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Difference of Schirmer Test Results Before and After Using Smartphones with Various Screen Brightness Levels

Dodik Dumadi[1], Maharani[2], Tanti Ajoe Kesoema[3], Riski Prihatningtias[2]*

[1]Student of Faculty of Medicine, Diponegoro University, Semarang, Indonesia
[2]Department of Ophtalmology, Faculty of Medicine, Diponegoro University, Semarang, Indonesia
[3]Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Diponegoro University, Semarang, Indonesia

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*) Correspondence to:
riskiprihatningtias@gmail.com

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ABSTRACT

Background: The use of smartphones and other digital devices such as laptops and tablets is familiar in Indonesian society. Excessive uses of the devices are associated with dry eye syndrome and tear film dysfunction. The intensity of blue light when penetrating the eye is believed to affect tear film stability. Thus it will encourage tear evaporation which proved by Schirmer test.
Objective: The use of smartphones and other digital devices such as laptops and tablets is familiar in Indonesian society. Excessive uses of the devices are associated with dry eye syndrome and tear film dysfunction. The intensity of blue light when penetrating the eye is believed to affect tear film stability. Thus it will encourage tear evaporation which proved by Schirmer test.
Methods: This study used pretest-posttest quasi-experimental study. The research subjects were students of the Faculty of Medicine, Diponegoro University (n = 30) who were selected by purposive sampling. In this study, the research subjects used smartphones for an hour with a predetermined screen brightness level, with the same room lighting. Before and after treatment the subject was measured the quantity of tears using the Schirmer test. Data were analyzed using the Wilcoxon test, Mann Whitney U test, and Kruskal Wallis test.
Results: The average pretest result on low brightness was 25,60 ± 9,44 and the post-test result was 17,60 ± 8,45. The pre-test result on medium brightness was 27,90 ± 9,46 and the post-test result was 24,80 ± 10,46. The pre-test result on high brightness was 23,60 ± 6,80 and the post-test result was 19,10 ± 7,95. The Schirmer test results before and after using smartphones with low brightness showed a significant different ($P<0.05$) and there was no significant difference for the pretest-posttest using smartphones with medium and high brightness. Comparison of Schirmer test results on low, medium and high screen brightness did not show a significant difference.
Conclusion: There is no significant difference between the Schirmer test results among low, medium and high screen brightness after one hour of smartphone usage.

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1. Introduction

The largest annual survey of American technology adoption, Forrester Research, reports that 73 percent of the 37,000 respondents claimed that the smartphones is the electronic device they use the most.[1] Indonesia is the fifth largest smartphone users in the world, the rate of smartphone use in Indonesia has increased dramatically since 2012. With 91 percent of Indonesia's population owning smartphones use it to access internet. In 2016, Internet users in Indonesia reached 132.7 million, around 51.7% of Indonesia's total population. While in 2017, internet users reached 143.26 million, approximately 54.7% of Indonesia's total population.[2]

Nowadays, more activities require smartphone use such as reading, writing, and entertainment activities like watching movies which of course demand our eyes to spend more time staring at screen, the duration of the eye staring at the smartphone for a long time is associated with decreased maximum blink interval. Previous research has reported that the average normal blink study rate is 12 – 15 times per minute, with an interval of 2 - 10 seconds for each blink. Blinking aims to spread the tears to protect the surface of the eye. If the interval is reduced, it can increase tear evaporation which later affects tear quantity.[3,4]

Visual Display Terminal is like a smartphone related to dry eye disease. This happens because smartphones have a screen that emits light through a Light Emitting Diode (LED) which produces blue light with a wavelength between 450 - 495 nm, the wavelength is near to ultraviolet length causing direct danger toward the eyes such as eye strain and dry eye. The effect of blue light depends not only on the light energy but also on the duration, the blink frequency, and the light intensity.[1,6]

On computer screens, laptops, tablets and smartphones whose screen brightness is increased will increase the blue light exposure produced by the screen, especially on screens with white background colors.[12] Blue light exposure can further increase the ROS production which will trigger several inflammatory mediators in the cornea and create a hyperosmotic environment on the surface of the tears and encourage tear evaporation which in turn affects the tear quantity, which will be measured by the Schirmer test.[9]

Overtime, users of smartphone are increasing there are 90% of smartphone users put their phones near their bed during night sleep, usually they wake up in the middle of the night and open the smartphone without adjusting the screen brightness, so that the smartphone is in a condition with high screen brightness that causes symptoms of burning sensations and dry eyes. Previous research study stated that there were significant differences in the symptoms of dry eyes and burning eyes associated with reading from a smartphone in conditions of dark and light. [1,7]

The following facts become important considering the large number of smartphone usage for a long period of time today. In previous studies there was a relationship between reading with smartphones in conditions of dark and light which showed symptoms of burning and dry eyes. However, there has not been any research comparing the use of smartphones with different screen brightness levels and their effect on high Schirmer test results, therefore a study was conducted to compare the Schirmer test results before and after using smartphones with different screen brightness levels.[1]

2. Methods

This study used pretest-posttest quasi-experimental study design. The research was conducted for 3 weeks on September 2020.

The research subjects were students of the Faculty of Medicine, Diponegoro University with a total sample of 30 who were selected by purposive sampling and met the exclusion and inclusion criteria. The inclusion criteria for research subjects are 19-22 years old, are students of the Faculty of Medicine at Diponegoro University, are willing to be research subjects, and have smartphones with AMOLED screens and IPS LCD. While the exclusion criteria in this study were those who suffering from certain eye diseases such as Sjogren's syndrome, allergic conjunctivitis, vitamin A deficiency, red eyes, dry eyes, wearing contact lenses, wearing anti-radiation glasses, using eye drops before the study conducted and particular drugs.

In this study, research subjects were treated using smartphones with low, medium and high screen brightness that had been determined in each group. Each subject looked at the smartphone for an hour with viewing distance of 30 cm from the smartphone, before and after the treatment using the smartphone the subject's eyes quantity was measured using the Schirmer test. The Schirmer test is a test used to assess total tear production using Schirmer tear test strip and folded 5 mm. A 5 mm folded paper is inserted into the lateral one-third of the inferior fornix of the eye then the treated individual is instructed to close his eyes and wait for 5 minutes After 5 minutes the Schirmer tear test strip was removed from the eye and the wet strip was measured on a millimeter scale.

The independent variable in this study is the brightness level of the smartphone screen, while the dependent variable in this study is the Schirmer test results. Hypothesis testing to compare the pre and post-tests after using a smartphone has been analyzed by the Wilcoxon test. Meanwhile, the Mann Whitney U test was used to test the hypothesis to compare the two independent variables and the Kruskal Wallis Test was conducted to test the hypothesis which compared the three independent variables.

3. Results

The research data will be processed statistically to determine whether there is a significant difference in the pre-post Schirmer test for each brightness, and the comparison results of the post-test Schirmer comparison in each brightness. The results of statistical data analysis can be seen in the following table.

Table 1. Comparison between Schirmer pre and post-test results in various brightness levels

Schirmer test results	Group		
	Low brightness	Medium brightness	High brightness
Pre test	25,60 ± 9,44	27,90 ± 9,46	23,60 ± 6,80
Post test	17,60 ± 8,45	24,80 ± 10,46	19,10 ± 7,95
P	0,008₩*	0,261₩	0,172₩

Information: ₩ *Wilcoxon test*, * Significant (p < 0,05)

The Wilcoxon test results for the pre-post Schirmer test with low brightness treatment obtained a significant difference (p <0.05), while the Wilcoxon test results for the Schirmer pre-post-test for medium and high brightness treatment did not show a significant difference (p> 0.05).

Table 2. Comparison between Schirmer post test results and smartphone brightness

Schirmer test results	Smartphone brightness		p
Post test	Low brightness	Medium brightness	0,117‡
	Low brightness	High brightness	0,819‡
	Medium brightness	High brightness	0,166‡

Information: ‡ *Mann whitney*, * Signifikan (p < 0,05)

The results of the Mann Whitney test to determine the difference in the Schirmer post-test results of low and medium brightness treatment did not show a significant difference (p> 0.05). The Schirmer post-test results of low and high brightness treatment did not show a significant difference (p> 0.05). The results of the Schirmer post-test with medium to high brightness treatment did not show a significant difference (p> 0.05).

Table 3. Comparison of Schirmer post test results in low, medium, and high brightness

Schirmer test results	Smartphone brigthness			p
Post test	Low	Medium	High	0,228ᴷ

Information: ᴷ *Kruskal Wallis*, * Significant (p < 0,05)

The results of the Kruskal Wallis test for the Schirmer post-test with low, medium and high brightness treatments did not show a significant difference (p> 0.05)

4. Discussion

In the low-brightness group to compare the pre and post-test results, the Wilcoxon test was used to find a significant difference in the pre and post-test Schirmer in the low brightness treatment. This can happen because when using a smartphone with low brightness it requires higher concentration because dark background making it hard to see what it is showing, in previous studies it was found that a reduction in blink rate of more than 3 minutes in smartphone activities require higher concentration, because the reduction in the number of blink increased tear evaporation and decreased the Schirmer post test results in the low screen brightness treatment group.[3,5,10]

In the medium and high brightness groups there was no significant difference in the pre-post Schirmer test after using a smartphone with medium or high screen brightness for an hour, this could happen because the room conditions were not too light and dark parallel to the brightness of the smartphone screen so that the eyes are more comfortable to see a smartphone with optimal brightness parallel to the room and does not really need high concentration, so that the eyes can blink optimally. For normal people, blinking is useful for spreading the tear film to the surface area of the eye, so that there is no excess tear evaporation. [3,5,10] In previous studies that compared the treatment of reading using a smartphone in conditions of dark and light with equalizing smartphone lighting, there were dry eye symptoms and a burning sensation when reading a smartphone in dark conditions rather than light, this shows that room lighting conditions also affect eye comfort to see a smartphone.[1] The duration of smartphone use also affects the high results of the Schirmer test, where the increase in ROS which affects the inflammatory response is associated with the tear film instability which encourages evaporation which later affects the tear quantity, only occurs in long-term exposure to blue light, whereas in this study it was only conducted for 1 hour.[11] Madudoc et al. also said that there were no significant differences in the Schirmer test results on the use of tablets for an hour.[12]

There were no significant results for the comparison of post-test results between the low and medium brightness groups, low to high, medium to high brightness groups, and the comparison of the three. Based on previous studies, most of the reduction in tear volume was reported in computer users.[34] A decrease in Schirmer score was reported to decrease in computer users longer than two hours a day or computer use that was used for more than 4

years. There have been many studies reporting a decrease in the tear volume in computer use, but studies comparing the effect on the use of digital devices such as smartphones are still conflicting because smartphones or handheld devices differ from computers in terms of viewing distance, screen size, screen lighting and usage patterns.[5,13]

Gelbiowski et al, said there were no significant differences in the results of the Schirmer test after reading from a smartphone for an hour, and Madudoc et al. also said that there were no significant differences in the Schirmer test results on the use of tablets for an hour. [11,12]

Blue light has a wavelength between 450-495 mm which is near to ultraviolet light, on a smartphone screen increased the screen brightness which will increase the exposure level to blue light produced by the screen leading to dry eyes.[6,8] Blue light exposure can significantly cause oxidative damage and apoptosis to the cornea. Blue light exposure increases the production of reactive oxygen species (ROS) in corneal epithelial cells which will activate the ROS-nucleotide-binding domain, leucine-rich-containing family, pyrin-domain containing-3 (NLRP3) - interleukin (IL) -1β signaling pathway which will trigger inflammation in human epithelial cells (HCECs) caused by hyperosmotic pressure of NLRP3 and increased secretion of IL-1 beta.[13] This inflammatory response in the cornea is associated with the development of dry eye disease. The release of inflammatory factors reduces the tear secretion and mucin, thereby increasing the tear film instability, which in turn promotes tear evaporation and creates a hyperosmotic environment on the tear surface. However, this can only happen with long-term blue light exposure and with frequent exposure to frequency.[14]

The limitation in this study is that the researcher cannot control confounding variables such as measuring the number of blinks of the subjects, there are 2 types of smartphone screens used in this study, the researcher also does not equate what is done when the treatment uses a smartphone so the research subjects are free to use their smartphone for anything in which smartphone use with high concentrations such as watching videos and playing games also have an effect on the amount of blinking which also affects the tear evaporation which later affects the Schirmer test results.[3,5]

5. Conclusion

The Based on the presentation of the data and the discussion that has been presented, it can be concluded that there was no significant difference between the Schirmer test results on low, medium and high screen brightness after one hour of smartphone use treatment, there was no significant difference between the Schirmer test results before and after smartphone use for an hour on medium and high screen brightness, but there were significant differences between the Schirmer test results before and after using the smartphone for an hour on low screen brightness

Ethical Approval

This research has obtained ethical approval from the Medical and Health Research Ethics Commission (KEPK), Faculty of Medicine, Diponegoro University with Number 148 / EC / KEPK / FK-UNDIP / VI / 2020.

Conflicts of Interest

The authors declare no conflict of interest.

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Author Contribution

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