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Tear Quantity and Quality in Smartphone Users Amongst Students of University of Benin.

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Abstract

Purpose: This study was aimed at investigating how smartphone use affects tear quantity and tear quality in students of the University of Benin, Benin City, Edo state, Nigeria.

Methods: The study involved 300 participants, comprising 174 males and 126 females, aged between 16 and 25 years, with mean age of 20.76 ± 3.00 years. The study began by instructing participants to refrain from using smartphones for 60 minutes. Baseline measurements for tear quantity and tear quality were obtained through Schirmer and invasive tear breakup time test respectively. Subsequently, participants were asked to read an article on a smartphone for 60 minutes, followed by the same tear tests.

Results: Statistical analysis, using paired t-tests, revealed a statistically significant decrease ($p < 0.05$) in tear quantity after smartphone use: right eye (RE) from 17.08 ± 3.01 mm to 14.71 ± 2.63 mm and left eye (LE) from 17.01 ± 2.63 mm to 14.91 ± 2.47 mm. Tear quality also showed a statistically significant decline ($p < 0.05$) after smartphone use: RE from 16.17 ± 2.90 secs to 14.26 ± 2.67 secs and LE from 16.17 ± 2.74 secs to 14.46 ± 2.67 secs.

Conclusion: Smartphone use was found to lead to reduced tear quantity and tear quality among University of Benin students.

Keywords: Smartphone, Tear quantity, Tear quality, Students.

Introduction

Visual display terminals (VDTs) are extensively utilized by both VDT workers and the general public, including those actively engaged in smartphone usage¹. The prevalence of smartphone use has significantly impacted our daily lives. Unlike earlier

generations, modern smartphones enable a broader range of activities, such as web browsing, video streaming, group messaging, and social networking, leading to increased screen time. As a result of the growing dependence on computers, mobile phones, and the internet, young adults have become more engrossed in tasks like document handling, gaming,

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and online searches. An illustrative survey indicates that average daily smartphone usage surged from 98 minutes in 2011 to 195 minutes in 2013².

The tear film is comprised of three layers, the outer lipid layer, middle aqueous layer, and inner mucin layer. These layers are produced by the meibomian glands, lacrimal glands, and the goblet cells respectively. The lipid layer is responsible for slowing down the rate of tear evaporation.³ Sensory innervation plays a crucial role in regulating tear production. Afferent neurons of the trigeminal nerve (V1) located in the cornea and eyelids detect sensory stimuli such as temperature changes through various receptors. These neurons trigger autonomic and somatic reflexes, resulting in increased tear production and blinking.⁴ Both the lacrimal and meibomian glands, which produce the aqueous and lipid layers of the tear film, respectively, are innervated by both sympathetic and parasympathetic nerves. This intricate neuronal network orchestrates tear secretion. Parasympathetic activation in response to pain, irritation, and cold promotes increased aqueous and mucin production, enhancing tear production. Meanwhile, sympathetic inputs stimulate secretion from conjunctival epithelial cells, contributing to tear composition.⁴ This tear film envelops the ocular surface, plays a critical role in sustaining the health of the conjunctiva and the avascular cornea while shielding the eye from environmental factors. Additionally, it lubricates

the ocular surface, ensuring smooth light refraction and, consequently, high-quality vision. Blinking is instrumental in distributing the tear film across the ocular surface, which is essential for maintaining ocular moisture. Typically, an individual blinks about 15 times per minute; however, individuals fixated on smartphones tend to blink less frequently. Extended periods of staring at smaller screen can hasten the onset of ocular complaints such as headaches, blurred vision, eye discomfort, dry eyes, and muscle strain⁵. Complete blink is essential to replenish the tear film layers including the lipid layer⁶. The disruption of the lipid layer caused by altered blinking patterns (decreased blink rate as well as incomplete blink) during digital device use can leave the ocular surface unprotected for long periods. This can cause increased tear evaporation and hyperosmolarity, which in turn could affect the tear quantity and quality⁷.

In contrast, older populations tend to exhibit less addictive mobile phone behavior due to self-regulation⁸. A study involving participants with pediatric dry eye disease (DED) demonstrated that individuals in the DED group spent more time on their cellphones compared to those in the non-DED group⁹. Research indicates that the blue light emitted by smartphone screens negatively impacts human corneal epithelial cells¹⁰. According to Lee¹¹, excessive exposure to blue light can lead to the deterioration of the tear film and increased levels

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of inflammatory markers and reactive oxygen species (ROS) production at the ocular surface in mice. This, in turn, can affect tear quantity and quality. Therefore, the present study was aimed at investigating the impact of smartphone usage on tear quantity and tear quality among University of Benin students.

Materials and Methods

The study adhered to ethical guidelines set forth by the Ethical Committee of the Department of Optometry, University of Benin, Nigeria and followed the principles outlined in the Declaration of Helsinki, which govern ethical practices in medical research involving human subjects. The research involved 300 University of Benin students aged between 16 and 25 years who do not wear contact lenses, exhibited no abnormalities in the eyelids or ocular surface, and had no history of eye surgery. Prior to participation, the research objectives and procedures were comprehensively explained to each participant, and their informed consent was duly obtained. A thorough case history was conducted for each participant to confirm their absence of ocular trauma, soft contact lens usage, and the absence of systemic or topical ocular medications that could potentially induce dry eye. Visual acuity assessments were also carried out for medico-legal reasons.

Participants who met the aforementioned inclusion criteria were instructed to abstain from smartphone usage for a duration of 60 minutes. Subsequently, Schirmer's test and Invasive Tear Break Up Time assessments were performed, with the obtained

values documented. Following this, participants were tasked with reading an article on a smartphone for a period of 60 minutes, Schirmer's test and Invasive Tear Break Up Time assessments were conducted once more.^{12,13}

Schirmer Test 1 Techniques:

Two strips were removed from sterile packaging and labeled 'R' (right) and 'L' (left). Each strip was bent at the notch to form a 90-degree angle. Participants were instructed to gaze upward, and their lower eyelids were gently pulled downward using an index finger. The bent end of the strip was hooked over the center of the lower eyelid and allowed to rest inside. This procedure was repeated for the other eye, and the time was noted. Participants were directed not to squeeze their eyes but simply to keep them gently closed. After a five-minute interval, participants were instructed to open both eyes and look upward. Carefully, both strips were removed, and the length of the moistened area on each strip, measured from the notch, was marked with a pen. These measurements were recorded below each strip, e.g., "10 mm in 5 minutes." If the strips were fully moistened before five minutes had elapsed, this was recorded accordingly, e.g., "30 mm in 3 minutes." A test result showing less than 5mm of wetting in 5 minutes strongly indicated aqueous deficiency¹⁴.

Invasive Tear Break Up Time:

This technique involved the use of standardized fluorescein dye, with the eye observed through a slit lamp. Participants were seated comfortably and

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12. Lee, H. S., Cui, L., Li, Y., Choi, J. S., Choi, J. H., Li, Z., Kim, G. E., Choi, W., and Yoon, K. C. Influence of light emitting diode-derived blue light overexposure on mouse ocular surface. *PLoS One*.2016;11(8): e0167671.
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asked to look downward. The fluorescein strip was then used to stain the eye, and participants were instructed to keep their eyes open while looking straight ahead. Under cobalt blue illumination with the slit lamp, the tear film was observed, specifically noting the time between the last blink and the appearance of the first black spot, which indicated the tear film's breakup. This result was recorded in

seconds as the Tear Break Up Time (TBUT). The TBUT can be used to assess tear film quality and determine corneal integrity. A normal TBUT should fall between 15 and 45 seconds, while a TBUT of less than 10 seconds indicated an unstable tear film¹⁵. The study employed Student's Paired t-test to analyze the impact of smartphone use on tear quantity and tear stability.

Results

A total of 300 subjects, 174 males and 126 females, within the age range of 16 – 25 years old with mean age of 20.76 ± 3.00 years old were enlisted in the study.

Table 1: Mean Age of the sampled population.

Mean Age \pm SD (years)				
N	Male	N	Female	
174	20.17 ± 2.98	126	20.83 ± 3.03	

Table 2: Tear quantity of the sampled population with respect to time (in mm/5mins)

Variables	Right Eye (Mean \pm SD)	p-value	Left Eye (Mean \pm SD)	p-value
Baseline	17.08 ± 3.01		17.01 ± 2.63	
After 60 mins	14.71 ± 2.63	0.001	14.91 ± 2.47	0.001

Table 2 showed a significant decrease in mean tear quantity after usage of smartphone on both the right and left eyes. ($p < 0.05$)

Table 3: Tear quality of the sampled population with respect to time (in secs).

Variables	Right Eye (Mean \pm SD)	p-value	Left Eye (Mean \pm SD)	p-value
Baseline	16.17 ± 2.90		16.17 ± 2.74	
After 60 mins	14.26 ± 2.72	0.001	14.46 ± 2.67	0.001

Table 3 showed a significant difference in tear quality after usage of smartphone on both the right and left eyes ($p < 0.05$).

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Discussion

Tears play a vital role in the eye's health by providing lubrication, protection against infection, irritants, and dust, and maintaining optical clarity and smoothness on the eye's surface. Imbalances in tear composition can lead to decreased tear production or increased tear evaporation, as observed in patients with dry eye syndrome¹⁶.

This study investigated the impact of smartphone use on tear quantity and tear quality among students of the University of Benin in Benin City, Nigeria. Each participant served as their own control, and the study compared the results before and after smartphone use to determine any differences in tear quantity and tear stability.

Table 2 revealed a reduction in mean tear quantity after smartphone use ($p = 0.001$) Schultz¹⁷ suggested that factors increasing tear evaporation may also reduce tear production. Smartphone use is associated with reduced eye blinking rates and incomplete blinks, leading to increased exposure of the ocular surface². This heightened exposure results in greater evaporation, which, in turn, can lead to decreased tear production.

Table 3 demonstrated a decrease in mean tear quality after smartphone use ($p = 0.001$) consistent with a study by Choi *et al.*², which also reported reduced tear quality following smartphone use. The results indicated a statistically significant decrease in tear quantity due to smartphone use ($p < 0.05$),

which contradicted the findings of Wang *et al.*¹⁸, who found no effect on tear quantity after two hours of smartphone reading. This discrepancy might be attributed to differences in the study's time frame, as the researchers in this study focused on a specific time range (8 - 10 am).

Similarly, tear quality was significantly affected by smartphone use ($p < 0.05$), aligning with the findings of Bettach *et al.*¹⁴, who investigated the influence of smartphone screen reading on tear film stability. Inconsistencies were noted with other studies, such as Kim *et al.*¹⁵ and Golebiowski *et al.*¹³, which examined tear quality after 60 minutes of smartphone or tablet use. Kim *et al.*¹⁹ reported reduced tear break-up time after gaming or watching a movie on a tablet, while Golebiowski *et al.*¹³ found no significant change in tear break-up time after reading from a smartphone. This disparity may be attributed to differences in sample size, with this research involving 300 participants compared to the smaller sample of 12 young adults in Golebiowski *et al.*'s¹³ study.

The study was however with some limitations. The history of prolonged use of their smartphone might have had some effect as well as environmental factors the subjects have been exposed to. We tried to reduce this limitation by letting them take 60 minutes break before the start of the experiment. We also took readings for all subjects within same time of the day and within same condition to reduce environmental impact.

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Conclusion

The results of this study, indicate that smartphone use significantly affects tear quantity and tear quality. It is therefore recommended that smartphone users should take breaks periodically to improve their blink rates which will in turn improve the distribution of the tear film across the ocular surface.

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