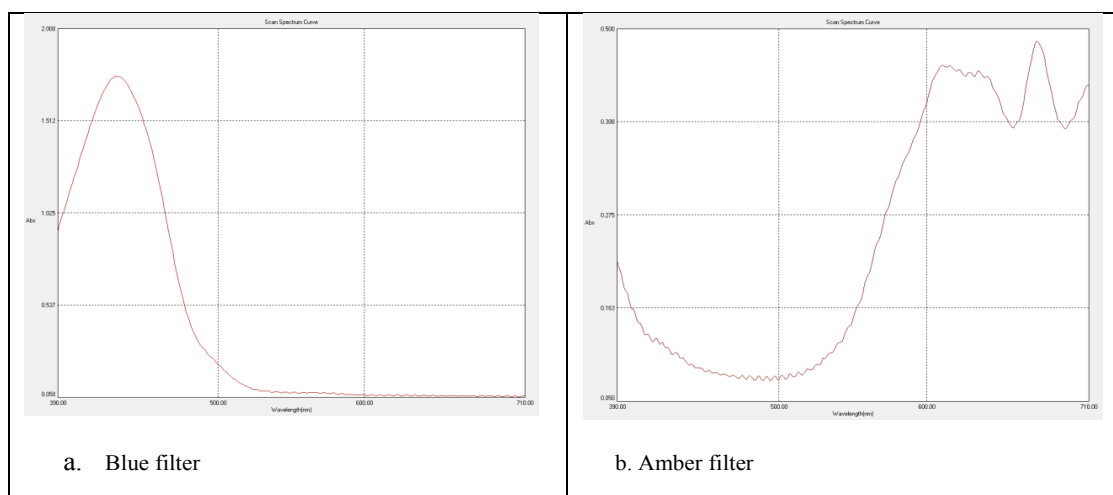


Figure 1: The output spectra of the light passing through the blue (panel a.) and amber (panel b) filters which covered the screens of the participants’ mobile phones.

was 15 students (34.9%), while 28 students (65.1%) were female. The majority of students who participated in this study were G.P., Ph.D. or M.D. students (24 students, 55.84%). Demographic characteristics of the participants are shown in Table 1.

The mean sleep delay time for the “no filter” night was 20.84 ± 9.15 minutes, while the sleep delay times for amber and blue filters were 15.26 ± 1.04 and 26.33 ± 1.59 minutes, respectively.

Table 1: Demographic characteristics of participants.

Characteristics	
Age (Mean \pm SD) (years)	23.6 \pm 8.8
Sex	Frequency (%)
Male	15 (34.9%)
Female	28 (65.1%)
Education	Frequency (%)
College Students	6 (14%)
BSc Students	12 (27.9%)
MSc Students	1 (2.3%)
GP, Ph.D., MD Students	24 (55.84%)

Discussion

Based on the findings obtained in our study, it was revealed that the mean sleep delay time for the amber filter was the shortest, while it was intermediate for “no filter” and the longest sleep delay time was observed for blue filters. These findings are generally in line with the results of the study conducted by Korean researchers who reported that fine control of blue light in smartphone displays could reduce the adverse health effects of blue light emitted from the displays of smartphones at night [31]. However, the shortcomings of the paper published by Oh et al. have been addressed previously [32]. As discussed by Mortazavi et al., the first shortcoming in their study was due to this point that the authors only focused on the visible component of the electromagnetic radiation spectrum and ignored the reports which indicated a significant association between exposure to RF-EMFs of mobile or cordless phones and sleep problems [33, 34]. It is worth noting that exposure to electromagnetic fields can also affect the level of plasma melatonin [35, 36]. Moreover, in contrast with Oh et al., we paid attention to the confounding factor of the very low sensitivity of human eye to short wavelengths in the visible spectrum

and controlled the light intensity. It has long been known that both scotopic and photopic eye sensitivities depend on the wavelength of light and the highest eye sensitivity in the photopic vision occurs in yellow-green region [37].

Our findings are generally in line with the findings obtained in a study conducted on sleep quality and the level of melatonin in 12 adults who used either blue-light shield or control eyewear two hours before sleep while using a self-luminous portable device. This study demonstrated significantly better sleep efficacy and sleep latency for users of the blue-light shield. Interestingly, individuals who used blue-light shield showed a higher level of sleepiness during portable device use [38].

These findings demonstrate that exposure to blue light may lead to sleep problems, while amber filter was capable of improving the sleep quality through decreasing the sleep delay time. These findings are generally in line with the growing body of evidence which shows blue light can suppress the secretion of melatonin, a hormone that controls the circadian rhythms.

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Conflict of Interest

None Declared.

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