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IMPACT OF SMARTPHONE USE ON INTRAOCULAR PRESSURE: A COMPARATIVE STUDY OF DARK AND BRIGHT ROOM CONDITIONS IN HEALTHY YOUNG ADULTS: A CROSS-SECTIONAL STUDY

Original Research

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ABSTRACT

Background: Intraocular pressure (IOP) is a critical determinant in the development and progression of glaucoma. Emerging evidence suggests that prolonged smartphone use, particularly involving sustained near-vision tasks, may induce transient elevations in IOP. However, the influence of ambient lighting conditions during smartphone use on IOP changes remains insufficiently explored, especially among healthy young adults who represent a high smartphone-using population.

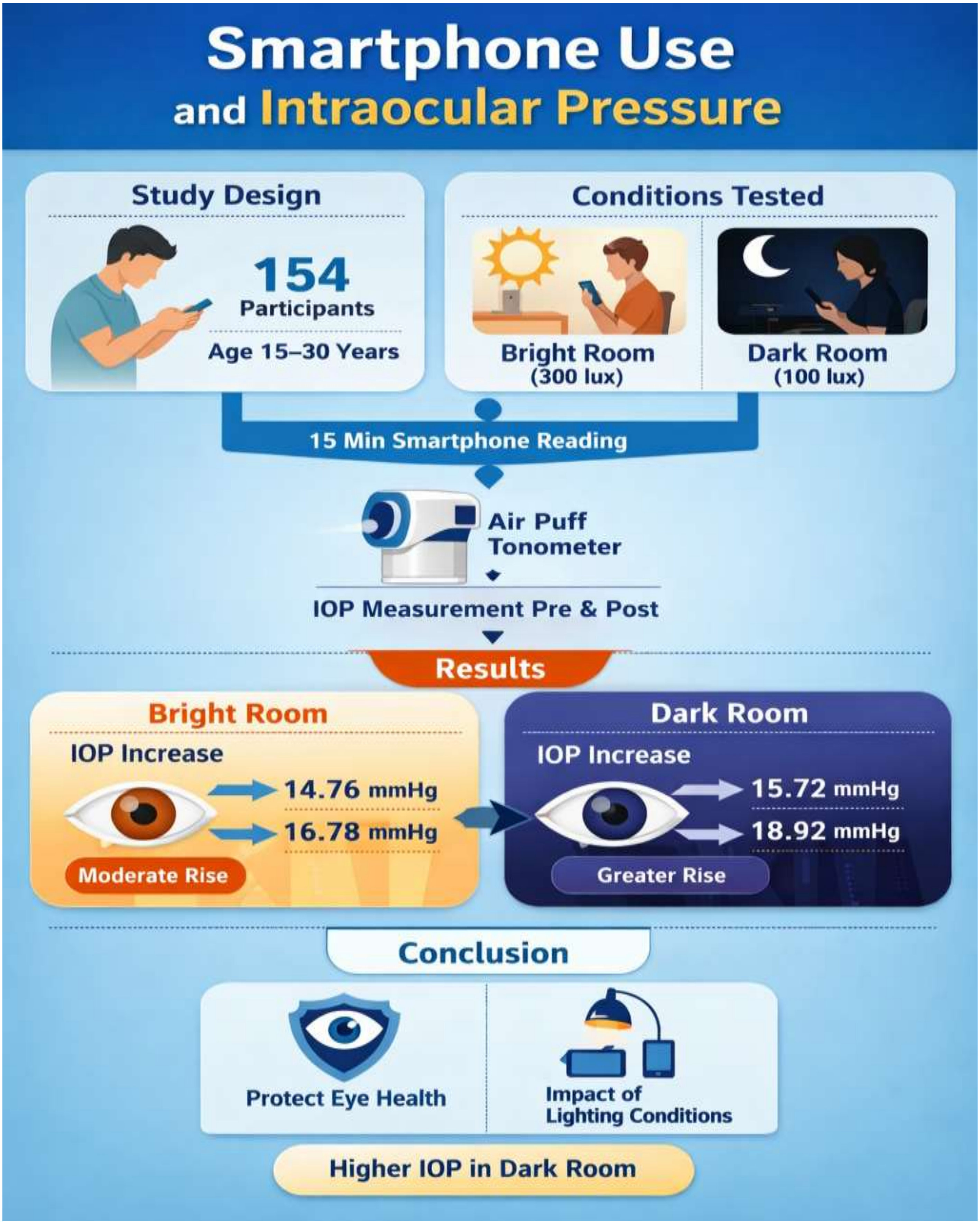
Objective: To assess the effect of smartphone use on intraocular pressure under bright and dark room lighting conditions in healthy young adults.

Methods: A comparative cross-sectional study was conducted involving 154 healthy participants aged 15–30 years. Baseline IOP was measured using a non-contact air puff tonometer under standardized bright (300 lux) and dark (100 lux) room conditions. Participants then performed a continuous smartphone reading task for 15 minutes, after which IOP was re-measured in the same lighting environment. Each participant underwent assessments in both lighting conditions with a washout interval. Data were analyzed using SPSS version 27. Paired t-tests were applied to compare pre- and post-reading IOP within each lighting condition, while comparative analysis between bright and dark room post-reading IOP values was performed. Statistical significance was set at $p < 0.05$.

Results: A statistically significant increase in IOP was observed following smartphone use in both lighting conditions ($p < 0.001$). In the bright room, mean IOP increased from 14.76 ± 2.54 mmHg before reading to 16.78 ± 2.47 mmHg after reading. In the dark room, mean IOP rose from 15.72 ± 2.66 mmHg to 18.92 ± 2.51 mmHg following smartphone use. The post-reading IOP was significantly higher in the dark room compared to the bright room, indicating a greater magnitude of IOP elevation under low-light conditions.

Conclusion: Smartphone use resulted in a significant short-term increase in intraocular pressure in healthy young adults, with dark room conditions producing a more pronounced effect than bright environments. These findings highlight ambient lighting as an important modifiable factor during smartphone use and emphasize the need for preventive strategies and further research on long-term ocular health implications, particularly for individuals at risk of glaucoma.

Keywords: Air Puff Tonometry, Intraocular Pressure, Lighting, Mobile Phones, Near Vision, Young Adults.


Smartphone Use
and Intraocular Pressure
Study Design
154
Participants
Age 15–30 Years
Conditions Tested
Bright Room
(300 lux)
Dark Room
(100 lux)
15 Min Smartphone Reading
Air Puff
Tonometer
IOP Measurement Pre & Post
Results
Bright Room
IOP Increase
14.76 mmHg
16.78 mmHg
Moderate Rise
Dark Room
IOP Increase
15.72 mmHg
18.92 mmHg
Greater Rise
Conclusion
Protect Eye Health
Impact of
Lighting Conditions
Higher IOP in Dark Room

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INTRODUCTION

Intraocular pressure (IOP) refers to the fluid pressure within the eye and is primarily regulated by the balance between production and drainage of aqueous humor (1). This delicate equilibrium is essential for maintaining the structural integrity of the globe and normal visual function. Persistent disruption of IOP homeostasis is widely recognized as the most significant modifiable risk factor for glaucoma, a heterogeneous group of optic neuropathies characterized by progressive retinal ganglion cell loss and irreversible blindness if left untreated (2). Under physiological conditions, IOP typically ranges between 10 and 21 mmHg, and deviations beyond this range may predispose individuals to ocular hypertension or glaucomatous damage (1). As a result, accurate measurement of IOP—commonly performed using non-contact methods such as air-puff tonometry—remains a cornerstone in ophthalmic screening and clinical practice (3). Elevated IOP is often asymptomatic, particularly in early stages, making routine monitoring crucial for individuals at risk of glaucoma. In parallel with this clinical concern, modern lifestyles have undergone a profound transformation with the widespread adoption of digital devices, especially smartphones (4). Smartphone use involves sustained near-vision tasks requiring continuous accommodation, convergence, and attentional engagement, all of which may transiently influence ocular physiology, including IOP regulation (5). Given that smartphones are now deeply embedded in daily life for communication, education, work, and entertainment, users frequently spend prolonged hours engaging with these devices (6).

Epidemiological surveys indicate that smartphone penetration exceeds 80% among adults in developed countries, with a substantial proportion of users spending several hours daily on their devices. While smartphones offer undeniable convenience, extended screen exposure has been associated with a spectrum of visual complaints such as eyestrain, dryness, blurred vision, and headaches—collectively described as Computer Vision Syndrome (CVS) (7,8). These symptoms reflect the increasing visual demand placed on the accommodative system and ocular surface during sustained digital tasks. Consequently, concerns have emerged regarding not only subjective discomfort but also subtle physiological changes that may occur with habitual smartphone use (9). Despite growing awareness of digital eye strain, the relationship between smartphone use and IOP remains incompletely understood, particularly when environmental factors are considered. Lighting conditions represent a critical yet often overlooked variable influencing ocular dynamics. Ambient illumination modulates pupil size and accommodative effort, both of which are closely linked to aqueous humor outflow and IOP regulation (10–12). Bright lighting induces pupillary constriction and reduces accommodative load, whereas dim lighting promotes pupil dilation and sustained accommodation, potentially impeding aqueous humor drainage (13,14). Experimental and clinical observations suggest that darker environments may be associated with transient elevations in IOP, while brighter conditions may facilitate parasympathetic activity and lower IOP (15,16).

Several studies have explored IOP changes during smartphone use, reporting short-term elevations associated with near-vision activities, particularly among individuals with myopia or glaucoma (17,18). Notably, a study demonstrated that smartphone gaming resulted in increased IOP under both bright and dark conditions, with a more pronounced rise in low-light environments (17). Similarly, another study reported greater IOP elevation during smartphone-based reading compared with printed text, especially under dim illumination (16). Although these findings underscore the potential interaction between digital device use and lighting, direct comparative evidence focusing specifically on dark versus bright room conditions remains limited. This knowledge gap is particularly relevant for young adults, a population with high smartphone dependency yet relatively low baseline risk for glaucoma. Studying this group allows isolation of smartphone- and environment-related effects on IOP without substantial confounding from age-related ocular pathology or systemic comorbidities (19–21). Understanding how modifiable environmental factors such as lighting influence IOP during smartphone use may therefore have important implications for preventive eye care and public health guidance. Accordingly, the objective of the present study is to evaluate the effect of smartphone use on intraocular pressure under bright and dark room lighting conditions in healthy young adults by comparing pre- and post-use IOP measurements, with the aim of clarifying whether ambient illumination significantly modulates IOP changes during smartphone exposure.

METHODS

A comparative cross-sectional study design was employed to evaluate the effects of smartphone use on intraocular pressure (IOP) under bright and dark room lighting conditions. The study was conducted at two tertiary care medical centers, Layton Rahmatullah Benevolent Trust (LRBT) Eye Hospital and Sehat Medical Complex. A total of 144 participants aged between 15 and 30 years were recruited using non-probability convenience sampling. This age group was selected to minimize confounding from age-related ocular or systemic conditions and to reflect a population with high smartphone usage. Eligibility criteria included normal baseline IOP ranging from 10 to

21 mmHg, absence of refractive errors, no prior history of ocular disease, ocular surgery, or trauma, and no systemic illnesses or medication use known to influence IOP. Individuals who did not meet these criteria were excluded from the study. Ethical approval for the study was obtained from the relevant institutional ethics review committee of the participating centers. All participants were thoroughly informed about the study objectives, procedures, and potential risks prior to enrollment. Written informed consent was obtained from each participant, and for participants below 18 years of age, assent was obtained along with consent from a parent or legal guardian, in accordance with ethical research standards.

Baseline IOP measurements were recorded for all participants under two standardized ambient lighting conditions: a bright room and a dark room. Ambient illumination was controlled using a lux meter, with the bright room maintained at approximately 300 lux and the dark room at approximately 100 lux. Intraocular pressure was measured using a non-contact air-puff tonometer, with measurements taken in a seated position after a brief rest period to minimize physiological fluctuations. Following baseline assessment, participants were instructed to perform a continuous reading task on a smartphone for 15 minutes. Smartphone screen brightness was adjusted to correspond with the ambient lighting conditions, with higher brightness in the bright room and lower brightness in the dark room to simulate real-world usage. Immediately after completion of the reading task, post-exposure IOP measurements were obtained under the same lighting conditions. Each participant underwent both lighting conditions in a crossover manner, with a 30-minute washout interval between sessions to allow IOP to return to baseline levels and to reduce carryover effects. The order of exposure to bright and dark room conditions was kept consistent to maintain procedural uniformity. Data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) version 27. Descriptive statistics were calculated for demographic variables and IOP measurements. Paired t-tests were applied to compare pre- and post-smartphone use IOP values within each lighting condition. Differences in the magnitude of IOP change between bright and dark room conditions were analyzed using inferential statistical testing, with statistical significance set at a p-value of less than 0.05.

RESULTS

A total of 154 participants aged between 15 and 30 years were included in the final analysis. The majority of participants belonged to the 23–26-year age group (51.3%), followed by those aged 19–22 years (26.0%), while smaller proportions were observed in the 27–30-year (18.2%) and 15–18-year (4.5%) age categories. Females constituted 60.4% of the study population, whereas males accounted for 39.6%. Most participants were students (81.2%), with smaller proportions engaged in employment (10.4%), household responsibilities (5.8%), or business activities (2.6%), reflecting a predominantly young, academically active cohort. Baseline intraocular pressure measurements were within the normal physiological range in both lighting conditions. In the bright room setting, the mean pre-reading IOP was 14.76 ± 2.54 mmHg. Following 15 minutes of smartphone reading, the mean IOP increased to 16.78 ± 2.47 mmHg, demonstrating a statistically significant rise ($p = 0.001$). This finding indicated a clear elevation in IOP associated with short-term smartphone use under bright ambient lighting. A similar but more pronounced pattern was observed under dark room conditions. The mean pre-reading IOP in the dark room was 15.72 ± 2.66 mmHg, which increased substantially to 18.92 ± 2.51 mmHg after the reading task. This change was also statistically significant ($p = 0.001$) and reflected a greater magnitude of IOP elevation compared with the bright room environment. The absolute increase in IOP in dark conditions exceeded that observed under bright lighting, suggesting a differential effect of ambient illumination on IOP response during smartphone use. Direct comparison of post-reading IOP values between lighting conditions revealed a significant difference. The mean post-reading IOP was higher in the dark room (18.92 ± 2.51 mmHg) than in the bright room (16.78 ± 2.47 mmHg), with a mean difference of −2.14 mmHg that reached statistical significance ($p = 0.001$). This result confirmed that dark room conditions were associated with a greater elevation in IOP following smartphone reading compared with bright room conditions. Overall, the findings demonstrated that short-term smartphone reading resulted in a significant increase in intraocular pressure in healthy young adults, with the magnitude of change being substantially higher in low-light environments.

Table 1: Distribution of Data According to Age

	Frequency	Percentage
15-18	7	4.5%
19-22	40	26.0%
23-26	79	51.3%
27-30	28	18.2%
Total	154	100%

Table 2: Distribution of Data According to Gender

	Frequency	Percentage
Male	61	39.6%
Female	93	60.4%
Total	154	100%

Table 3: Distribution of Data According to Occupation

	Frequency	Percentage
Student	125	81.2%
Job	16	10.4%
Businessman	4	2.6%
Housewife	9	5.8%
Total	154	100%

Table 4: Assessment of Pre-IOP and Post-IOP in a Bright Room After Reading on a Smartphone

	Total Number	Mean ± Std. Deviation	P-Value
Bright Room Pre-IOP	154	14.76 ± 2.54	0.001
Bright Room Post-IOP	154	16.78 ± 2.47	

Table 5: Assessment of Pre-IOP and Post-IOP in a Dark Room After Reading on a Smartphone

	Total Number	Mean ± Std. Deviation	P-value
Dark Room Pre-IOP	154	15.72 ± 2.66	0.001
Dark Room Post-IOP	154	18.92 ± 2.51	

Table 6: Assessment of the Difference in IOP Between Bright and Dark Room After Reading on a Smartphone

	Total Number	Mean ± Std. Deviation	Mean Difference	P-value
Bright Room Post-IOP	154	16.78 ± 2.47	-2.14	0.001
Dark Room Post-IOP	154	18.92 ± 2.51	-2.14	

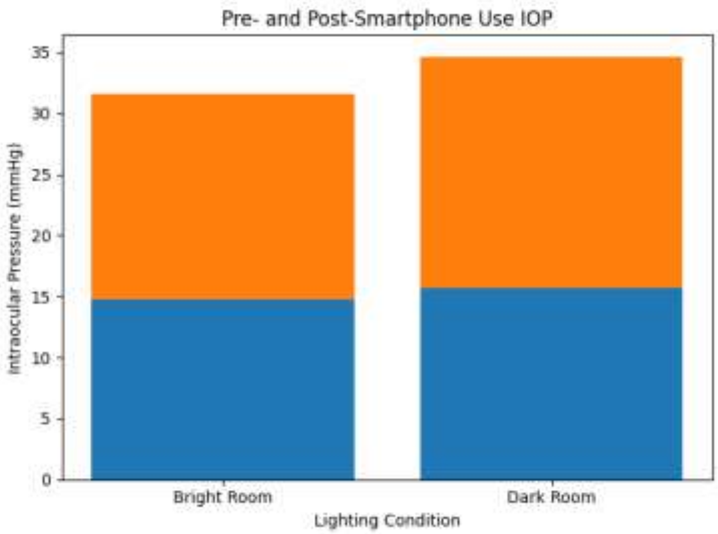

Figure 2 pre-and post-Smartphone use IOP

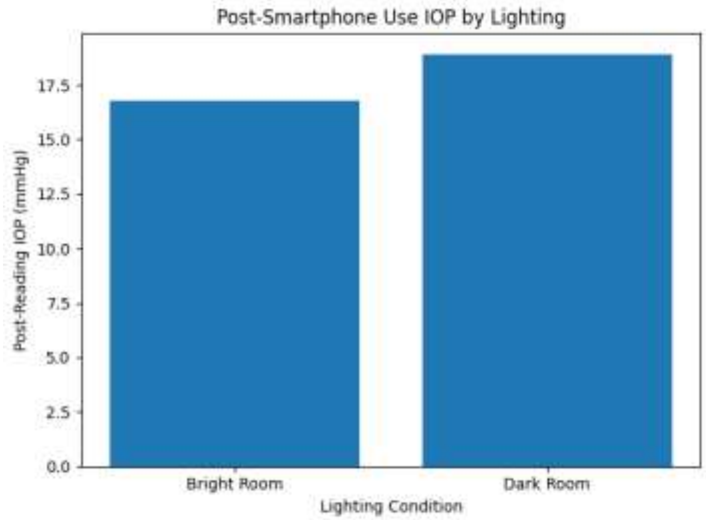

Figure 2 post-Smartphone use IOP by Lighting

DISCUSSION

The present study examined the effect of smartphone use on intraocular pressure (IOP) under bright and dark room conditions in healthy young individuals and demonstrated a significant rise in IOP following short-term smartphone reading in both environments. Importantly, the magnitude of IOP elevation was greater in the dark room than in the bright room, indicating that ambient lighting plays a meaningful role in modulating IOP responses during near-vision digital tasks. These findings align with existing evidence suggesting that smartphone use is associated with transient increases in IOP, while extending current knowledge by highlighting lighting conditions as an influential environmental factor (15,16). Previous investigations have consistently reported short-term elevations in IOP during smartphone use or prolonged near-work activities. However, most earlier studies primarily focused on screen time duration or type of visual task, with limited emphasis on ambient illumination. The present findings support and expand these observations by demonstrating that low-light environments amplify IOP changes induced by smartphone use. This suggests that digital device–related ocular stress is not solely dependent on accommodative demand but is also influenced by surrounding visual conditions, an aspect that has received comparatively little attention in earlier research (16). The physiological basis for the observed IOP changes is likely multifactorial. Near-vision tasks such as smartphone reading require sustained accommodation, which increases ciliary muscle contraction and may transiently elevate IOP (17). In dark environments, pupil dilation further compounds this effect by reducing the efficiency of aqueous humor outflow through the trabecular meshwork, thereby contributing to higher IOP levels (18). Conversely, bright lighting induces pupillary constriction and may facilitate aqueous humor drainage, partially mitigating IOP elevation (19). Additionally, convergence associated with prolonged near viewing increases extraocular muscle activity, which may further influence IOP fluctuations, particularly under conditions of pupil dilation and heightened accommodative effort (5). The combined impact of these mechanisms likely explains the greater IOP rise observed in dark room conditions. From a clinical and public health perspective, the findings carry potential implications for ocular health and glaucoma risk. Although the IOP elevations observed were short term and occurred in young, healthy individuals, repeated or prolonged exposure to conditions that elevate IOP may contribute to ocular hypertension over time, particularly in individuals with predisposing risk factors (20,21). Given that smartphone use is often prolonged during nighttime or in low-light settings, the results underscore the importance of appropriate lighting during digital device use. Awareness of these modifiable behavioral and environmental factors may help reduce cumulative ocular stress and support long-term eye health (22).

The study possessed several strengths, including a controlled comparison of bright and dark room conditions, standardized measurement of IOP before and after smartphone use, and a relatively large sample of young adults with minimal confounding ocular or systemic conditions. These factors strengthened the internal validity of the findings and allowed clearer attribution of IOP changes to smartphone use and lighting conditions. Nevertheless, certain limitations should be acknowledged. The cross-sectional design limited the ability to assess long-term effects of repeated smartphone exposure on IOP and glaucoma risk. The study population consisted predominantly of students, which may restrict generalizability to other age groups or occupational settings. In addition, the use of a non-contact air-puff tonometer, while practical and non-invasive, may have introduced measurement variability compared with gold-standard applanation techniques. Other potentially relevant factors, such as posture during smartphone use, screen font size, viewing distance, and duration beyond 15 minutes, were not assessed and may influence IOP responses (23). Future research would benefit from longitudinal designs to evaluate whether repeated short-term IOP elevations translate into sustained ocular hypertension or structural optic nerve changes. Inclusion of diverse age groups, individuals with refractive errors or glaucoma risk factors, and the use of multiple tonometry techniques could further enhance understanding. Examination of additional variables such as posture, blink rate, and accommodative amplitude may also provide a more comprehensive view of digital device–related IOP dynamics. Overall, the findings suggest that smartphone use induces measurable increases in intraocular pressure, with dark room conditions exerting a greater effect than bright environments. These results reinforce the importance of considering ambient lighting as a modifiable factor during smartphone use and contribute meaningful insight into the interaction between modern digital habits and ocular physiology.

CONCLUSION

This study concluded that smartphone use leads to a measurable increase in intraocular pressure under both bright and dark room conditions, with a more pronounced effect observed in low-light environments. By directly comparing lighting conditions, the findings highlighted the important role of ambient illumination in modulating IOP changes during smartphone use, likely through mechanisms involving increased accommodation and pupil dilation in darker settings. While the observed IOP elevation was transient in healthy young individuals, the results carry meaningful implications for ocular health, particularly for individuals at risk of ocular hypertension or glaucoma. The study underscores the importance of adopting safe smartphone habits, such as using devices in adequately lit environments, to minimize avoidable ocular stress. Overall, this research contributes valuable evidence to understanding how everyday digital behaviors interact with environmental factors to influence eye physiology and supports the need for greater awareness and further investigation into the long-term ocular effects of smartphone use.

AUTHOR CONTRIBUTIONS

Author	Contribution
Sonia Shahid	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Maria Arshad	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Usama Elahi	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Eman Arooj	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Shah Fahad	Contributed to Data Collection and Analysis

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Sadia	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Sidra Sattar*	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Ushma	Writing - Review & Editing, Assistance with Data Curation

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