ORIGINAL ARTICLE

Exploring the relationship between smartphone use and ocular health in young adults: A cross-sectional study of chronic smartphone users in Salem, Tamil Nadu

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Abstract

Background: Recent international reports on ocular health shared that diplopia and dry eye are the prevalent ocular disorders caused by the overuse of smartphones in young adults. Studies on smartphone usage in young adults reported that smartphone use begins at the age group ranging from 12-18 years old, the minimum duration of smartphone use per day is 4-6 hrs. *Aim and Objectives:* To investigate the ocular impact and SmartPhone Vision Syndrome (SPVS) among chronic smartphone users. *Material and Methods:* The observational study was done on 100 volunteers. A structured questionnaire was used to collect the details of smartphone usage followed by the Schirmer test, visual acuity test, and Intraocular Pressure (IOP) were taken as some of the parameters in the study. *Results:* The continuous use of smartphones caused various problems such as headaches, eye dryness, earache, fatigue, and musculoskeletal manifestations. The Schirmer test, visual acuity, and IOP of both the right and left eye were analyzed to check out the ocular defects in chronic usage of smartphones. The ocular manifestations are noted and correlated with the duration of usage. *Conclusion:* It is suggested that the minimization of screen time to be educated among all age groups. It is required to spread awareness among young adults about the adverse effects of prolonged use of smartphones.

Keywords: Ocular Impact, Smartphones, Schirmer Test, Visual Acuity, Intraocular pressure

Introduction

Frequent usage of smartphones in daily life between different age groups especially adolescents and young adults leads to a significant impact on regular activity [1]. Smartphone usage in 2023 has increased by over seven billion worldwide; this may reach over 7.7 billion in 2028 [2]. The daily usage of the internet has increased from 35% to 89% from 2006 to 2020 [3]. Smartphone usage and accessing the internet via smartphone in Britain is 78%, in Korea 89.8%, in Australia 95% [4-6]. An experimental study in India showed that 75% of students spent one to five hours duration of mobile phones on gaming platforms. Studies on smartphone usage in young adults reported that smartphone use begins in the age group ranging from 12-18 years old, where the minimum duration of smartphone use per day is 4-6 hours [7].

Continuous/prolonged use of smartphones has been coupled with various symptoms of eye discomfort [8]. Certain research indicates that smartphones and tablets may cause more symptoms compared to desktop computers [9]. Smartphones exhibit distinct usage patterns and characteristics compared to printed material and computers. This disparity encompasses variations in viewing position, distance, and overall usage habits. As a result, smartphones are expected to have a distinctive impact on the visual system and ocular surface [10].

Recent international reports on ocular health shared that diplopia and dry eye diseases are prevalent ocular disorders caused by the overuse of smartphones in young adults. Increasing use of smart devices can also cause acute acquired comitant esotropia in adolescents [11]. As well previous studies disclosed that blue light rays emitted from smartphones adversely affected the corneal epithelial cells [12]. Previous animal studies evidenced that elevated levels of inflammatory biomarkers, production of Reactive Oxygen Species (ROS), and deterioration of ocular tear film were caused by overexposure to blue light emitted by smartphones [13]. Furthermore, various health problems such as eye dryness, strain, irritation, sore eyes, burning, headache, earache, fatigue, anxiety, lack of concentration, lack of sleep, and musculoskeletal manifestations were caused by the prolonged use of smartphones [5, 14-16].

The limited literature regarding the etiology of the reported ocular symptoms of smartphone usage worldwide/India leads to severe health crises among young adults [8]. To overcome this situation, we need more knowledge about smartphone usage with limited timings and precautions while using smartphones and to implement awareness programs for decreasing the impact of smartphone use. This study was designed to explore the ocular impact and SmartPhone Vision Syndrome (SPVS) among chronic smartphone users by evaluating tear volume assessment and tear film stability. Therefore, this study will improve our understanding of the prolonged use of smartphones and their impact on ocular health in young adults.

Material and Methods

Study setting

The analytical cross-sectional study was conducted in Vinayaka Mission's Kirupananda Variyar Medical College and Hospitals, Vinayaka Mission's Research Foundation (DU), Salem. The present study was approved by the Institutional Ethics Committee (IEC) of Vinayaka Mission's Kirupananda Variyar Medical College and Hospitals, Salem, India (VMKVMC&H/IEC/22/38). Informed consent was taken from all the study participants from the period of 2022 to 2023.

Study participants

One-hundred healthy volunteers above 18 years of age without any ocular diseases, or systemic ailments that could affect ocular conditions participated in this study. Two study groups were included a smartphone group with 50 volunteers and a control group with 50 volunteers based on the data collected from participants used the structured questionnaire. A control group was divided based on the criteria of smartphone and its type; the duration of smartphone usage was less than half an hour. The smartphone group was divided based on the criteria of smartphone and its type; the duration of smartphone usage was two hours per day.

Assessment of ocular status

Various ocular parameters were examined by the ophthalmologist. Visual acuity was measured by the electronic version of the Snellen chart. Intraocular Pressure (IOP) was measured by a non-contact Tonometer.

Assessment of tear volume and tear film stability

Tear volume assessment - Schirmer's test

A small paper strip with rulers printed was kept on inferior conjunctival fornices. The strips were removed after 5 minutes and the amount of tears produced in that time was measured by reading the length of wetting in millimeters (mm). Interpre-

tations < 10 mm of tear production in 5 minutes were suggestive of some form of dry eye. This test was done on the both right and left eye and was analyzed to check out the ocular defects in chronic usage of smartphones.

Tear film stability test - Fluorescein BUT (FBUT)

The tear break-up time test used fluorescein dye. The cornea was observed under the cobalt blue light and time was counted in seconds. The time of the last blink until a tear from the eye appears that was no longer covered with fluorescein-stained tears. The longer the BUT, the more stable the tear film. A BUT > 8-10 seconds was usually considered normal.

Smartphone Vision Syndrome Score (SVSS)

SVSS was analyzed in both groups. The ocular manifestations are noted and correlated with the duration of usage.

Statistical analysis

Data were collected and analyzed statistically. The comparison of both groups was done by student paired 't' test. The values of $p < 0.05$ and $p < 0.001$ were considered statistically significant.

Results

The study included 100 participants, divided into two groups: the control group and the smartphone group. In the control group, 56% were female and 44% were male. In the smartphone group, 68% were female and 32% were male. The average age of participants was 21.47 ± 1.2 years in the smartphone group and 26.87 ± 5.3 years in the control group. A comparison of both groups revealed that smartphone use per day and visual acuity differences were highly statistically significant ($p < 0.001$) (Table 1).

The preliminary data was collected using a structured questionnaire, with the details presented below. Approximately 45% of participants use smartphones for activities such as education, chatting, and watching videos, with an average usage duration of 2 to 3 hours per day (Figure 1).

The average smartphone screen exposure time per day was approximately 3 to 5 hours for 53% of the study participants (Figure 2). Additionally, 80% of participants reported that they generally maintain an interval between their eyes and the phone screen, although the duration of this interval varies among individuals. There was no statistical significance regarding the smartphone screen brightness of both groups. Only 7% of study participants used artificial tears while smartphone readings.

In this study, prolonged smartphone use was associated with various ocular problems, including redness, itching, lacrimation, visual disturbances, headaches, dryness of the eyes, and eye strain. The bar diagram illustrates that redness, itching, and visual disturbances are the most frequently reported symptoms, followed by lacrimation, headaches, dryness of the eyes, and eye strain. The blue bars represent the symptoms of redness, itching, and visual disturbances, which are highly and frequently associated with prolonged smartphone use. The brown bars indicate that eye strain, dryness of the eyes, and lacrimation are moderately associated symptoms. The grey bars show that headaches, dryness of the eyes, and eye strain are rarely reported. The orange bar denotes that none of the participants reported the symptoms listed (Figure 3).

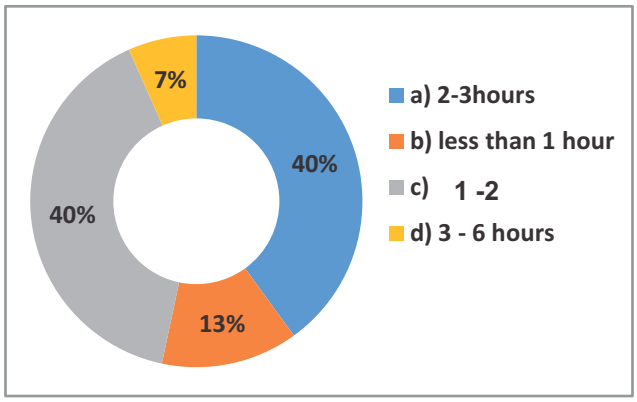

Figure 1: The duration of smartphone usage

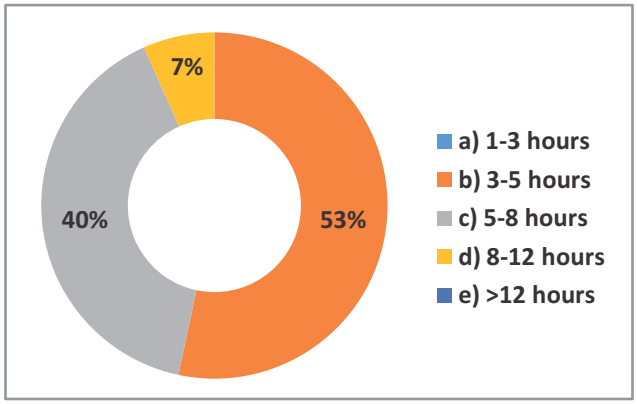

Figure 2: The average smartphone screen exposure time per day

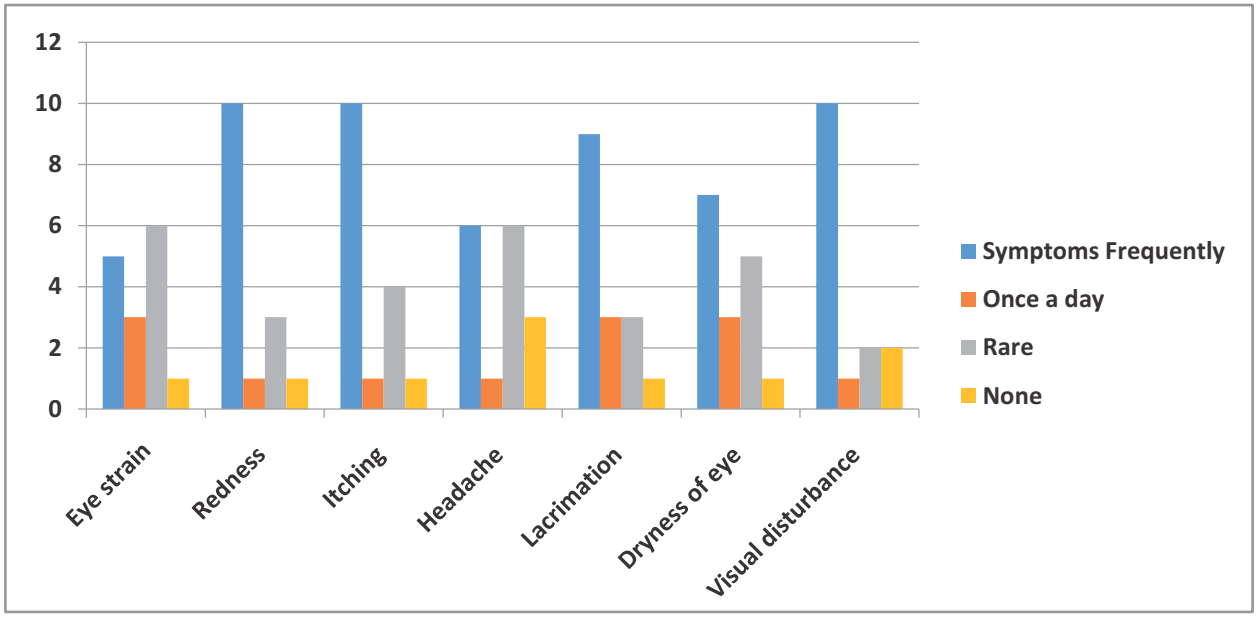

Figure 3: Associated ocular symptoms with the continuous use of a smartphone

In table 1, participants in the smartphone group spent an average of 2.18 hours per day using their smartphones. The visual acuity in the smartphone group was 0.83, compared to 0.45 in the control group. Additionally, about 53% of participants in the smartphone group used spectacles, while 34% of participants in the control group did. High statistical significance was found for age, visual acuity, and continuous smartphone use when comparing the two groups (** $p < 0.001$).

Intra-ocular Pressure (IOP) was measured in the study participants and compared between the right and left eyes at three intervals: baseline, after one hour, and after four hours. The IOP in the smartphone group increased with longer mobile phone usage, compared to the control group, and this difference was found to be statistically significant (** $p < 0.001$) (Table 2).

This study found that the tear breakup time, measured using the FBUT method, significantly increased ($p < 0.01$) with longer phone usage in the smartphone group. Tear volume was assessed using Schirmer's test, which measures tear production over five minutes. Results indicated that Schirmer's test result of less than 10 mm, suggestive of dry eye, was significantly reduced ($p < 0.01$) in the smartphone group as phone usage duration increased. Schirmer's test also revealed a greater level of eye dryness in the smartphone group compared to the control group (Table 3).

Table 4 showed SVSS scores analyzed using a standardized questionnaire with scores based on participants' responses. The analysis revealed a significant increase in fatigue, burning, and dryness of the eyes in the smartphone group ($p < 0.01$). However, no significant difference was observed between the two groups concerning dullness of the eyes and blurred vision (Table 4).

Table 1: Visual acuity and the use of spectacles

Parameters	Control group (N=50)	Smartphone group (N=50)
Age	26.87 ± 5.3	21.47 ± 1.2**
Sex (M/F)	28/22	34/16
Usage/day (hrs)	0.68 ± 0.34	2.18 ± 0.87**
Visual acuity	0.45 ± 0.32	0.83 ± 0.42**
Use of spectacles	34%	53%

The smartphone group showed significantly increased [** High statistical significance ($p < 0.001$)] parameters such as visual acuity, age, and smartphone use per day in hours. Sex ratio and spectacle usage while smartphone reading showed non-significance ($p > 0.050$).

Table 2: Intra-ocular Pressure (IOP)

IOP	Control group (N=50)	Smartphone group (N=50)		
	Baseline	Baseline	1h	4h
Right eye (mmHg)	16.41 ± 1.97	16.27 ± 1.94	20.84 ± 1.24	23.41 ± 1.68**
Left eye (mmHg)	16.07 ± 2.27	16.06 ± 2.16	20.63 ± 1.32	23.32 ± 1.13**

*** Highly Significant at p < 0.001. IOP between 11 and 21 mmHg are considered normal.*

Table 3: Tear film stability test and tear volume assessment

Parameters	Control group (N=50)	Smartphone group (N=50)		
	Baseline	Baseline	1h	4h
F BUT (s)	8.35 ± 2.30	9.76 ± 2.05	10.42 ± 1.74	12.06 ± 1.92*
Shirmer Test (mm)	13.85 ± 3.2	13.64 ± 2.85	9.58 ± 3.8	7.26 ± 3.21*

Both the parameters were performed to be statistically significant (significance at p < 0.01).*

Table 4: Smartphone Vision Syndrome Score (SVSS)

Parameters	Control group (N=50)	Smartphone group (N=50)		
	Baseline	Baseline	1h	4h
Fatigue	0.50 ± 0.51	0.52 ± 0.71	1.5 ± 0.92*	2.34 ± 1.3*
Burning	0.10 ± 0.31	0.14 ± 0.40	0.48 ± 0.7*	0.94 ± 1.3*
Dryness	0.73 ± 0.45	0.78 ± 0.99	1.56 ±1.2*	2.2 ± 1.5*
Blurred vision	0.23 ± 0.43	0.28 ± 0.69	0.40 ± 0.53#	0.38 ± 0.5#
Dullness	0.33 ± 0.48	0.36 ± 0.77	0.44 ± 0.61#	0.52 ± 0.7#

Significantly increased fatigue, burning, and dryness of the eye were observed in the smartphone group (significance at p < 0.01). # - Non-significant*

Discussion

As the use of smartphones becomes more extensive and cohesive in a daily activity. Continuous usage of smartphones leads to various ocular health problems become a serious issue nowadays. Recent literature revealed various adverse effects on ocular health due to prolonged smartphone usage [5, 8, 17-18]. This study also investigated the purpose, duration, mobile screen brightness, and screen exposure time per day. This study also showed how these mobile phone amenities affected visual acuity, IOP, tear film, and tear volume level between two groups of participants. Previous literature showed that the higher addiction rate of smartphones was twenties (teenage) when compared to the thirties and forties which was lesser [19]. This current study also showed that the teenage group (Average age - 21) was significantly affected and addicted to smartphones. Studies revealed that dry eye-like symptoms such as dryness, burning, and irritation are commonly observed while continuous usage of smart devices [20]. Similarly, the current study exposed that fatigue, burning, and dryness of the eye are the significantly associated symptoms of smartphone usage. Decreased visual acuity, increased Dry Eye Disease (DED), ocular fatigue, glare, and irritation are the profound symptoms of smartphones used with short watching distances [5]. Likewise, the participants of the smartphone group revealed significantly increased dryness, eye burning, and fatigue when compared to the control group.

An increased ocular surface exposure to the smartphone, incomplete eye closure, and decreased blink rate are the harmful factors due to prolonged smartphone use which may alter the tear film stability and homeostatic balance of the eye [21]. In the present study, ocular tear film stability was found to be increased and the homoeostatic balance was affected similar to the above study. Nowadays, the increased use of mobile phones and other visual aids in teaching and learning platforms is rapidly improving knowledge among young adults. However, the duration of use, intervals, and screen exposure time are crucial factors that significantly impact the ocular health of this age group [22-23]. A study by Choi *et al*. showed that chronic usage of smartphones altered the homeostatic balance of ocular surface system and tear stability which was associated with the decline of FBUT and NIKBUT [24]. The FBUT parameter of this study also displayed tearing instability. The cross-sectional study from Saudi Arabia exposed that prolonged use of smart aids leads to headaches [25]. Another study determined that mobile/ smartphones and their electromagnetic fields impact visual, hearing, and neurological systems [26]. Similarly, the preset study showed various visual disturbances with major notable symptoms such as headache, dryness of the eye, and eye strain. A study showed that headache, lack of concentration, lack of sleep, exhaustion, anxiety, irritability, eye strain, and fatigue are the main accompanied symptoms of chronic smartphone and computer usage. Among these symptoms, headache was the frequent and most occurred symptom which was present in half of the study participants, while other visual problems were in the fifth rank [27-30].

Limitations

The study was done in a small sample to check out the significance and impact along with the need for the study. Further, the study will be continued with more study participants from various centres and different age groups of people.

Conclusion

An adverse effect of tear film via the decreased rate of eye blinking, and incomplete closure of the eye was the impact of continuous smartphone use. The study also suggests the screen time limitation and usage of smartphones for young adults. The prevalence of eye diseases is high in all age groups therefore it is very essential to educate about the adverse effects of smartphone use. The management of ocular problems associated with excessive smartphone use should be further recommended.

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