Evaluation of Intraocular Pressure Changes after Smartphone Usage under Bright Light and Dim Light in Healthy Individuals

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***ABSTRACT*:**

Introduction: Excessive smartphone use is associated with various eye-related issues commonly referred to as Computer Vision Syndrome (CVS. The proposed mechanism for CVS is a sustained effort for accommodation and the accompanying ocular-surface-related changes such as dry eye while using electronic devices. Intraocular pressure (IOP) also shows temporary but significant fluctuations while using these devices.

Methodology: The study was approved by the institutional research and ethics committee. All emmetropic patients attending OPD at the ophthalmology department of tertiary care hospital, aged more than 18 years and ≤ 50 years were included in the study after taking written and informed consent. The participants were requested to conduct standardized work with a smartphone (i.e., either reading or watching videos) under bright light [1100-1300 LUX] and dim light [350-477 LUX] conditions. On each light setting, 5 sets of intraocular pressure(IOP) measurements were taken using a non-contact tonometer: (1) pre-work (baseline) (2) during smartphone work [5, 15, and 25 minutes], and (3) post-work [5 and 15 minutes].

Results: Under bright and dim light conditions, in both eyes the mean baseline IOP increased after the 25 minutes of smartphone work. In both bright light and dim light conditions, IOP returned to the baseline in both eyes at post-work 15 minutes, more rise in IOP was noted in dim light conditions. A greater number of younger individuals showed a rise in IOP when compared to the elderly. More females had raised IOP when compared to males.

Conclusions: In conclusion, using a smartphone while working can temporarily raise IOP in bright and dim light. In addition, there was more rise in IOP in the dim light. Smartphone users are advised to take a break if they use their device for reading or texting for longer than ten minutes. Further, they can avoid using their device in dim light areas whenever possible.

***Keywords*:** Non contact Tonometer, Glaucoma, Computer vision syndrome, Reading, Texting

INTRODUCTION

The popularity of smartphones has surged significantly since they were first introduced.[1] By 2020, the smartphone penetration rate in India had reached up to 54 percent, and it was estimated to reach about 96 percent by 2040.[1] The rate of smartphone usage in India has increased among the general population ranking the fourth highest worldwide. It was recently estimated more than 50% of smartphone users connect to the Internet for more than 30 minutes / more than 4 hours daily. Mobile device users are said to spend over 20 hours per week on tasks like email, texting, and social media, highlighting their strong dependence on smartphones for communication.

Excessive smartphone use is associated with various eye-related issues commonly called Computer Vision Syndrome (CVS). CVS includes eyestrain, ocular discomfort, dry eye, diplopia, and blurry vision, experienced by electronic-device users. The proposed mechanism for CVS is a sustained effort for accommodation and the accompanying ocular-surface-related changes such as dry eye while using electronic devices. Intraocular pressure (IOP) shows temporary but significant fluctuations while using these devices.[2]

The exact impact of smartphone use on IOP remains uncertain. Increased demands on accommodation and vergence when viewing small text on a small screen for extended periods, leads to higher IOP. At night, usage of smartphone might disrupt the natural circadian fluctuations in IOP, leading to increased levels.[3] We found very limited literature on changes in IOP on the use of smartphones. Hence with this background, the study was done to determine the effect of smartphone use on IOP, among healthy individuals.

AIMS & OBJECTIVES

To evaluate the effects of intraocular pressure changes after smartphone usage under bright light and dim light in healthy individuals.

MATERIALS AND METHODS

DATA COLLECTION METHOD:

A prospective observational study was carried out in the outpatient department of ophthalmology, Sri Manakula Vinayagar Medical College and Hospital (SMVMCH), Madagadipet, Kalitheerthalkuppam, Puducherry. Considering the mean IOP after 25 minutes of exposure to smartphone use in daylight and dim light among healthy individuals (15.3 ± 1.8 and 17 ± 1.7 mmHg Respectively) in a study by Ahnul ha et al.[4] The sample size for the present study was found to be 50 at 95% confidence interval and 95% power. Assuming a high nonresponse rate of 30% the sample size was increased to 65 which was rounded off to 70, after the approval from the institutional research and ethics committee(EC/85/2022). The data collection was done for a period of 18 months (September 2022- March 2024). Subjects were selected according to consecutive sampling methods for which inclusion and exclusion criteria were delineated. The inclusion criteria included emmetropic patients who are attending OPD of SMVMCH, age more than 18 years and ≤ 50 years, both male and female. Exclusion criteria included patients with anterior segment pathology (corneal opacities and dense cataracts), patients with glaucoma, previous ocular surgery, amblyopia, retinal pathologies, connective tissue disease, hypertension, and diabetes mellitus. Written and informed consent were obtained from participants and then they were enrolled in the study. Demographic details of the participants regarding name, age, and gender were obtained. A detailed history including the average duration of smartphone usage under bright light and dim light was noted.

All the patients underwent a complete ophthalmic examination at their first visit with standard methods. Best-corrected visual acuity (BCVA) was measured using a Snellen chart. A thorough slit-lamp examination was done to rule out corneal pathologies.

Testing Parameters:

IOP measurement was done using a non-contact tonometer (NCT). During all examinations average of three NCT readings was noted as true IOP. First baseline IOP was taken. After that participants were requested to conduct a standardized work (either reading or watching videos). All participants were asked to use the same mobile (Samsung Galaxy S8 screen size 84.8cm^2) of the same brightness (510 LUX) provided by the principal investigator. They were asked to do a standardized work in an upright sitting posture at a viewing distance of 30 cm, with a neck posture of 45 degrees. During the smartphone usage, participants were asked to continuously maintain the same distance and head posture.

Each participant underwent standardized work in two different room lighting conditions.

On each light setting (bright room and dim room light) 5 sets of readings were taken using NCT.

1 . Prework (Baseline IOP)

2 . During smartphone usage (5,15 and 25 minutes)

3 . Post work (5 & 15 minutes)

The total duration of smartphone usage was 25 minutes.

A. **First under bright room light** (1100-1300 LUX).

(a) IOP was measured at 5,15- and 25 minutes during smartphone usage under bright room light

(b) IOP was again measured post-standardized work at 5 & 15 minutes.

B. **The second examination was done under dim room light** (350-477 LUX).

For this patient were called 2 hours after the first examination or at their convenience. Again, baseline IOP was taken (average of three readings). They were asked to do standardized work in Dim room light (350-477 LUX).

(a) IOP was measured at 5,15- and 25 minutes during smartphone usage under dim room light.

(b) IOP was again measured post-standardized work at 5 & 15 minutes.

- Central corneal thickness was done (CCT) using pachymetry.
- Dilated fundus examination was done with a slit lamp biomicroscope using 90 dioptre lenses.

STATISTICAL ANALYSIS AND TEST APPLIED

Data obtained was entered in the software open Epi info version 7.2.1.0 and was analyzed by using SPSS software version 25.0. Description of categorical variables like age, gender, and average duration of smartphone usage in bright light and dim light was mentioned in frequency and percentage. CCT and IOP measurements in bright and dim light while using a smartphone was mentioned in mean and standard deviation.

The maximum mean change of IOP was defined as the difference between the maximum IOP during smartphone work (either at 15 or 25 minutes of work) and the pre-work IOP.

ΔIOP = Maximum IOP – Prework IOP / Prework IOP x 100

The Pearson coefficient was used to evaluate the IOP changes in bright and dim light in healthy individuals. A probability value (p-value) <0.05 was considered highly statistically significant.

We considered IOP to be increased at 25 minutes of work when the difference from baseline IOP was $\geq$2mmhg and we also noted eye, gender, and age category which had a greater number of participants with increased IOP in bright light and dim light conditions.

Results

A total of 70 participants were recruited for the present study. There were 36 males and 34 females Their mean age was 28.6 ± 4.4 (range: 18–50) years. More number of participants used smartphones in dim light for 1-2 hours. Similarly, a greater number of participants used smartphones in bright light for 2-3 hours [Table 1].

Table 1: Distribution of age, gender average smartphone usage in dim light and bright light

Variable	**Number of participants(%)**	
AGE		
18-26	28(40)	
27-34	12 (17.1)	
35-42	16(22.9)	
43-50	14(20)	
Gender		
Female	34 (48.6)	
Male	36 (51.4%)	
Usage of smartphone in hours	**Dim Light**	**Bright Light**
1-2 Hours	27(38.6%)	17(24.3%)
2-3 Hours	26(237.1%)	29(41.4%)
3-4 Hours	11(15.7%)	9(12.9%)
Above 4 Hours	6(8.6%)	15(21.4%)

We considered IOP to be increased at 25 minutes of work when the difference from baseline IOP was $\geq$2mmhg. We found that the highest number of participants with raised IOP was in the age group of 18 – 26 years in both light conditions. A higher number of females had higher IOP under dim light conditions whereas, a higher number of males had higher IOP in bright light conditions. The right eye showed a rise in IOP when compared to the left eye in both light conditions [Table 2].

Table 2: Showing study participants with the rise in IOP ≥2mmof Hg in bright and dim light according to gender, eye, and age

Variable	**Percentage**	
Gender	No of participants with rise in IOP≥2mm of Hg in Dim Light	No of participants with rise in IOP≥2mm of Hg in Bright Light
Male	21	19
Female	26	15
Eye		
Right eye	56	55
Left eye	50	54
Age in years		
18-26	21	16

27-34	7	8
35-42	10	10
43-50	9	6

IOP= Intraocular Pressure

The average of post-work IOP % showed a significant change from the average baseline IOP%(P<0.001)in the right eye under both light conditions [Table 3].

Table 3: Correlation of average postwork IOP % with an average of baseline IOP %

	Eye	Dim light		Bright light	
		Correlation Coefficient	P Value	Correlation Coefficient	P Value
Baseline IOP	Right eye	0.920**	0.001	0.942**	0.001
	Left eye	0.873**	0.004	0.910**	0.007

IOP= Intraocular Pressure

There was a change in IOP% in the right eye from prework 0 to 6.29 ± 2.25 at 5 minutes to 8.56 ±2.28 at 15 minutes, and to 15.89 ± 2.72 at 25 minutes. In the left eye, IOP% changed from prework 0 to 5.55 ± 2.16 at 5 minutes to 11.01 ± 2.22 at 15 minutes, and to 14.92 ± 3.08 at 25 minutes [Figure 1].

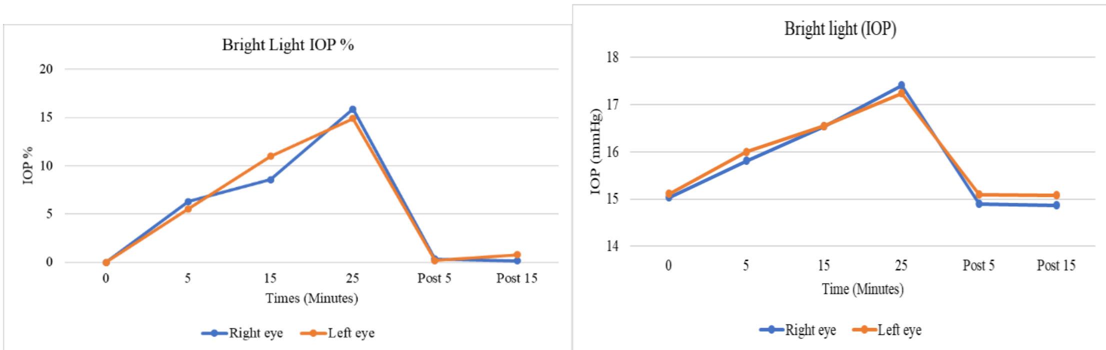

Figure 1: Intraocular pressure (IOP) changes of healthy participants in bright light for both eyes.

There was a change in IOP% in RE from prework 0 to 5.25 ± 2.09 at 5 minutes and to 13.41 ± 2.45 at 15 minutes, and 17.52 ± 2.24 at 25 minutes, whereas in LE IOP% changed from prework 0 to 3.89 ± 3.76 at 5 minutes and to 9.23 ± 3.57 at 15 minutes, and 15.66 ± 2.45 at 25 minutes [Figure 2].

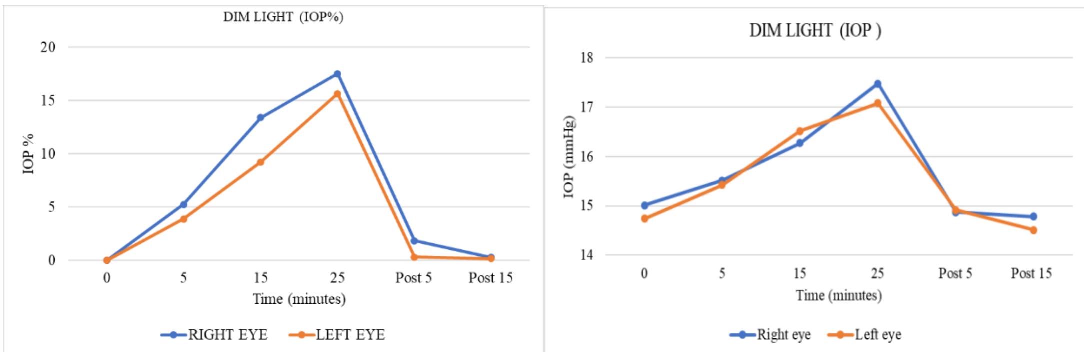

Figure 2: Intraocular pressure (IOP) changes of healthy participants in Dim light for both eyes

DISCUSSION:

The rate of smartphone usage in India has increased among the general population ranking the fourth highest worldwide. Intraocular pressure (IOP) shows temporary but significant fluctuations while using these devices. The current study showed that using a smartphone while working can temporarily raise IOP in both bright and dim light conditions. In the current study under dim light, IOP fluctuated more with a P value of 0.001 in the right eye and 0.004 in the left eye. Low ambient lighting causes more visual fatigue and reduces visual performance during screen work.[7] Structural changes in the eye and the high contrast between the smartphone screen and the environment in low light can contribute to increased IOP compared to bright light conditions. Whether or not these changes in IOP during smartphone use in normal subjects would increase the risk of glaucoma could not be determined.

IOP fluctuated more with a P value of 0.001 in the right eye and 0.004 in the left eye. A greater number of younger participants, aged 18 to 26 years, experienced a rise in IOP than older participants. Also, a greater number of females experienced a rise in IOP at 25 minutes compared to males. We also noted that IOP returned to normal levels after 15 minutes of smartphone usage. The underlying ocular dynamics for these IOP changes during and after smartphone work are unclear**.** The various mechanisms postulated for increase of IOP after smartphone usage: 1) Accommodation and convergence; 2) external ocular muscle (EOM) contraction; 3) psychophysiological stress; 4) dry eye; 5) neck-flexion posture.6) Low ambient illumination. Interestingly, changes in IOP during smartphone usage were more visible in low light**.**

A study by Ha A et al. found that, under the daylight condition, the mean baseline IOP was 13.7 ± 1.8 mmHg, and the mean IOP increased after 5 minutes of work (14.1 ± 1.8 mmHg; +2.0 ± 1.9%; $P < 0.001$). When the smartphone work lasted for 15 minutes, the IOP showed a further significant increase (15.5± 1.7 mmHg; +12.9 ± 4.4%; $P < 0.001$), which persisted over the course of the 25 minutes of smartphone work (15.3 ± 1.8 mmHg; +11.1 ± 3.9%; $P < 0.001$).[4] In the present study similar findings were observed under bright light conditions, in the right eye the mean baseline IOP was 15.04 ± 2.55 mmHg, and the mean IOP increased after 5 minutes of work (15.81 ± 2.49 mmHg; 6.29 ± 2.25%;). When the smartphone work lasted for 15 minutes, the IOP showed a further significant increase (16.54 ± 2.36 mmHg; 8.56±2.28%;), which persisted over the course of the 25 minutes of smartphone work (17.41 ± 2.306 mmHg; 15.89±2.72%). In left eye, the mean baseline IOP was 15.11 ± 2.32 mmHg, and the mean IOP increased after 5 minutes of work (16.00 ± 2.23 mmHg; 5.55 ± 2.16%). When the smartphone work lasted for 15 minutes, the IOP showed a further significant increase (16.55 ± 2.30 mmHg; 11.01 ± 2.22%), which persisted over the course of the 25 minutes of smartphone work (17.24 ± 2.12 mmHg; 14.92 ± 3.08%) **[Figure: 1].**

A study done by Ha A et al showed that under low light conditions, the mean IOP was significantly increased immediately after 5 minutes of smartphone work (from 13.9 ± 1.9 to 15.6 ± 1.8 mmHg; +12.1 ± 4.8%; $P < 0.001$); this IOP increase continued: 17.3 ± 1.9 [+24.7 ± 10.3%] at 15 minutes' work, and 17.0 ± 1.7 mmHg [+23.1 ± 9.5%] at 25 minutes' work ($P < 0.001$ at both check-out points).[4] In the present study similar findings were observed under dim light conditions, in the right eye the mean baseline IOP was 15.01 ± 2.23 mmHg, and the mean IOP increased after 5 minutes of work (15.51 ± 2.28 mmHg; 5.25 ± 2.09%). When the smartphone work lasted for 15 minutes, the IOP showed a further significant increase (16.27 ± 2.13 mmHg; 13.41 ± 2.45%), which persisted over the course of the 25 minutes of smartphone work (17.48 ± 2.05 mmHg; 17.52 ± 2.24%). In the left eye, the mean baseline IOP was 14.74 ± 2.51 mmHg, and the mean IOP increased after 5 minutes of work (15.42 ± 2.38 mmHg; 3.89 ± 3.76%). When the smartphone work lasted for 15 minutes, the IOP showed a further significant increase (16.52 ± 2.06 mmHg; 9.23 ± 3.57%), which persisted over the course of the 25 minutes of smartphone work (17.08 ± 2.131 mmHg; 15.66 ± 2.45%). **[Figure:2].**

Another study that observed the effect of reading for thirty minutes with a printed text and a smartphone on IOP in medically treated POAG patients and sixty healthy volunteers showed IOP rise during smartphone usage supporting the present study**.**[5]

A study done at Seoul National University Bundang also showed the time-dependent rise in IOP associated with smartphone use. The right eye's IOP rose from 16.77 ± 3. 25 mm Hg to 17.8 ± 2.76 mm Hg, and in the left eye from 16.75 ± 2.73 mmHg to 18.38± 2.96 mm Hg. They noted a small but significant increase in IOP on exposure to mobile phones on healthy subjects, which was similar to the present study.[6]

We noted the IOP changes in both eyes. We found right eye IOP fluctuations (p value<0.001 in both bright and dim light) were more significant than left eye (p value<0.004 in dim light; p value<0.007 in bright light [**Table 3**]. Under bright light conditions, 55 participants in the right eye and 54 in the left eye showed a rise in IOP≥2mm Hg. Under the dim light, 56 participants in the right eye and 50 in the left eye showed a rise in IOP≥2mm Hg [**Table 2**]. In contrast to the present study, Ha A et al observed the correlation of IOP with smartphone usage under daylight and low light conditions only in the right eye of their study participants. Another **s**tudy by Qudsiya SM et al on computer screen time showed 70% of cases, there was an increase in IOP in the left eye, and in 67% of cases, the right eye. The IOP discrepancies between the left and right eyes were attributed to either eye dominance or the direction of reading/writing script from left to right. Eye dominance refers to the preference of one eye over the other when performing tasks that require visual input, such as reading or aiming. The direction of the script could also play a role, as the dominant eye may experience more strain when reading from left to right.[2]

In all our participant's average post-work IOP under the bright light condition in the right eye was restored after stopping work for 5 minutes, (14.90 ± 2.23 mmHg; 0.34 ± 3.20%) and returned to the baseline at post-work 15 minutes (14.87 ± 2.37 mmHg; 0.15 ± 3.03%). In the left eye, after stopping work for 5 minutes, the IOP was restored (15.10 ± 2.39 mmHg; 0.17 ± 3.63%) and at post-work 15 minutes, the IOP returned to the baseline (15.08 ± 2.24 mmHg; 0.79 ± 2.23%) **[Figure: 1].** Average post-work IOP in dim light in the right eye was restored after stopping work for 5 minutes, (14.87 ± 2.22 mmHg; 1.83 ± 3.73%), and at post-work 15 minutes, the IOP returned to the baseline (14.78 ± 2.15 mmHg; 0.27 ± 3.59%). In the left eye, after stopping work for 5 minutes, the IOP was restored (14.91 ± 2.73 mmHg; 0.31 ± 3.38%) and at post-work 15 minutes, the IOP returned to the baseline (14.51 ± 2.17 mmHg; 0.17 ± 2.28%) **[Figure: 2].** Supporting the findings of the present study, an Indian study by Srivastava RM et al noted IOP returned to normal levels after 20 minutes of computer work or reading text.[5]

However, previous reports have shown, that short-term increases in IOP play an important role in the progression of the disease in glaucoma patients.[8,9] In particular, in normal tension glaucoma patients with relatively low baseline and follow-up IOP levels**,** increased IOP fluctuations appear to play a greater role in glaucoma progression.[9,10] However we had all the healthy participants in our study, hence this aspect was not studied in the current study.

We strictly followed a standard protocol for working with smartphones for all our study participants. All participants were asked to use the same mobile (Samsung Galaxy S8 screen size 84.8cm^2) with the same brightness (510 LUX) provided by the principal investigator. They were asked to do a standardized work in an upright sitting posture at a viewing distance of 30 cm, with a neck posture of 45 degrees. During the smartphone usage, participants were asked to continuously maintain the same distance, sitting posture, and neck flexion. In this study, both eyes were evaluated at the same time and compared. All IOP readings were taken by the same investigator and were taken using single-instrument non-contact tonometry (multiple readings are taken using non-contact tonometry). Furthermore, we found very few studies related to IOP fluctuations with smartphone usage under different illumination.

In the current study, we did not consider standard font size, style, background, and text colors which might have impacted our IOP readings. Secondly, there was a time constraint on the study protocol's execution. Longer periods of smartphone use, such as when watching movies or playing games, can result in IOP elevation. Therefore, more studies with larger-scale patient cohorts and varied experimental setups should be anticipated to gather more comprehensive data on the connection between smartphone usage and IOP. Third, even though the subjects were closely monitored by the examiner the entire time to make sure, they were focused on their work, it's possible that their concentration might deteriorated. Fourth, every participant in the current study was of South Indian origin. Furthermore, we included only healthy individuals in our study. Future research on other ethnic groups and participants with primary open-angle glaucoma, normal tension glaucoma, and refractive errors may be required to get in-depth literature on this subject.

CONCLUSIONS:

In conclusion, using a smartphone while working can temporarily raise IOP in both bright and dim light. In addition, there was more rise in IOP under dim light condition. A greater number of younger individuals showed a rise in IOP when compared to the elderly. More females had raised IOP when compared to males. Through this study, we insist that smartphone users take a break if they use their device for reading or texting for longer than ten minutes. Further, they are advised to avoid using their device in dim light areas whenever possible.

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