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The Effect of a Screen Protector on Blue Light Intensity Emitted from Different Hand-held Devices

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Abstract:

PURPOSE: In response to growing concern about the effect of blue light on ocular tissue, companies have created mobile device screen protectors to block blue light. This project evaluates one of these screen protectors' ability to reduce blue light intensity.

METHODS: The intensity of light at 450 nm from an iPhone 8, iPhone X, and iPad was measured in a dark room. The averages of three measurements were taken with and without the screen protector at different distances, settings of brightness, and Apple's night shift (NS) mode. Results were analyzed using paired *t*-tests.

RESULTS: At 33 cm, 100% brightness, and 0% NS, the screen protector decreased intensity by 43.9%, 32.3%, and 34.9% for the iPhone 8, iPhone X, and iPad, respectively. At 33 cm and 100% brightness, increasing NS mode from 0% to 100% decreased intensity by 81.2%, 84.2%, and 86.5%. At 33 cm without NS, decreasing the brightness from 100% to 0% decreased intensity by 99.5%, 99.8%, and 97.8%.

CONCLUSIONS: The screen protector decreased the intensity at 450 nm for every setting other than those at 0% brightness. Decreasing brightness and applying NS mode were more effective in reducing blue light. More research is needed to determine the benefits of decreasing blue light exposure from electronic devices.

Keywords:

Blue light, mobile devices, screen protector

Introduction

With near-ubiquitous use of high-intensity light-emitting diodes in artificial lighting and backlit displays of smartphones, tablets, and computers, the human eye is becoming increasingly exposed to blue light beyond what is found in ambient daylight. Phototoxicity of short-wavelength light (400–500 nm) to the retina of animal models, such as rats and monkeys, has been well established for many years.[1-4] Cultured human retinal pigment epithelial (RPE) cells are also susceptible to phototoxicity from visible light in a wavelength-dependent manner.[5,6]

Although the intensity of blue light emitted from electronic devices is much lower than from daylight, there is evidence that even at low intensity, artificial blue light from digital devices can cause oxidative damage to human RPEs *in vitro*.[7,8] Intrinsically photosensitive retinal ganglion cells, which express melanopsin and are maximally sensitive to blue light, regulate nonvisual physiological responses such as circadian clock, sleep, and melatonin suppression.[9-16] Exposure to digital displays can suppress melatonin levels and modulate sleep.[17-22] Blue

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and visible light exposure can also potentially contribute to age-related macular degeneration;[23-25] however, results are mixed and inconclusive because various factors can play a role in the development of this disease.[26,27]

Potential negative health outcomes associated with blue light exposure have led to the development and marketing of products that claim to block it. These include blue light-blocking glasses, intraocular lenses, and screen protectors (adherent glass over the display of smartphones and tablets). A recent systematic review evaluating the efficacy of blue light-blocking spectacle lenses on visual performance, macular health, and the sleep-wake cycle found that there is currently no high-quality evidence supporting their advantage.[28] Alternatively, smartphone applications are available that claim to block blue light emitted from electronic devices, such as night shift (NS) in Apple Inc. products. A practical advantage of using blue light-blocking screen protectors over applications like NS is the preservation of normal colors on the screen, while the latter tints the display color orange-red. The present study aims to determine the efficacy of a blue light-blocking screen protector on three handheld devices (iPhone 8, iPhone X, and iPad 9.7″) in reducing blue light intensity.

Methods

Using the CCS 200 compact charge-coupled device spectrometer and accompanying software from Thorlabs™, the intensity of blue light emitted at 450 nm from an iPhone 8, iPhone X, and iPad 9.7″ was measured with and without EyeJust™ screen protectors. 450 nm was chosen because it was the wavelength correlating with the peak intensity of blue light emitted from the devices [Figure 1]. A white screen was displayed on each of the devices while collecting measurements. Three measurements were collected and averaged for each setting.

A setting was defined as containing the following characteristics: (1) with or without the screen protector applied to the device, (2) distance away from the spectrometer, (3) percentage of brightness set on the display setting of the device, and (4) setting of NS mode set on the display setting of the device. Distances consisted of 15, 20, 25, 30, 33, and 40 cm from the spectrometer. Percent brightness and NS mode consisted of 0%, 50%, and 100%. Measurements were taken in a closed, dark room with the ceiling lights off and the spectrometer set to zero using its background correct function.

Three measurements of intensity at 450 nm were taken and averaged for each setting. The units of intensity as read by the spectrometer were arbitrary according to the program. Thus, the percent reduction in intensities was investigated rather than absolute value reduction in intensity. The averaged measurements of each setting were compared and tested for statistical significance using paired *t*-tests.

Results

The screen protector reduced the intensity of blue light with statistical significance defined as $P < 0.01$ in every setting except those where the brightness was set at 0% [Table 1].

Evaluating the efficacy of the screen protector at different settings of NS showed a consistent percent reduction at 100% and 50% brightness [Figure 2]. At 33 cm, 100% brightness, and 0% NS, the screen protector resulted in a decrease in blue light intensity of 43.9%, 32.3%, and 34.9% for the iPhone 8, iPhone X, and iPad, respectively. When NS mode was increased to 50%, applying the screen protector resulted in a percent reduction of 50.8%, 34.2%, and 31.5% for the three devices. When NS mode was increased 100%, the percent reduction in blue light intensity for the three devices was 49.6%, 47.7%, and 29.4%.

Decreasing brightness also was effective in decreasing blue light intensity. At 33 cm, decreasing the brightness from 100% to 50% resulted in a decrease of 70.3%,

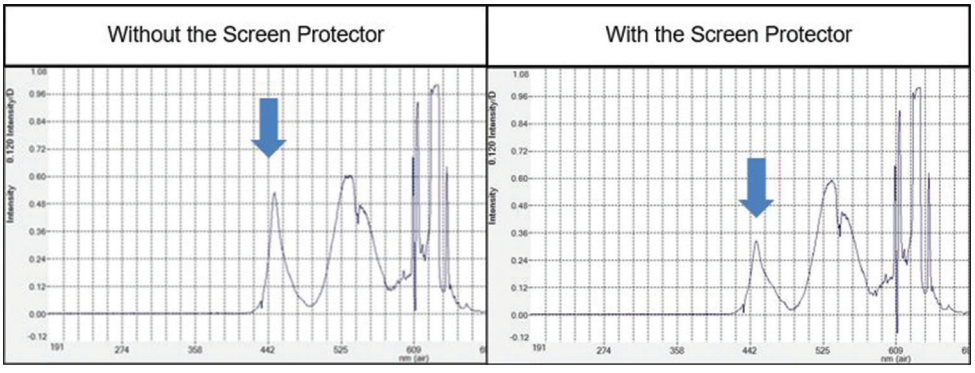

Figure 1: Two images from the spectrometer software that show intensity for each wavelength in nanometers. The arrow points to the distribution correlating with blue light which ranges from 420 nm to 490 nm. The wavelength with the highest intensity was 450 nm. A decrease in the distribution correlating with blue light is seen when the screen protector is applied

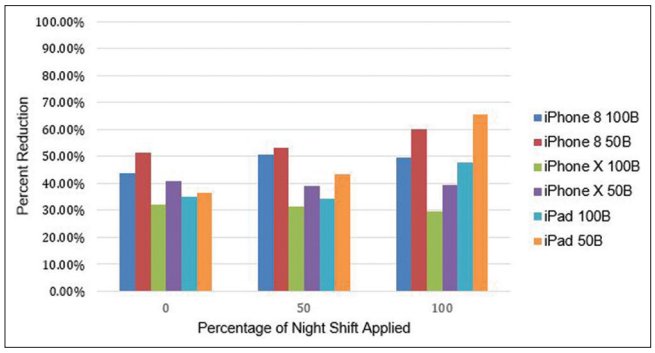

Figure 2: The efficacy of the screen protector at 0%, 50%, and 100% night shift applied with either 100% or 50% brightness (b)

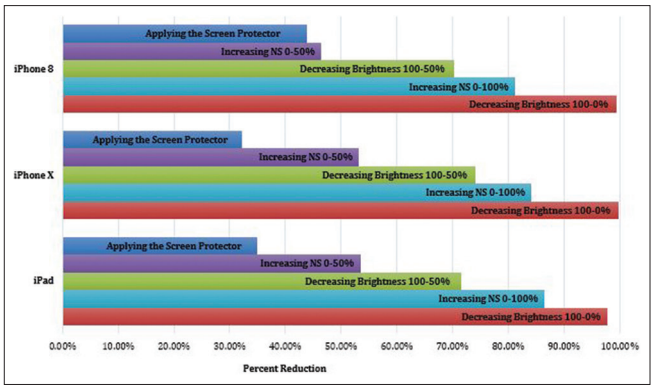

Figure 3: Comparing percent reductions of intensity of light at 450 nm as measured by applying the screen protector, adjusting night shift, or adjusting brightness (b)

74.2%, and 71.5% for the iPhone 8, iPhone X, and iPad, respectively [Table 2]. Decreasing the brightness from 100% to 0% resulted in a decrease of 99.5%, 99.8%, and 97.8%. Comparing any setting with 0% brightness to a device that was turned off was not statistically significant.

Finally, increasing NS mode also effectively decreased blue light intensity. At 33 cm and 100% brightness, increasing NS mode from 0% to 50% resulted in a decrease of intensity by 46.4%, 53.2%, and 53.4% for the three devices, and increasing NS mode from 0% to 100% resulted in decreases by 81.2%, 84.2%, and 86.5% [Table 3]. At 50% brightness, increasing NS mode had similar percent reductions.

Discussion

Although application of the screen protector in different settings conveyed varied percent reductions of intensity of light emitted at 450 nm, it consistently provided added benefit in reducing intensity for every setting other than those with 0% brightness. Indeed, having a device at 0% brightness was equivalent to having the device turned off as the differences between the mean intensity levels were not statistically significant. In addition, comparing different distances did not show differences in the efficacy of the screen protector.

Despite its ability to decrease blue light at 450 nm, the screen protector was the least effective when compared to increasing NS mode and decreasing screen brightness [Figure 3]. When evaluating reducing blue light intensity of the iPhone 8 at full brightness, the screen protector was roughly half as efficacious as turning on full NS. Likewise, decreasing brightness to 50% or 0% measured greater percent reductions in intensity. Applying the screen protector was most equivalent to setting NS at 50% as both of these changes reduced the intensity by a little less than half.

Subjectively, the screen protector offers the advantage of not altering the screen's appearance while operating the device. Applying NS mode turns the screen orange-red, and this may alter the users' experience making it less desirable to use. Decreasing the brightness of the phone dims the lighting of the phone making it more difficult to visualize images on the screen. Although less effective,

Table 1: Percent Reduction in Blue Light by Applying the Screen Protector at Different Settings

			iPhone 8		iPhone X		iPad	
Setting	Brightness	NS	%Reduction	*P*-Value	%Reduction	*P*-Value	%Reduction	*P*-Value
Dark Room	100	0	44%	<.01	32%	<.01	35%	<.01
		50	51%	<.01	31%	<.01	34%	<.01
		100	50%	<.01	29%	<.01	48%	<.01
	50	0	51%	<.01	41%	<.01	37%	<.01
		50	53%	<.01	39%	<.01	43%	<.01
		100	60%	<.01	39%	<.01	65%	<.01
	0	0	-13%	0.56	16%	0.79	13%	0.15
		50	-26%	0.51	66%	0.34	0%	1.00
		100	-21%	0.81	-13%	0.85	6%	0.71
Ambient Light	100	0	42%	<.01	38%	<.01	48%	<.01
		50	29%	<.01	31%	<.01	32%	<.01
		100	33%	<.01	23%	<.01	24%	<.01
	50	0	43%	<.01	20%	<.01	38%	<.01
		50	42%	<.01	16%	<.01	20%	<.01
		100	37%	<.01	8%	0.3	11%	<.01
	0	0	0%	0.99	-42%	0.05	-38%	0.02
		50	-32%	0.13	-67%	0.09	-68%	0.15
		100	18%	0.27	-7%	0.81	-61%	0.03

Table 2: Effect of Decreasing Brightness on Blue Light Intensity

		From 100B to 50B		From 50B to 0B		From 100B to 0B	
Setting	Device	%Reduction	*P*-Value	%Reduction	*P*-Value	%Reduction	*P*-Value
Dark Room	iPhone 8	70.26%	<.01	98.17%	<.01	99.45%	<.01
	iPhone X	74.19%	<.01	99.34%	<.01	99.83%	<.01
	iPad	71.50%	<.01	92.23%	<.01	97.79%	<.01
Ambient Light	iPhone 8	72.18%	<.01	95.82%	<.01	98.84%	<.01
	iPhone X	78.23%	<.01	95.50%	<.01	99.02%	<.01
	iPad	72.66%	<.01	96.02%	<.01	98.91%	<.01

Table 3: Effect of Night Shift Mode on Blue Light Intensity

			0NS to 50NS		50NS to 100NS		0NS to 100NS	
Setting	Device	Brightness	%Reduction	*P*-Value	%Reduction	*P*-Value	%Reduction	*P*-Value
Dark Room	iPhone 8	100	46.41%	<.01	64.91%	<.01	81.20%	<.01
		50	44.05%	<.01	56.39%	<.01	75.60%	<.01
	iPhone X	100	53.21%	<.01	66.20%	<.01	84.18%	<.01
		50	45.47%	<.01	58.75%	<.01	77.50%	<.01
	iPad	100	53.44%	<.01	70.99%	<.01	86.49%	<.01
		50	51.97%	<.01	67.79%	<.01	84.53%	<.01
Ambient Light	iPhone 8	100	60.51%	<.01	56.36%	<.01	82.77%	<.01
		50	40.48%	<.01	54.69%	<.01	73.03%	<.01
	iPhone X	100	56.43%	<.01	66.40%	<.01	85.36%	<.01
		50	43.05%	<.01	56.49%	<.01	75.22%	<.01
	iPad	100	63.97%	<.01	71.93%	<.01	89.89%	<.01
		50	62.69%	<.01	67.21%	<.01	87.76%	<.01

the screen protector preserves the appearance of the screen subjectively while at the same time effectively reducing blue light intensity.

This experiment is not without limitations. The program through which the spectrometer was run provided arbitrary units of intensity. Although measurements for one device were collected the same day, each of the three devices was measured on three different days. As such, comparing absolute values of intensity between devices is subject to error. In addition, the intensity of 450 nm was compared instead of the whole array of blue light emitted from the devices, which ranged from 420 to 490 nm. Although it would have been more accurate to calculate the area under the curve in order to assess the full range of blue light emitted from the devices, the distribution appears to decrease with regularity between different settings, and 450 nm represents the reduction occurring across the blue light range [Figure 1].

The screen protector decreased the intensity of blue light from 30% to 60% depending on the setting and the device. This was accomplished without changing the appearance of the screen. This study evaluated the ability of this specific screen protector to block blue light in comparison to a device without a screen protector. Future research can focus on comparing the screen protector to other screen protectors that claim to block blue light. In addition, future research could delineate the health benefits from using screen protectors. However, comparing the screen protector against other screen protectors that do and do not claim to block blue light would also be prudent. Future research should focus on comparing these screen protectors to other screen protectors in their ability to block blue light. While the screen protector consistently provided a percent reduction in blue light intensity, the effect this has on ocular or general health is unknown. Reducing blue light intensity may provide benefits of better sleep and protection against retinal diseases such as macular degeneration, but further research is needed to investigate this potential health risk.[23-25]

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Conflicts of interest

There are no conflicts of interest.

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