JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)

Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : 10.14710/dmj.v13i1.41988
JKD (DMJ), Volume 13, Number 1, January 2024 : 44-50

INCIDENT OF DRY EYE IN FK UNDIP STUDENTS USING SMARTPHONES

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ABSTRACT

Background: Smartphone use is increasing over time and often causes Dry Eye Syndrome (DES). Dry Eye Syndrome (DES) is a multifactorial disease of the ocular surface characterized by loss of homeostasis and causes various ocular symptoms. The Schirmer test is a measurement of the tears quantity to diagnose DES. **Objective:** To determine the effect of smartphone use on the results of Schirmer test measurements. **Methods:** This was a quasi-experimental research with a pre-test and post-test design. The research subjects consisted of 36 students selected based on inclusion and exclusion criteria using consecutive sampling. The experimental group (n=18) used a smartphone for 2 hours by watching the video (film), while the control group (n=18) did not use the smartphone. Schirmer tests were carried out before and after observation for 5 minutes using Schirmer paper strips. Statistical tests used the Shapiro-Wilk test with a meaning value of $p \geq 0,05$, Chi-square test, Paired t-test, Wilcoxon test, and Mann-Whitney test with a meaning value of $p < 0,05$. **Results:** There was a significant decrease in the Schirmer test results ($p = 0,020$) by $1,334 \pm 0,8937$ mm in the experimental group and a non-significant increase ($p = 0,582$) in the control group by $0,362 \pm 0,4086$ mm. There was a significant difference in the decrease of Schirmer test results between the experimental group compared to the control group ($p = 0,048$). **Conclusion:** The use of smartphones influences the decrease in Schirmer test measurement results.
Keywords: Dry Eye Syndrome, Medical Students, Schirmer Test, Smartphone

INTRODUCTION

In the current era of globalization, smartphones and computers are widely used in companies, universities, schools, and home.[1,2] Smartphone, a common example of a Visual Display Terminal (VDT), is a device that are useful to access various information and making it easier to communicate with other people.[2,3] Data obtained from Nezwoo shows that currently, Indonesia is in fourth place as the country with the most smartphone use in 2022 after China, India, and the United States with 192,15 million users out of a total of 275,5 million inhabitants. The percentage of smartphone users in Indonesia reached 69,7%.[4]

The American Optometric Association defines Computer Vision Syndrome (CVS) as a complex eye and vision problem related to prolonged use of smartphones, computers, tablets, and e-readers.[5] The symptoms are related to Dry Eye Syndrome (DES) or Dry Eye Disease (DED), namely a condition where tears are unable to lubricate the entire surface of the eye, which causes hyperosmolarity in the tear film.[6,7]

In 2020, the World Health Organization (WHO) declared the COVID-19 outbreak to be a pandemic so the face-to-face learning system switched to online learning for between 4 and 6 hours a day which had a bad impact on eyesight, especially for students.[8,9] The results of research on medical students in Saudi Arabia found that using smartphones for more than 2 hours each day caused 74% of students to complain of one or more symptoms of CVS. This figure increased to 95% during the pandemic due to online lecture activities.[10] Garcia *et al.* (2022) found that 51.8% of University of Murcia students experienced Dry Eye Syndrome (DES) during the COVID-19 pandemic which was obtained through measuring the Ocular Surface Disease Index (OSDI) questionnaire.[11] Kamil *et al.* (2020) stated that dryness in the tears occurs after 1 hour of smartphone use.[12]

Smartphones as an example of a Visual Display Terminal emit light through a Light-Emitting Diode (LED) which has a wavelength of 400-490 nm and has an emission peak in the blue light range.[13,14] Increasing the screen brightness level increases the production of Reactive Oxygen Species (ROS) which trigger inflammatory mediators in the cornea. This condition creates hyperosmotic tear film and increases evaporation, thereby affecting the quantity of tears which can be measured with the Schirmer test.[13] The Schirmer test is a method for assessing tear production that is relatively simple and objective with a sensitivity of 83% and a specificity of 57%.[15–

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[17] The Schirmer I test can be used to measure basal tear production and lacrimation reflex and does not require anesthesia in the examination procedure.[15] Tears consist of 3 layers, namely oil, water, and mucus. The oil layer functions to prevent evaporation of the water layer. Meanwhile, the mucus layer helps distribute tears throughout the eyeball.[18]

Medical students are a group that is closely related to smartphone use. Until now there has been no research that discusses the influence of smartphone use on the Schirmer test, especially after the COVID-19 pandemic. This study aims to determine the effect of smartphone use on the number of tears after smartphone exposure with the Schirmer test in medical students as a group that is vulnerable to DES.

METHODS

This research is a quasi-experimental research with a pre-test and post-test design. This research was carried out offline at the Faculty of Medicine, Diponegoro University in May–July 2023. Research subjects were obtained using the concecutive sampling method. The inclusion criteria for this study were that students were willing to participate in the research (informed consent) and had an android smartphone. The exclusion criteria for this study were a history of certain eye diseases that reduce tear production, such as Sjogren's syndrome, red eyes, dry eyes, allergic conjunctivitis, diabetes, rheumatoid arthritis, lupus, scleroderma, thyroid hormone disorders, vitamin A deficiency, history of keratorefractive surgical procedures, such as LASIK (Laser-Assisted In Situ Keratomileusis), LASEK (Laser Epithelial Keratomileusis), and PRK (Photoreactive Keratectomy), daily use of contact lenses, use of eye drops, eye ointment, or eyewash, as well as consumption of medications that affecting tear production, such as antihistamines, antidepressants, antihypertensives, diuretics, and psychotropics. The dropout criteria for this study were research subjects who did not follow research procedures and did not use a smartphone for > 1 hour in the experimental group during the research.

This research used primary data to get the research subject's identity obtained by filling in a google form (name, age, gender, history of certain diseases, history of keratorefractive surgical procedures, use of contact lenses, eye drops, eye ointment, eyewash, consumption history certain medications, and screen time per day). The Schirmer test measurement results were obtained through direct measurements of research subjects.

A total of 36 students were divided into 2 groups, namely the experimental and control groups. The experimental group used their android smartphones and watched video (film) for 2 hours. The control group did not use a smartphone for 2 hours. Activities carried out can include reading books, drawing, playing various games, or having conversation with other control group subjects while maintaining calm. Schirmer test measurements were carried out before and after observation using a Schirmer paper strip, inserted in the lateral third of the inferior conjunctiva in both eyes for 5 minutes with the eyes remaining open and blinking normally during the examination.

Data were analyzed using the IBS SPSS Statistics program. Shapiro Wilk for normality test and Chi-square to analyze the relationship beetween gender and age on the Schirmer test results. Paired t-test to analyze differences in Schirmer test measurement results before and after smartphone use for 2 hours in the experimental group, Wilcoxon test for the control group, and Mann-Whitney test to analyze differences in Schirmer test measurement results for the experimental group and the control. The significant value is $p<0.05$.

RESULTS

Characteristics of Research Subjects

The data shows that the total research subjects were 36 students who were divided into 2 groups, namely the experimental and control groups. The research subjects were students from the Faculty of Medicine, Diponegoro University, class 2020-2022. The subjects were mostly women (72,2%) aged 20 years (47,2%). A total of 28 students from the class of 2020, 6 students from the class of 2021, and 2 students from the class of 2022.

Table 1 shows that the Chi-square test has non- significant value. Gender ($p = 1.000$) and age ($p = 0.133$) did not influence the Schirmer test measurement results.

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Table 1. Characteristics of Research Subjects

Variable	Group		p
	SU	Control	
	n (%)	n (%)	
Sex			1,000[¥]
Male	5 (27,8)	5 (27,8)	
Female	13 (72.2)	13 (72.2)	
Age			0,133[¥]
18 years	3 (16,7)	1 (5,6)	
19 years	2 (11,1)	0 (0,0)	
20 years	9 (50,0)	8 (44,4)	
21 years	3 (16,7)	9 (50,0)	
22 years	1 (5,6)	0 (0,0)	

[1] Significant (p<0.05); [¥] Chi square (p<0.05), SU: Smartphone Use

Tear Quantity Analysis

Schirmer test measurements were carried out before and after observations in the experimental and control groups. Changes in the results of the Schirmer test measurements in each group based on the pre-test and post-test scores can be seen in table 2.

Table 2. Changes in Schirmer Test Results in The Smartphone Use and Control Group

Changes in Schirmer Test Results	Group			
	SU		Control	
	n	%	n	%
Increase	4	22,22	7	38,89
Decrease	12	66,67	5	27,78
No Difference	2	11,11	6	33,33

SU : Smartphone Use

The data was tested with a normality test. In this study, the number of research subjects was less than 50 (36 students) so the Shapiro-Wilk test was carried out.

Table 3. Descriptive and Normality of Schirmer Pre-Test and Post-Test Measurement Results

Schirmer Test	Group	Mean ± SD (mm)	Median (min–max)	p[£]
Pre-test	SU	29,556 ± 4,7585	30,5 (17,5 – 35)	0,102[1] 0,015*
	Control	27,944 ± 6,4986	26,5 (15,0 – 35)	
Post-test	SU	28,222 ± 5,6522	29,5 (14,5 – 35)	0,115[1] 0,024*
	Control	28,306 ± 6,9072	30,0 (13,5 – 35)	

[1] Normal (p ≥ 0,05); [£] Uji Shapiro-wilk, SU : Smartphone Use

The normality test showed that the average Schirmer test measurement results for the right and left eyes in the treatment group were normally distributed. The homogeneity test table shows that the data comes from a population that has the same or homogeneous variance. Thus, the data in the experimental group is parametric so a paired t-test was carried out to test the difference in Schirmer test measurement results before and after using a smartphone for 2 hours.

Table 4. Homogeneity of Variance Test

		Levene Statistic	df1	df2	Sig.
Schirmer Test Result	Based on Mean	1.722	3	68	.171[1]
	Based on Median	1.323	3	68	.274
	Based on Median and with adjusted df	1.323	3	63.39	.275
	Based on trimmed mean	1.749	3	68	.165

[1] Signifikan (p > 0,05)

The results of the Schirmer test measurements in the control group were not normally distributed. The data in the control group is non-parametric so the Wilcoxon test was carried out to test the hypothesis regarding the difference in Schirmer test measurement results before and after 2 hours without using a smartphone. The Mann-Whitney test was carried out to test the hypothesis regarding differences in Schirmer test measurement results between the experimental and control groups.

Table 5. Differences in Schirmer Test Pre-Test and Post-Test Results in Each Group

Schirmer Test	Group	
	SU (mm)	Control (mm)
Pre-test	29,556 ± 4,7585	27,944 ± 6,4986
Post-test	28,222 ± 5,6522	28,306 ± 6,9072
p	0,020[€1]	0,582[†]

[1] Significant (p < 0.05); [€] Paired t-test; [†] Wilcoxon, SU : Smartphone Use

The paired t-test showed that there was a significant difference between the results of the Schirmer test measurements before and after using the smartphone for 2 hours in the experimental group (p = 0,020). The Wilcoxon test showed that there was non-significant difference in the results of the Schirmer test measurements in the control group (p = 0,582).

The Mann-Whitney test showed that there was a significant difference between the experimental and control groups (p = 0,048).

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Table 6. Differences in Schirmer Test Results for Smartphone Use and Control Groups

Group	Mean ± SD (mm)	p
SU	1,334 ± 0,8937	0,048‡[1]
Control	0,362 ± 0,4086	

[1] Significant ($p < 0.05$); ‡ Mann Whitney, SU : Smartphone Use

The decrease of Schirmer test measurement results in the experimental group was greater than in the control group. A graph of the decrease in Schirmer test measurement results (pre-test and post-test) in each group can be seen in the graph below.

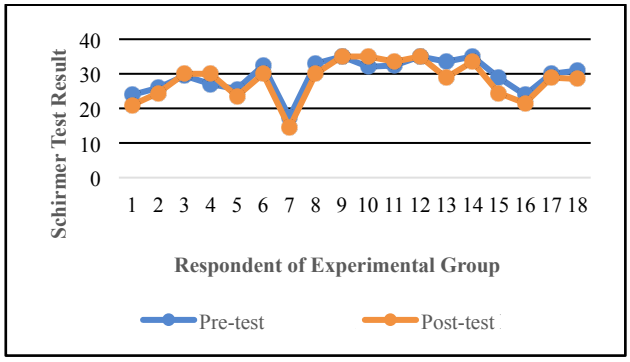

Fig. 1 Schirmer Test Results of Experimental Group

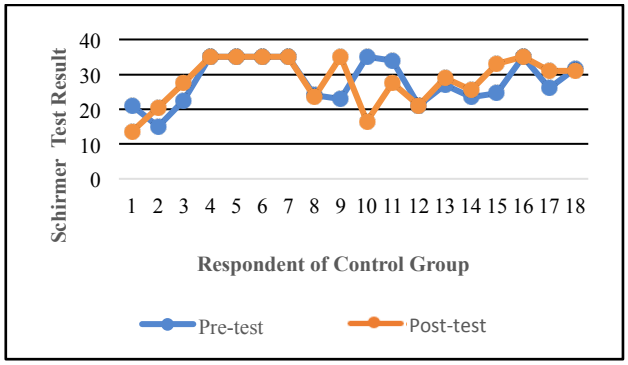

Fig. 2 Schirmer Test Results of Control Group

DISCUSSION

Statistical tests in the experimental group showed a significant decrease in Schirmer test measurement results before and after using the smartphone for 2 hours (p = 0,020). In the treatment group, 12 people (66,67%) experienced a decrease in the Schirmer test measurement results, 4 (22,22%) people experienced an increase, and 2 other people (11,11%) had no difference in examination results before and after use smartphone for 2 hours. The results of this study are in line with research by Irfan et al. (2018) which obtained similar positive results. Using a computer for 2 hours caused a significant decrease in the quantity of tears (p = 0.015).[19]

In the control group, there was a non-significant decrease (p = 0,582). A total of 5 people (27,78%) experienced a decrease in the results of the Schirmer test measurement, 7 people (38,89%) experienced an increase, and 6 people (33,33%) remained the same. Activities carried out by research subjects included reading books, having conversation with other control group subjects while maintaining calm, singing, eating, and others.

Akib et al. (2021) found that long-term use of smartphones by reading on smartphones can significantly reduce the quantity of tears (p < 0,001). The percentage of subjects experiencing Dry Eye Mild syndrome (DES) reached 78,6%.[20] Wang et al. (2021) stated that using a smartphone for 2 hours can worsen the level of eye dryness. Subjects who suffer from mild dry eye become moderate, while moderate dry eye becomes severe.[21]

Using a smartphone or computer can trigger the evaporation of the tear film due to a decrease in blinking frequency and imperfect blinking. This is a condition when the eyelids do not close completely when blinking. Wang et al. (2018) found that incomplete eye closure can reduce the thickness and instability of the tear film. This indicates that decreased blink frequency and incomplete eye closure may be predisposing factors for DES.[20]

Smartphone use affects the quantity of tears. The tear evaporation occurs more quickly due to the lengthening of the blink interval, thereby reducing eye blinks. The frequency of blinking in normal people is approximately 20 times per minute. Prolonged use of smartphones can reduce blinking frequency up to 60%. Blinking speed has decreased to 5-6 times per minute (1/3 of normal).[22,23] This decrease affects the quantity of tears and causes stress on the cornea which triggers dry eye.[24]

Incomplete eye closure and an increase in the open eye area can disrupt the homeostasis of the ocular surface system. Smartphone use can increase imperfect eye closure from 6 blinks in 1 minute to 15 blinks.[22,25] This triggers tear film instability and

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epithelial damage that causes various eye symptoms.[22,26]

This research was conducted using smartphone media. Blink speed when using a smartphone is lower compared to using other Visual Display Terminals (VDT).[22,27] Stability and continuously focused vision require visual emphasis to maintain saccades, namely rapid movements between one fixation point and another. Fixation is a condition where the eyes are quite stable between a quarter to half a second. The amplitude of saccades can be influenced by small screen size so that visual emphasis can maintain visual stability. The flashing frequency will decrease as a result of visual stabilization.[22]

Smartphones are a form of VDT that emit light through Light-Emitting Diodes (LED) and cause electromagnetic radiation. This radiation can damage cells, chemical bonds, and neutral molecules.[13,14,22] LED screens emit blue light. Excessive exposure to blue light can cause oxidative damage due to oxidative stress response, apoptosis, and inflammation on the surface of the eye, thereby triggering DES.[22]

The research results showed that several research subjects experienced an increase in the tear quantity. These results are in line with research conducted by Wu et al. (2015) that eye stimulation affects blinking and tear secretion. Pain stimulation during the Schirmer test will trigger nociceptors as pain receptors. The blink response due to stimulation of the surface of the eye is very fast, less than 1 second, while the increase in lacrimation is slower, around 6 seconds, which is caused by differences in innervation. Blinking involves innervation of the eye muscles, whereas lacrimation stimulation of the lacrimal gland for tear secretion.[28]

Kamil et al. (2020) found that dryness of the tear film occurred after 1 hour using smartphone. The control group did not do smartphone fasting before the study was conducted. This causes there to still be an influence of smartphone use before the research was carried out on the pre-test Schirmer test measurement results so some research subjects experienced an increase in the Schirmer test measurement results after the research.[12]

There are several limitations in carrying out this research. Control of several variables that have the potential to be confounding is still limited. Some of these confounding variables can be intrinsic and extrinsic factors. Intrinsic factors are the level of eye sensitivity which influences the frequency of blinking, thus influencing the Schirmer test measurement results. Extrinsic factors include the absence of smartphone fasting before the research so that the daily screen time for each research subject was different, emotional tension when watching films, differences in screen size, and environmental conditions. The reachable population only includes Diponegoro University Medical Students. Conditions of refractive errors, such as myopia, hypermetropia, and astigmatism may also be correlated with the incidence of Dry Eye Syndrome (DES).

CONCLUSION AND SUGGESTION

Conclusion

The use of smartphones has a significant effect on the results of Schirmer test measurements in Diponegoro University Medical Students. The results of the Schirmer test measurements after using a smartphone experienced a significant decrease compared to before smartphone use for 2 hours. The results of the Schirmer test measurements in the control group before and after observation were not significantly different. The decrease in Schirmer test measurement results in the experimental group was greater than control group.

Suggestion

Further research needs to be carried out with different methods, designs, and instruments as well as controlling confounding variables, both intrinsic and extrinsic factors. Further research needs to be carried out with a wider accessible population, not only Diponegoro University Medical Students so that more representative research results can be obtained regarding the influence of smartphone use on Schirmer test measurement results. Further research needs to be done by paying attention to conditions of refractive errors, such as myopia, hypermetropia, and astigmatism.

ETHICAL APPROVAL

This study is approved ethically by the Health Research Ethics Committee of the Faculty of Medicine of Diponegoro University with certificate number 227/EC/KEPK/FK-UNDIP/V/2023.

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CONFLICTS OF INTEREST

There is no conflict of interest related to the materials, methods, and findings in this study.

FUNDING

Financial resources used in this research are solely independent of the author.

ACKNOWLEDGEMENTS

This study was supported by the Department of Ophthalmology, Faculty of Medicine, Diponegoro University.

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