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Research Article

The effect of using the smartphone blue light filter feature on tear production

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ABSTRACT

Smartphones today have been used to support human activities. It makes the human eye always exposed to smartphone screens that use light-emitting diodes (LEDs) that emit light with a blue electromagnetic spectrum known as blue light. The effect of blue light on human eyes is still being studied. This study aims to determine the effect of using smartphone blue light filter features on tear production. This was a quasi-experimental, pre-post study, involving 40 samples who met the inclusion and exclusion criteria. Subjects were asked to use a smartphone within 1 week without activating a blue light filter. After this, tear production was measured using the Schirmer test under topical anesthesia. Then, subjects were asked to use a smartphone again within 1 week by activating the blue light filter and being measured again using the Schirmer test under topical anesthesia. Data obtained were analyzed using SPSS 25 software. There was a statistically significant (sig=0.000) difference in Schirmer test values before and after the usage of smartphone blue light filters. Each increase in the duration of smartphone usage for one minute will decrease Schirmer test results by 0.000625 mm, and so will the multiplication. The duration of smartphone usage has a 21.6% contribution of influence on the results of the Schirmer test. In conclusion, there is an effect of using the blue light filter feature on tear production between the use of a smartphone without activating the blue light filter with the use of a smartphone that activates the blue light filter feature.

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INTRODUCTION

Smartphones today have become a part of human life. Since its first appearance in 2012, smartphone users in the world have increased from time to time, including in Indonesia. According to a survey portal, in 2021, 76.26 percent of the population in Indonesia used a smartphone. The number of smartphone users in the country is estimated to reach 269 million by 2028. With its ability to access the mobile internet, smartphones have become very useful in our lives. In our daily activities, smartphones can be used as a means of communicating, accessing social media, studying, working, and getting entertainment. The smartphone screen uses a lighting source in the form of light-emitting diodes (LEDs), which produce polychromatic "white" colours by combining blue LEDs with a yellow phosphor. This has the effect of producing a light that appears white, but which has a spectral distribution that peaks in the blue portion of the electromagnetic spectrum (Behar-Cohen et al., 2011).

With the increasing activity we do using smartphones, the more intensity of the eyes exposed to blue light emitted from LEDs. In existing research, there is no consensus in the scientific community on the impact of blue light on human health and physiology(Wong & Bahmani, 2022). Much of the concern about the effect of blue light on the eye has focused on the retina, and scientific understanding of the potential impact of blue light on the ocular surface and other anterior ocular structures remains limited. In mice, overexposure to blue LEDs has been associated with apoptosis and oxidative damage to the cornea (H. S. Lee et al., 2016). Reduced cell viability and increased production of reactive oxygen species have similarly been observed after exposing human corneal(J.-B. Lee et al., 2014) and conjunctival (Marek et al., 2018) epithelial cells to different wavelengths and intensities of blue light. Such responses can be associated with ocular surface inflammation, leading some researchers to propose that blue light may provoke or aggravate symptoms of dry eye disease(Marek et al., 2019). Yet, the effects of filtering blue light on critical flicker frequency (CFF), and ocular discomfort(Lin et al., 2017), (Ide et al., 2015) associated with dry eye disease have been mixed. Another research indicates that the utilization of wrap-around goggles equipped with blue light filters of varying densities (low, medium, and high) during daily computer usage does not result in significant changes in tear production for individuals in both normal and dry eye categories. However, there is a noticeable enhancement in reported Computer Vision Syndrome (CVS)-related issues within the dry eye group, despite the absence of a significant impact on tear production (Cheng et al., 2014).

Tear film itself plays an important role in providing a comfortable condition on the ocular surface. The tear film, with a thickness ranging from approximately 2 to 5 µm over the cornea, consists of three primary components: lipid, aqueous, and mucin. The outermost layer, known as the lipid layer, is generated by the meibomian glands in the eyelids, serving to minimize the evaporation of tears. The middle layer, comprised of aqueous substances, is the thickest part of the tear film and is produced by the lacrimal glands situated in the orbits, along (O'Neil, et al., 2019)with the accessory lacrimal glands (Krause and Wolfring) in the conjunctiva. The basal layer consists of mucins, or glycoproteins, primarily secreted by conjunctival goblet cells. Mucins play a crucial role in facilitating the even distribution of the tear film across the corneal epithelium by regulating surface tension (O'Neil, et al., 2019). To prevent the potential adverse effects of

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blue light in the eyes, smartphones today have been equipped with blue light filter features that can be activated by users. This study was conducted to assess whether there is an effect of the use of blue light filters in smartphones on tear production as one of the physiological functions of the human eye.

METHODS

This research used a quasi-experimental, pre-post-study design. The research was conducted over four weeks during December 2022. The subjects in this research were students of the Faculty of Medicine and Health Science, Universitas Muhammadiyah Yogyakarta, which is determined by the sample size formula

$$n = \left(\frac{(Z\alpha + Z\beta)SD}{(x^1 - x^2)}\right)^2 = \left(\frac{(1.96 + 1.282)5.093}{(2.6)}\right)^2$$

with a total sample of 40, selected by purposive sampling, who met the inclusion and exclusion criteria. The inclusion criteria for this research were men or women, students of Universitas Muhammadiyah Yogyakarta aged 20-29 years old, actively using smartphones in daily activity, and willing to be involved as research subjects. Whereas the exclusion criteria were subjects who suffered from certain eye diseases such as eye infections, glaucoma, retinopathy, Sjogren's syndrome, wearing contact lenses, wearing glasses, using certain drugs such as beta-blockers, antidepressants, antihistamines, stimulants, antihypertensives, and steroid. In this study, each subject was asked to use a smartphone within 1 week with a duration according to their daily use, without activating the blue light filter feature on his smartphone. After this first 1-week treatment, each subject had their tear production measured using the Schirmer test under topical anesthesia before measurement. After that, subjects were asked to use a smartphone within the next 1 week, with a duration according to daily use, by activating the blue light filter feature on their smartphone. After this second 1-week treatment, each subject had their tear production measured again using the Schirmer test under topical anesthesia before the measurement.

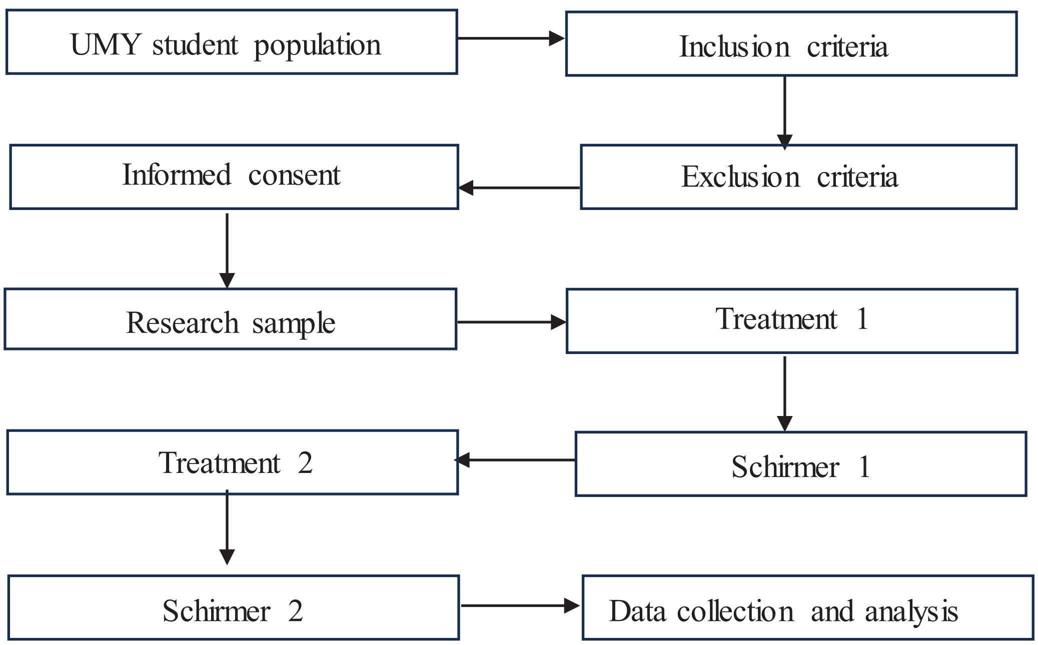

Figure 1. Research process flowchart

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Schirmer test procedures were performed in the morning after each subject had undergone treatment in the first and second weeks. Schirmer test procedure is performed under anesthesia to obtain the results of basal tear production, where basal tear production reflects the actual tear production by the tear glands and is not affected by tear production in response to uncomfortable conditions on the ocular surface due to Schirmer's test procedure. Data obtained in the form of subject characteristics, duration of smartphone usage time in each subject before and after treatment, and Schirmer test results in each subject before and after treatment were recorded and analyzed by univariate and bivariate analysis using SPSS 25 software. This research has received ethical clearance from KEPK FKIK UMY with number 011/EC-KEPK FKIK UMY/XII/2022.

Characteristics of the subjects

This study involved 40 subjects who were students of the Universitas Muhammadiyah Yogyakarta. A description of the characteristics of the research subject is presented in the following table 1.

Most of the subjects were male with the most aged at 23 years (minimum age of 22 years and maximum of 24 years).

Univariate analysis

Univariate analysis included minimum, maximum, and median values for each variable, namely Schirmer test results and duration of smartphone use before and after treatment.

From Table 2 above, the median of Schirmer test results after treatment showed improvement compared to the median of Schirmer test results before treatment.

Table 1. Subjects characteristics

Subjects characteristics	N	Percentage (%)
Gender		
Male	35	87.5
Female	5	12.5
Age (years)		
22	5	12.5
23	34	85
24	1	2.5

Table 2. Descriptive statistic for all variable

Variable	N	Minimum	Maximum	Median
Schirmer (mm) (before treatment)	40	15	23	19
Schirmer (mm) (after treatment)	40	17	24	21
Smartphone duration (minutes) (before treatment)	40	2724	7960	4532
Smartphone duration (minutes) (after treatment)	40	2932	7750	4625

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Bivariate analysis

Before performing bivariate analysis, a normality test was first carried out using the Shapiro-Wilk test which is suitable for use in a sample count of less than 50, according to the number of samples of 40 subjects in this study. From the results of the normality test, the results of the data were not normally distributed, so non-parametric analysis was then carried out using the Wilcoxon method to determine whether there was a statistical difference between the results of the Schirmer test before and after treatment.

Based on Table 3 above, a significance value of 0.000 (sig<0.05) is obtained, so it can be concluded that there was a statistically significant difference in Schirmer test values before and after treatment. To determine the effect of the duration of smartphone usage on the Schirmer test results after treatment, a simple linear regression analysis was carried out, with the independent variable being the duration of smartphone usage and the dependent variable being the Schirmer test results. From SPSS, obtained simple linear regression analysis is following this equation.

From the simple linear regression equation above, it was found that there was a reverse relationship between the duration of smartphone usage after treatment (X) and the results of the Schirmer test after treatment (Y). This shows that each increase in the duration of smartphone usage for one minute will cause a decrease in Schirmer test results by 0.000625 mm, and so will the multiplication.

The contribution of the smartphone usage duration for influencing the Schirmer test results after treatment can be shown by the value of R square (coefficient of determination) based on the table below.

Table 3. Wilcoxon Test on Schirmer Results before and after Treatment

	Schirmer (before treatment) Schirmer (after treatment)
Z	-5.513
Asymp. Sig (2-tailed)	0.000

$$Y = 24.229 - 0.000652X$$

Information:

Y = Schirmer test result (mm) after treatment

X = Duration of smartphone usage (minute) after treatment

Table 4. Coefficient of Determination (after treatment)

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of Estimate**
1	0.465	0.216	0.195	1.41021

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Based on the table 4 above, the value of R square is 0.216 or 21.6%. This means that the duration of smartphone usage has a 21.6% contribution of influence on the results of the Schirmer test. While the remaining 78.4% is the contribution of other variables besides the duration of smartphone use.

DISCUSSION

This study involved 40 male and female subjects who were all normal individuals who did not experience tear production deficiency, with a Schirmer test result range of 15-23 mm. In this study, using the Wilcoxon test to determine whether there is a statistical difference between the results of the Schirmer test before and after treatment, a significance value of 0.000 (sig<0.05) is obtained, so it can be concluded that there was a statistically significant difference in Schirmer test values before and after treatment.

From the comparison of the median value on Schirmer test results before and after treatment, it was found that the median value of Schirmer test results without using the blue light filter feature (19 mm) was lower than the median value of Schirmer test results using the blue light filter feature (21 mm). This shows that after using the blue light filter feature on the smartphone screen, dryness conditions on the surface of the eye were reduced compared to when not activating the blue light filter feature on the smartphone layer, which was marked by an increase in the median value of Schirmer test results after using the blue light filter feature. This is similar to the previous studies that state that the highest prevalence of asthenopia symptoms appear in individuals using gadget devices are symptoms of dry eyes and tired eyes (Sheppard & Wolffsohn, 2018)(Downie et al., 2018)(Palavets & Rosenfield, 2019).

The median duration of smartphone use without the use of the blue light filter feature (4532 minutes) is not much different from the median duration of smartphone use with the use of the blue light filter feature (4625 minutes). This shows that by neither activating nor activating the blue light filter feature, each subject spent an average of about 4600 minutes (±76 hours) a week, or equivalent to 657.15 minutes (10.86 hours) per day. This is a condition that is at risk of causing symptoms of eye fatigue due to screen use known as asthenopia. In previous studies, it was stated that the symptoms associated with asthenopia appeared significantly closer to one hour of smartphone use. Exposure to blue light causes phototoxicity and oxidative stress so the use of a smartphone for one hour continuously without pause can cause various symptoms of asthenopia (Long et al., 2017)(Kim et al., 2016)(Zhao et al., 2018).

In this study, under the condition of using a smartphone by activating the blue light filter feature, a simple linear regression pattern is obtained where each increase in the duration of smartphone usage for one minute will cause a decrease in Schirmer test results by 0.000625 mm, and so will the multiplication. This shows that the longer the duration of smartphone use, the more susceptible it will be to dryness on the surface of the eye. This is in line with previous research which states that the longer the duration of smartphone use, the eyes will tend to focus on the screen, resulting in reduced blinking frequency that triggers dry eyes (Machmud, 2018).

From the coefficient of determination after treatment analysis, it is found that the value of R square is 0.216 or 21.6%. This means that the duration of smartphone usage has a 21.6% contribution of influence on the results of the Schirmer test. While the remaining 78.4% is the contribution of other variables besides the duration of smartphone use. This is still a

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weakness in this study, where other factors that also affect the results of the Schirmer test cannot be controlled in this study. This can be improved in future studies, by controlling for confounding factors other than the duration of smartphone use such as air humidity, smoke exposure, environmental dust, etc., which can affect Schirmer test results.

CONCLUSION

There is an effect of using the blue light filter feature on tear production, which is shown by the presence of a statistically significant difference in Schirmer test result between the use of a smartphone without activating the blue light filter feature with the use of a smartphone that activates the blue light filter feature. The results of this study are expected to provide a solution to reduce the discomfort of smartphone use caused by dryness on the ocular surface, smartphone users can activate the blue light filter feature available on their smartphones.

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