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EFFECT OF SMARTPHONE USAGE ON REFRACTIVE ERRORS AND OCULAR HEALTH IN TEENAGERS

Original Research

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ABSTRACT

Background: The widespread adoption of smartphones has transformed communication and entertainment, particularly among teenagers. However, prolonged smartphone use has been associated with adverse effects on ocular health, including myopia and symptoms of Computer Vision Syndrome (CVS). As teenagers' visual systems are still developing, they are more susceptible to refractive errors and eye fatigue due to extended screen exposure. This study aimed to investigate the relationship between smartphone usage patterns, refractive errors, and ocular symptoms in teenagers.

Objective: The study aimed to assess the impact of smartphone usage on refractive errors and ocular symptoms, focusing on the association between screen time duration and the prevalence of myopia and CVS-related symptoms in teenagers.

Methods: This observational, cross-sectional study included 200 participants aged 13–18 years. Smartphone usage was categorized as shorter use (<2 hours/day), intermediate use (2 hours/day), and excessive use (>2 hours/day). Continuous use was defined as screen time without breaks for 20 minutes or more. Data were collected using a structured questionnaire, including information on smartphone habits, refractive errors (myopia, hyperopia, astigmatism), and ocular symptoms (headache, eye strain, redness, and inflammation). Comprehensive eye examinations, including visual acuity and refraction tests, were performed. Statistical analysis was used to determine the associations between smartphone usage patterns and ocular health outcomes ($P \leq 0.05$).

Results: Excessive smartphone users showed a higher prevalence of myopia (54 cases) compared to shorter users (5 cases). Headaches (51 cases), eye strain (50 cases), redness (16 cases), and inflammation (15 cases) were significantly more frequent in excessive users compared to shorter users ($P \leq 0.001$). A significant association was observed between continuous smartphone use and multiple ocular symptoms, with 72% of continuous users reporting headaches and 70% experiencing eye strain ($P \leq 0.01$).

Conclusion: Excessive smartphone use is strongly associated with myopia progression and CVS symptoms in teenagers. The findings emphasize the need for preventive measures, including healthy screen habits, early screening for refractive errors, and regular visual breaks, to safeguard ocular health in this vulnerable population.

Keywords: adolescents, blue light, computer vision syndrome, eye strain, myopia, ocular health, smartphone usage

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INTRODUCTION

The widespread adoption of smartphones has fundamentally reshaped the ways in which modern society communicates, accesses information, and engages in recreational activities. Among teenagers, this technological evolution has brought profound changes in daily habits and lifestyle patterns. However, these advancements come with growing concerns regarding the potential negative impact on their health, particularly ocular health. The adolescent population, characterized by ongoing physiological development, is particularly vulnerable to environmental factors that may influence visual and ocular outcomes. Increasing evidence suggests a strong link between extensive smartphone usage and the prevalence of refractive errors, including myopia (nearsightedness) and hyperopia (farsightedness), as well as broader ocular health issues. These associations are especially concerning given projections that nearly half of the global population may be myopic by 2050, with approximately 10% experiencing high myopia associated with severe visual impairment (1). This alarming trend highlights the urgency of understanding contributing factors, such as prolonged and unregulated smartphone usage. Teenagers often engage with smartphones for extended periods, relying on them for both academic and recreational purposes, making their developing visual systems susceptible to various adverse effects. One significant concern is digital eye strain (DES), which manifests as a combination of symptoms such as eye fatigue, dryness, blurred vision, and headaches. These symptoms result from sustained screen exposure, particularly when combined with inadequate exposure to natural light or infrequent breaks. Research suggests that up to 60% of teenagers with habitual smartphone use experience DES symptoms (2). The visual strain induced by the close distance at which smartphones are typically held amplifies the load on the ciliary muscles, which are responsible for near focusing. Prolonged accommodation at such close distances may lead to accommodative fatigue, potentially contributing to myopia progression (3).

Additionally, the blue light emitted by smartphone screens raises concerns about potential retinal damage and sleep disruptions. Blue light has been implicated in cellular damage to the retina and interference with circadian rhythms, negatively affecting sleep quality. Poor sleep, in turn, exacerbates the risk of ocular health deterioration by impairing the body's ability to repair and maintain tissues, including those in the eyes (4). These issues are compounded by the addictive nature of smartphones, particularly social media platforms, which promote compulsive usage through reward mechanisms such as notifications and likes. Studies indicate that teenagers spend an average of five to seven hours daily on social media, often prioritizing screen time over educational or outdoor activities. This habitual overuse has been linked to academic challenges, decreased motivation, and psychological stress, which indirectly affect ocular health (5). Epidemiological studies further substantiate the association between smartphone usage and myopia progression. Both cross-sectional and longitudinal studies highlight that teenager engaging in extensive screen time experience faster rates of myopia development compared to their peers with lower screen exposure (8). The closer proximity at which smartphones are used, compared to other digital devices, imposes an additional burden on the visual system, intensifying the risk of myopia. Dry eye disease, another prevalent condition linked to excessive smartphone use, has been reported to affect the ocular surface and tear film stability, leading to discomfort and reduced visual acuity. These findings emphasize the multidimensional impact of smartphone usage on teenagers' eye health (12, 13).

Beyond the physical implications, psychological factors such as stress and anxiety, exacerbated by smartphone addiction, further influence ocular health. Stress is known to worsen symptoms of dry eye and visual discomfort, creating a cyclical pattern of overuse and health deterioration. Studies suggest that female teenagers may be disproportionately affected, reporting higher levels of smartphone usage, particularly for social media engagement, which correlates with diminished academic performance and mental well-being (16, 17). These findings highlight the intertwined nature of psychological, behavioral, and physiological factors in the context of smartphone use. Given the increasing prevalence of screen-related visual challenges, it becomes critical to explore preventive strategies. Educational interventions promoting regulated screen use, frequent breaks, and engagement in outdoor activities could mitigate risks associated with smartphone overuse. Technological solutions such as blue light filters and proper screen positioning may alleviate visual strain, while regular eye examinations can facilitate early detection and management of refractive errors and other conditions. Despite these mitigation strategies, there remains a need for comprehensive understanding and evidence-based guidance to address this growing public health concern. This study aims to investigate the relationship between smartphone usage and its impact on refractive errors and overall ocular health in teenagers, a population particularly vulnerable to these risks. By analyzing patterns of smartphone use and their associated visual health outcomes, the objective is to provide actionable insights that can inform preventive measures and promote healthier habits in adolescents.

METHODS

The study employed an observational, cross-sectional design conducted over a duration of three months to investigate the impact of smartphone usage on ocular health. Participants were recruited from Lahore, ensuring a representative sample for the targeted population. The primary objective of the study was to examine the association between smartphone usage patterns and symptoms of Computer Vision Syndrome (CVS) through the use of a structured questionnaire and basic eye examinations. Ethical approval was

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obtained from the institutional review board, and informed consent was secured from all participants prior to their inclusion in the study. The study population comprised a total of 200 participants, of whom 130 were male and 70 were female. Participants were carefully selected based on predefined inclusion criteria, while individuals who did not meet these criteria were excluded from the study. The inclusion criteria and demographic characteristics of the participants were structured to ensure the reliability and validity of the data collected. It is worth noting that the exclusion criteria or any specific characteristics leading to the exclusion of participants were not explicitly detailed in the description, which may limit replicability or understanding of the participant selection process.

Data collection involved the administration of an adapted Computer Vision Syndrome Questionnaire (CVS-Q), a validated instrument tailored to assess symptoms associated with prolonged screen use. The questionnaire was further modified to address study-specific objectives, incorporating questions on smartphone ownership, duration of ownership, and average daily usage categorized into ≤1 hour, 2 hours, 3 hours, 4 hours, or ≥5 hours. Participants were also asked to report symptoms indicative of poor ocular health, such as headaches, redness, eye strain, and inflammation, to explore their association with smartphone usage. In addition to the questionnaire, baseline ocular assessments were performed. These included a comprehensive eye examination, measurement of visual acuity, and a refraction test to identify any refractive errors. The collected data provided insights into the prevalence of refractive errors and the overall ocular health of participants. However, the methodology did not clarify whether the eye examinations were conducted by a certified ophthalmologist or optometrist, a detail critical to ensuring the accuracy and clinical relevance of the findings.

RESULTS

The analysis revealed a significant association between smartphone usage and ocular health, highlighting its impact on refractive errors and ocular symptoms. The findings indicated that excessive smartphone usage correlated strongly with the prevalence of myopia and ocular discomfort, including headaches, eye strain, redness, and inflammation. Among the participants, myopia was reported in 54 individuals who engaged in excessive smartphone use, compared to only 5 cases among those with shorter usage. Similarly, headache prevalence was markedly higher among excessive users, with 51 individuals affected, compared to 3 cases in the shorter usage group. These results were statistically significant ($P \leq 0.01$), emphasizing the role of prolonged smartphone use in deteriorating visual health.

Table 1: age and gender distribution

Category	Frequency (%)
Age	
13-15 years	70 (35%)
16-18 years	130 (65%)
Gender	
Male	130 (65%)
Female	70 (35%)

Demographic analysis of the participants revealed that the majority were aged 16–18 years, accounting for 65% of the total sample, while 35% were aged 13–15 years. Gender distribution showed a predominance of male participants, who represented 65% of the sample, while females constituted 35%. This demographic overview suggests a higher representation of older teenagers and males within the study, aligning with potential patterns of smartphone use in this population.

Table 2 Relationship between Smartphone Usage and Refractive Error:

Smartphone usage	No refractive error	Myopia	Hyperopia	astigmatism	total	P
Shorter use(<2hours/day)	35	5	10	0	50	0.001
Intermediate use (2 hours/day)	30	36	0	4	70	
Excessive use(>2hours/day)	20	54	0	6	80	
Total	85	95	10	10	200	

Further analysis of the relationship between smartphone usage patterns and refractive errors demonstrated that excessive users were predominantly affected by myopia, with 54 cases identified, alongside 6 cases of astigmatism. Hyperopia was reported in 10 participants, primarily among those with shorter usage. Statistical analysis showed a significant association between increased smartphone usage and the likelihood of refractive errors ($P = 0.001$), particularly myopia, which was more prevalent as usage duration increased.

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Table 3: Relationship Between Smartphone Usage And Type Of Use With Ocular Symptoms:

Smartphone Usage	Headache		P	Eye strain		P	Redness		P	Inflammation		P
	No	Yes		No	Yes		No	Yes		No	Yes	0.01
Shorter	47	3	0.001	45	5	0.001	50	0	0.001	40	10	
Intermediate	37	33		36	4		40	30		30	10	
Excessive	29	51		30	50		64	16		65	15	
Type of Use												
Continuous	28	72	0.01	30	70	0.00	54	46	0.01	30	70	0.00
Persistent	85	15		86	14		100	0		85	15	

Ocular symptoms were also significantly associated with varying levels of smartphone use. Excessive users reported a notably higher frequency of headaches (51 cases), eye strain (50 cases), redness (16 cases), and inflammation (15 cases). In comparison, participants with shorter usage exhibited minimal symptoms, with 3 cases of headache and 5 cases of eye strain, and no reports of redness. These findings were statistically significant across all categories ($P \leq 0.01$), underscoring the dose-dependent relationship between smartphone use and ocular discomfort.

The study also examined the impact of smartphone usage type, categorizing participants into continuous and persistent users. Continuous users were significantly more likely to report symptoms of headaches (72 cases), eye strain (70 cases), redness (46 cases), and inflammation (70 cases) compared to persistent users, who showed far fewer cases of these symptoms. Continuous usage was strongly associated with increased ocular discomfort, with statistical significance observed across all parameters ($P \leq 0.01$). Overall, the results highlighted the considerable impact of prolonged smartphone use on both refractive errors and ocular symptoms. The findings underline the need for increased awareness and preventive strategies, particularly for younger populations, to mitigate the risks associated with excessive smartphone usage.

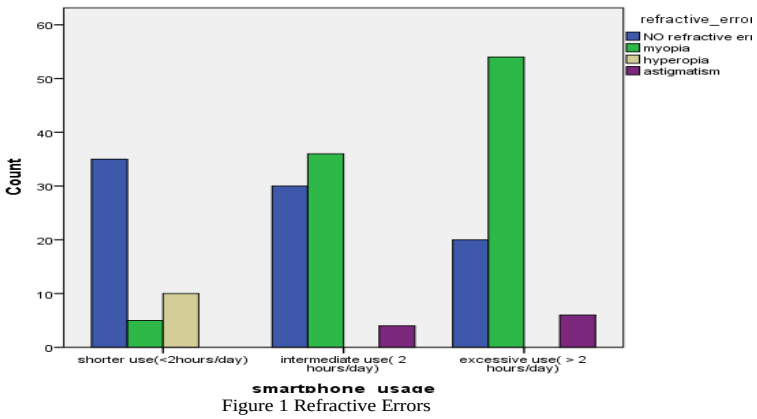

Figure 1 Refractive Errors

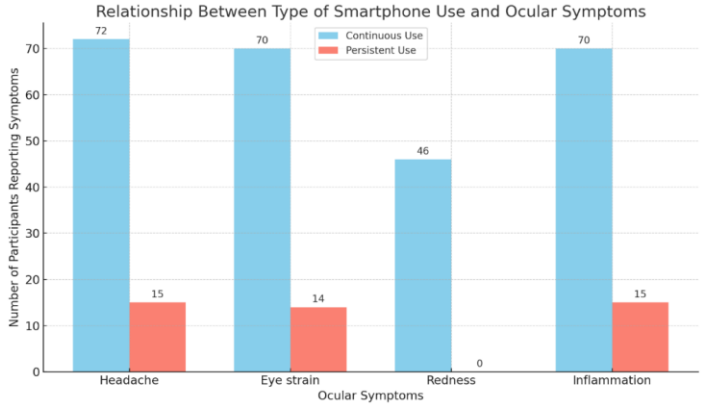

Figure 2 Relationship between Type of Use and Ocular Symptoms:

DISCUSSION

This study investigated the impact of smartphone usage on refractive errors and ocular health in teenagers, with a focus on the association between prolonged screen time and the prevalence of myopia and symptoms of computer vision syndrome (CVS). The findings revealed a significant correlation between excessive smartphone use and the increased prevalence of myopia, along with common CVS symptoms such as eye strain, headaches, redness, and blurred vision. These results align with the growing body of evidence that links prolonged exposure to digital screens with adverse effects on ocular health. Teenagers who reported excessive smartphone usage, defined as more than two hours per day, demonstrated a markedly higher prevalence of myopia compared to those with shorter durations of use. This pattern corroborates previous studies that have established excessive near work, including smartphone use, as a key contributor to myopia progression. The increased accommodative demand during prolonged near work is a plausible mechanism, as it promotes axial elongation of the eye, a well-documented cause of myopia progression. Adolescents, whose visual systems are still in the developmental phase, are particularly susceptible to environmental influences such as extended screen time, making this population highly vulnerable to refractive changes (1, 2). The association between smartphone usage and refractive errors is further supported by findings from other studies conducted across diverse populations. Research by Gopinath et al. (2019) demonstrated that children engaging in more than two hours of daily

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screen time exhibited a significantly higher prevalence of myopia compared to those with limited exposure. These findings are consistent with the present study, emphasizing the critical role of excessive screen exposure in the onset and progression of myopia among teenagers. The present study expands on this evidence by illustrating the relationship between smartphone usage patterns and ocular health within a younger demographic.

In addition to refractive errors, this study highlighted the substantial impact of smartphone use on symptoms of CVS. Excessive and continuous users were significantly more likely to report symptoms such as eye strain, headaches, and redness. These symptoms are characteristic of CVS, a condition that arises from prolonged exposure to digital screens and is often exacerbated by poor visual ergonomics. The high visual demands associated with smartphone use, combined with inadequate breaks and suboptimal lighting conditions, contribute to the development of these symptoms, particularly in teenagers. Mechanisms underlying the link between smartphone use and ocular symptoms include increased accommodative and convergence demands during near work, leading to sustained ciliary muscle contraction and potential accommodative spasms. This physiological response can result in temporary or permanent refractive changes. Moreover, blue light emitted by smartphone screens has been implicated in inducing oxidative stress in retinal cells, potentially contributing to ocular discomfort and long-term retinal damage. Reduced blink rates and incomplete blinking during prolonged screen use further exacerbate dry eye symptoms, which are frequently reported in users with high screen time (6, 7, 8). The strengths of this study lie in its focus on teenagers, a population highly vulnerable to the effects of excessive smartphone use, and its incorporation of both refractive errors and CVS symptoms. By examining these parameters concurrently, the study provides a comprehensive understanding of the ocular implications of smartphone use in this demographic. However, certain limitations must be acknowledged. The cross-sectional design precludes the establishment of causality, as the temporal relationship between smartphone use and ocular health outcomes cannot be determined. Additionally, self-reported data on smartphone usage may be subject to recall bias, potentially affecting the accuracy of the findings. Future studies employing longitudinal designs and objective measures of screen time would provide a more robust understanding of the causal relationships.

The results of this study underscore the need for public health interventions aimed at mitigating the ocular risks associated with excessive smartphone use. Early screening for refractive errors in teenagers with high smartphone usage could serve as a preventive measure against the progression of myopia. Educational initiatives should emphasize the importance of proper screen usage habits, including adherence to the "20-20-20 rule" to reduce eye strain and encourage regular breaks. Promoting outdoor activities is another effective strategy, as increased exposure to natural light has been shown to be protective against myopia in children and adolescents. These preventive measures are critical in addressing the rising prevalence of ocular health issues among teenagers in the digital age (9, 10). This study provides valuable insights into the relationship between smartphone usage and ocular health in teenagers, demonstrating significant associations with myopia and CVS symptoms. While the findings contribute to the growing body of evidence on this topic, future research should explore the long-term effects of smartphone use on other aspects of visual function, such as contrast sensitivity and retinal health, to develop more comprehensive preventive strategies.

CONCLUSION

This study highlights a significant link between excessive smartphone usage and the development of myopia and symptoms of Computer Vision Syndrome in teenagers. The findings emphasize that prolonged screen time during adolescence, a critical period for visual system development, contributes to adverse ocular health outcomes, including eye strain, headaches, and visual discomfort. These results underscore the need for public health initiatives focused on educating teenagers, parents, and educators about safe screen usage practices and promoting preventive measures such as regular visual breaks and increased outdoor activities. Early screening for refractive errors in high smartphone users may help detect and manage vision problems before they progress. While this study provides valuable insights, further longitudinal research is necessary to confirm these findings and broaden our understanding of the long-term impact of digital devices on adolescent eye health.

Author	Contribution
Khurram Nasir	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision Writing - Review & Editing, Assistance with Data Curation
Ummarah Shafiq	Methodology, Investigation, Data Curation, Writing - Review & Editing
Kashmala Zarin	Investigation, Data Curation, Formal Analysis, Software
Subhan Tahir	Software, Validation, Writing - Original Draft
Fariha Ambreen	Formal Analysis, Writing - Review & Editing

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