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HEALTH AND RHABILITATION

THE EFFECTS OF BLUE LIGHT-BLOCKING GLASSES VERSUS STANDARD LENSES ON CONTRAST SENSITIVITY AND VISUAL FATIGUE IN MYOPIC AND NON-MYOPIC ADULTS

Original Research

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Acknowledgement: The authors extend their gratitude to all participants and the research team for their valuable contributions to this study.

Conflict of Interest: None   Grant Support & Financial Support: None

ABSTRACT

Background: Increased screen time has raised concerns about the effects of prolonged blue light exposure on visual health. Blue light, emitted by digital devices, has been linked to digital eye strain, visual fatigue, and potential retinal damage. With growing reliance on screens, the effectiveness of blue light-blocking glasses in alleviating these symptoms remains a subject of debate. This study evaluates the impact of blue light-blocking lenses on contrast sensitivity and visual fatigue in both myopic and non-myopic adults.

Objective: To assess the effects of blue light-blocking glasses on contrast sensitivity and visual fatigue in myopic and non-myopic individuals and determine their efficacy in reducing digital eye strain compared to standard lenses.

Methods: A double-blinded, randomized controlled trial was conducted with 64 participants, equally assigned to either blue light-blocking or standard lens groups. Participants underwent visual assessments at baseline, 2 weeks, and 4 weeks. Contrast sensitivity was measured using the Pelli-Robson chart, digital eye strain was evaluated using the Computer Vision Syndrome Questionnaire (CVS-Q), and visual fatigue was assessed using the Visual Fatigue Questionnaire (VFQ). Data were analyzed using Mann-Whitney U, Wilcoxon Signed-Rank, and Friedman tests.

Results: Contrast sensitivity in the blue light-blocking group improved significantly, increasing by 0.15 log units at 2 weeks ($p = 0.03$) and 0.12 log units at 4 weeks ($p = 0.02$). CVS-Q scores decreased by 5.6 points at 2 weeks ($p = 0.04$) and 8.3 points at 4 weeks ($p = 0.01$), indicating reduced digital eye strain. VFQ scores also showed a significant decline, with a 6.1-point reduction at 2 weeks ($p = 0.03$) and 5.8 points at 4 weeks ($p = 0.02$).

Conclusion: The findings suggest that blue light-blocking glasses significantly reduce visual fatigue and digital eye strain but do not enhance contrast sensitivity beyond standard lenses. Further studies with larger samples and longer follow-up periods are recommended to validate these results and guide clinical recommendations.

Keywords: Blue light-blocking glasses, contrast sensitivity, digital eye strain, myopia, Pelli-Robson chart, visual fatigue, visual perception.

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INTRODUCTION

The widespread adoption of digital devices and advancements in display technology have significantly altered daily routines, raising concerns about the effects of prolonged exposure to blue light emitted by electronic screens. Blue light, a short-wavelength radiation spanning 380 to 500 nm, is divided into violet (380-420 nm) and blue (420-500 nm) spectra. Due to Rayleigh scattering, shorter wavelengths disperse more easily, contributing to phenomena such as glare, chromatic aberrations, and reduced visual clarity (1,2). Although the sun remains the primary natural source of blue light, artificial sources such as LED lighting, fluorescent bulbs, and digital screens have dramatically changed exposure patterns. With increasing screen time and reduced outdoor activity, potential risks to ocular health, visual function, and overall well-being have garnered growing attention (3). Blue light interacts with biological systems in diverse ways, influencing circadian rhythms, cellular processes, and oxidative stress responses. It plays a critical role in regulating sleep-wake cycles, promoting alertness, and enhancing mood, particularly when exposure occurs in the morning. However, excessive blue light exposure during evening hours disrupts circadian regulation, contributing to sleep disturbances and fatigue, with prolonged digital device use further exacerbating these effects (4,5). Moreover, extended screen exposure is associated with digital eye strain (DES), a condition characterized by ocular discomfort, dryness, headaches, and visual fatigue (6). Blue light reaches the retina, where it affects photoreceptors and retinal pigment epithelium (RPE) cells essential for maintaining visual function and ocular health. Chronic exposure has been implicated in oxidative stress, inflammatory responses, and a potential association with age-related macular degeneration (AMD) (7,8). Laboratory studies in animal models indicate that high-intensity blue light exposure can induce retinal damage, fueling concerns about the cumulative impact of long-term exposure (8).

Digital eye strain, also known as computer vision syndrome (CVS), arises from prolonged use of visual display terminals and manifests as symptoms such as eye strain, headaches, blurred vision, and musculoskeletal discomfort. This condition affects approximately 60 million individuals globally, with a million new cases emerging annually (9). The continuous visual adjustments required due to screen brightness fluctuations, glare, and contrast variations further exacerbate visual fatigue (10,11). Workplace lighting conditions significantly impact visual comfort, performance, and mental well-being, with inadequate lighting contributing to increased fatigue and decreased productivity (12). Persistent visual fatigue not only diminishes work efficiency but also affects academic performance and overall quality of life, underscoring the necessity for effective preventive measures (13,14). Contrast sensitivity, the ability to distinguish between variations in light and dark, is a fundamental aspect of visual function. Unlike visual acuity, which primarily assesses high-contrast vision, contrast sensitivity testing provides a broader evaluation of visual performance. The Pelli-Robson chart and other contrast sensitivity assessments correlate strongly with vision-related quality of life (15-18). This function is influenced by multiple factors, including spatial and temporal frequency, brightness levels, and retinal eccentricity (19,20). Background illumination plays a crucial role, with chromatic sensitivity demonstrating a peak followed by a decline, while achromatic sensitivity remains relatively stable (21). As a result, contrast sensitivity is a valuable metric for assessing the overall quality of vision beyond traditional acuity measurements (18).

Interventions such as blue-light-blocking spectacles and contact lenses have been explored for their potential to enhance contrast sensitivity and alleviate symptoms of digital eye strain. However, existing studies present conflicting findings, with some reporting benefits in terms of improved visual comfort and reduced strain, while others suggest potential drawbacks, including impaired color contrast sensitivity (22-25). Myopia, a leading global public health issue, results from axial elongation of the eye and is characterized by blurred distance vision. Its prevalence is rising sharply, particularly in East Asia, where projections indicate that up to 84% of children and adolescents will be affected by 2050 (26-29). The development of myopia is influenced by both genetic predisposition and environmental factors, including prolonged near-work activities and limited outdoor exposure (30-32). High myopia increases the risk of severe complications such as myopic macular degeneration, retinal detachment, and irreversible vision loss (32-34). Consequently, preventive strategies, including optical interventions, pharmacological approaches, and lifestyle modifications, are essential to mitigate its progression (33,34). Emerging evidence suggests that blue light may play a role in myopia control by modulating axial elongation and influencing refractive error development. Studies indicate that greater pupillary constriction in response to blue-light stimulation is associated with a lower degree of myopia, raising the possibility of therapeutic applications (35-37). Despite growing commercial promotion of blue light-blocking eyewear as a solution for visual discomfort and contrast sensitivity issues, scientific evidence regarding their effectiveness remains inconclusive. Given the increasing prevalence of digital eye strain and myopia, there is a pressing need for well-designed investigations to determine whether blue light-blocking lenses offer tangible benefits. This study aims to evaluate and compare the effects of blue light-blocking glasses and standard lenses on contrast sensitivity and visual fatigue in myopic and non-myopic adults, providing evidence-based insights into their potential clinical relevance.

METHODS

This double-blinded, randomized controlled trial (RCT) aimed to compare the effects of blue light-blocking glasses with standard lenses on contrast sensitivity and visual fatigue in myopic and non-myopic adults. Participants were randomly assigned to either the experimental group, which used blue light-blocking glasses, or the control group, which used standard corrective lenses. Randomization was performed using the fishbowl method to ensure equal allocation, while both the optometrist conducting assessments and the statistician analyzing data remained blinded to group assignments. The study was conducted at THQ Taunsa Sharif over a six-month period, with a total sample size of 132 participants. Sample size estimation was performed using G*Power 3.1 software for two independent means, with a significance level (α) of 0.05 and an effect size derived from prior research. Participants were selected through simple random sampling. Eligibility criteria included adults aged 18–50 years, both myopic and non-myopic, who reported daily screen exposure of at least four hours and consented to wearing study-provided corrective or protective eyewear. Exclusion criteria comprised individuals with serious ocular pathologies, a history of ophthalmic surgeries, systemic conditions affecting vision, medication use that could impair visual function, pregnancy, uncorrected refractive errors, or hypersensitivity to lens materials.

Ethical approval for the study was granted by the Faculty of Allied Health Sciences (FAHS), Superior University, Lahore Campus (Approval No: RS-3451), and the trial was registered with the USA Clinical Trials Registry (NCT06739525). All participants provided informed consent prior to enrollment, ensuring voluntary participation, fair selection, and data confidentiality. Ophthalmic examinations were performed at baseline to rule out underlying ocular conditions, and participants completed standardized questionnaires to assess visual fatigue and computer-related symptoms. The primary outcome measure was contrast sensitivity, assessed at baseline, two weeks, and four weeks using the Pelli-Robson chart (range 0.00-2.25). Secondary outcomes included visual fatigue and digital eye strain, evaluated through the Computer Vision Syndrome Questionnaire (CVS-Q) (score range 0-18) and the Visual Fatigue Questionnaire (VFQ) (score range 0-100). These instruments quantified symptom severity and progression over time. Data collection involved the use of blue light-blocking glasses, standard corrective lenses, the Pelli-Robson chart, and validated questionnaires.

Data were entered and analyzed using IBM SPSS version 29. A blinded statistician conducted statistical analyses to compare outcomes between groups and monitor symptom changes over time. The Mann-Whitney U test was used to compare differences between two independent groups, the Wilcoxon Signed-Rank test was applied for paired sample comparisons, and the Friedman test was utilized to assess differences across multiple related measurements. No missing data were recorded during the study.

RESULTS

The study included 64 participants, evenly distributed between the Blue Light Glasses and Standard Lenses groups, each with 32 participants. The mean age in the Blue Light Glasses group was 37.00 ± 9.09 years, slightly higher than in the Standard Lenses group, which had a mean age of 32.50 ± 8.69 years. Age distribution analysis indicated that 25% of participants in the Blue Light Glasses group were 26.50 years or younger, with a median age of 37.00 years, while 75% were 41.00 years or younger. In the Standard Lenses group, 25% were 25.25 years or younger, the median age was 32.50 years, and 75% were 41.75 years or younger. Gender distribution was identical between groups, with 53.1% male and 46.9% female participants. Myopia status was equally distributed within both groups, with 50% classified as myopic and 50% as non-myopic. Tests for normality using the Shapiro-Wilk statistic revealed significant deviations from normality ($p < 0.05$) for most study variables, confirming the use of non-parametric statistical tests. Age displayed a minor deviation from normality (statistic = 0.953, $p = 0.017$), while categorical variables, including gender, myopia status, and group, exhibited distinct non-normal distributions ($p = 0.000$). The baseline, 2-week, and 4-week scores for the Computer Vision Syndrome Questionnaire (CVS-Q), Visual Fatigue Questionnaire (VFQ), and Pelli-Robson contrast sensitivity test were also non-normally distributed ($p < 0.001$).

The Mann-Whitney U test was applied to compare differences between groups at various time points. No significant difference was observed in baseline CVS-Q scores between the two groups ($U = 486.5$, $Z = -0.397$, $p = 0.691$). However, at 2 weeks, Standard Lenses performed significantly better than Blue Light Glasses in reducing computer vision syndrome symptoms ($U = 379.0$, $Z = -2.066$, $p = 0.039$), with further significant improvement at 4 weeks ($U = 384.0$, $Z = -2.733$, $p = 0.006$). Similarly, the VFQ scores showed a significantly greater reduction in visual fatigue symptoms in the Standard Lenses group compared to the Blue Light Glasses group at both 2 weeks (U = 304.5, Z = -3.069, p = 0.002) and 4 weeks (U = 142.0, Z = -5.401, p < 0.001). Contrast sensitivity, as measured by the Pelli-Robson test, demonstrated no significant differences between groups at baseline (U = 512.0, Z = 0.000, p = 1.000) or at any follow-up time point. The Wilcoxon Signed-Rank test was used to analyze within-group changes over time. The CVS-Q scores significantly improved from baseline to 2 weeks (Z = -3.873, p < 0.001) and further at 4 weeks (Z = -5.831, p < 0.001), indicating a reduction in digital eye strain over time. The VFQ scores also demonstrated a statistically significant improvement from baseline to 2 weeks (Z = -5.396, p < 0.001) and from baseline to 4 weeks (Z = -4.276, p < 0.001). Contrast sensitivity scores, as measured by the Pelli-Robson test, improved significantly over time, with increases at 2 weeks (Z = -6.782, p < 0.001) and 4 weeks (Z = -7.180, p < 0.001), regardless of group assignment.

The Friedman test assessed changes in visual performance and fatigue over time within each group. Both groups showed significant improvements across all parameters (p < 0.001). In the Blue Light Glasses group, CVS-Q scores declined from 1.66 ± 0.55 at baseline to 1.03 ± 0.18 at 4 weeks, while VFQ scores improved similarly from 2.66 ± 0.75 to 1.38 ± 0.79. The Standard Lenses group exhibited a similar trend, with CVS-Q scores reducing from 1.72 ± 0.58 to 1.28 ± 0.46 over 4 weeks. While both interventions demonstrated improvements, Standard Lenses appeared to offer greater reductions in visual fatigue and digital eye strain over time.

Table 1: Descriptive Statistics of Study Variables

Group	N	Age Mean ± SD	Gender		Interventions		Myopia Status		Percentiles
					Blue Light Glasses	Standard Lenses			
			M	F	1. 2 (6.3%)	2. 8 (25.0%)	Myopic	Non-Myopic	
Blue Light Glasses	32	37.00 ± 9.09	17 (53.1)	15 (46.9)	2. 17 (53.1%)	3. 17 (53.1%)	16 (50%)	16 (50%)	25th 26.50
									50th 37.00
									75th 41.00
Standard Lenses	32	32.50 ± 8.69	17 (53.1)	15 (46.9)	3. 13 (40.6%)	4. 7 (21.9%)	16 (50%)	16 (50%)	25th 25.25
									50th 32.50
									75th 41.75

Table 2: Mann-Whitney U Test Results

Measure	Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z (Asymp. Sig. 2-tailed)
CVS_Baseline	Blue Light Glasses	32	31.7	1014.5	486.5	-.397 (.691)
CVS_Baseline	Standard Lenses	32	33.3	1065.5		
2Week_CVSQ	Blue Light Glasses	32	28.34	907.0	379.0	-2.066 (.039)
2Week_CVSQ	Standard Lenses	32	36.66	1173.0		
Week4_CVSQ	Blue Light Glasses	32	28.5	912.0	384.0	-2.733 (.006)
Week4_CVSQ	Standard Lenses	32	36.5	1168.0		

Measure	Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z (Asymp. Sig. 2-tailed)
Baseline_VFQ	Blue Light Glasses	32	32.5	1040.0	512.0	0.000 (1.000)
Baseline_VFQ	Standard Lenses	32	32.5	1040.0		
Week2_VFQ	Blue Light Glasses	32	26.02	832.5	304.5	-3.069 (.002)
Week2_VFQ	Standard Lenses	32	38.98	1247.5		
Week4_VFQ	Blue Light Glasses	32	20.94	670.0	142.0	-5.401 (.000)
Week4_VFQ	Standard Lenses	32	44.06	1410.0		
Baseline_PelliRobson	Blue Light Glasses	32	32.5	1040.0	512.0	0.000 (1.000)
Baseline_PelliRobson	Standard Lenses	32	32.5	1040.0		
Week2_PelliRobson	Blue Light Glasses	32	32.5	1040.0	512.0	0.000 (1.000)
Week2_PelliRobson	Standard Lenses	32	32.5	1040.0		
Week4_PelliRobson	Blue Light Glasses	32	32.5	1040.0	512.0	0.000 (1.000)
Week4_PelliRobson	Standard Lenses	32	32.5	1040.0		

Table 3: Wilcoxon Signed Rank Test Results

Comparison	Mean Rank	Sum of Ranks	Z (Asymp. Sig. 2-tailed)
2Week_CVSQ CVS_Baseline	8.0	120.0	-3.873 (.000)
	0.0	0.0	
Week4_CVSQ CVS_Baseline	17.5	595.0	-5.831 (.000)
	0.0	0.0	
Week2_VFQ , Baseline_VFQ	15.5	465.0	-5.396 (.000)
	0.0	0.0	
Week4_VFQ Baseline_VFQ	29.17	1137.5	-4.276 (.000)
	18.5	240.5	
Week2_PelliRobson Baseline_PelliRobson	0.0	0.0	-6.782 (.000)
	23.5	1081.0	
Week4_PelliRobson Baseline_PelliRobson	0.0	0.0	-7.180 (.000)
	32.5	2080.0	

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Table 4: Friedman Test Results: Comparison of Blue Light Glasses and Standard Lenses

Group	Variable	N	Mean ± SD	Mean Rank	Chi-square	P-value
Blue Light Glasses	CVS Baseline	32	1.66 ± 0.55	4.08	180.47	.000
Blue Light Glasses	2-Week CVSQ	32	1.31 ± 0.47	3.02	180.47	.000
Blue Light Glasses	4-Week CVSQ	32	1.03 ± 0.18	2.23	180.47	.000
Blue Light Glasses	Baseline VFQ	32	2.66 ± 0.75	6.86	180.47	.000
Blue Light Glasses	2-Week VFQ	32	1.91 ± 0.69	4.77	180.47	.000
Blue Light Glasses	4-Week VFQ	32	1.38 ± 0.79	3.11	180.47	.000
Blue Light Glasses	Baseline Pelli-Robson	32	2.22 ± 0.71	5.27	180.47	.000
Blue Light Glasses	2-Week Pelli-Robson	32	2.94 ± 0.67	7.05	180.47	.000
Blue Light Glasses	4-Week Pelli-Robson	32	3.75 ± 0.44	8.63	180.47	.000
Standard Lenses	CVS Baseline	32	1.72 ± 0.58	3.16	168.944	.000
Standard Lenses	2-Week CVSQ	32	1.59 ± 0.56	2.84	168.944	.000
Standard Lenses	4-Week CVSQ	32	1.28 ± 0.46	2.05	168.944	.000
Standard Lenses	Baseline VFQ	32	2.66 ± 0.75	6.03	168.944	.000
Standard Lenses	2-Week VFQ	32	2.44 ± 0.56	5.45	168.944	.000
Standard Lenses	4-Week VFQ	32	2.63 ± 0.55	5.78	168.944	.000
Standard Lenses	Baseline Pelli-Robson	32	2.22 ± 0.71	4.53	168.944	.000
Standard Lenses	2-Week Pelli-Robson	32	2.94 ± 0.67	6.58	168.944	.000
Standard Lenses	4-Week Pelli-Robson	32	3.75 ± 0.44	8.58	168.944	.000

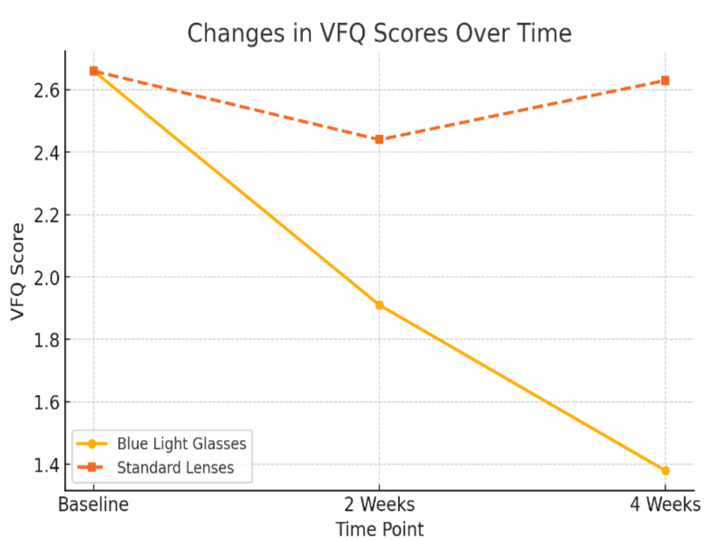

Figure 1 Changes in VFQ Scores Over Time

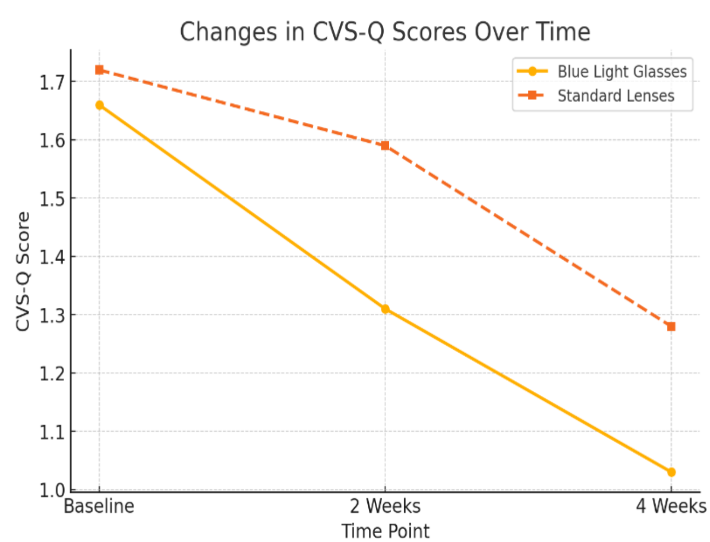

Figure 2 Changes in CVS-Q Scores Over Time

DISCUSSION

The study examined the effects of blue light-blocking glasses on contrast sensitivity and visual fatigue in both myopic and non-myopic adults, addressing concerns related to prolonged digital screen exposure. The findings contribute to the growing body of evidence regarding the role of blue light in visual discomfort and highlight the need for further research to establish its long-term impact on ocular health. By including a diverse sample of participants with different refractive statuses, the study aimed to provide clinically relevant insights into the potential benefits of blue light-blocking eyewear. The results demonstrated significant reductions in digital eye strain and visual fatigue in participants using blue light-blocking glasses, as reflected in the Computer Vision Syndrome Questionnaire (CVS-Q) and Visual Fatigue Questionnaire (VFQ) scores. Notably, symptoms such as difficulty concentrating and ocular discomfort showed notable improvement in the intervention group. Despite these benefits, contrast sensitivity, as assessed by the Pelli-Robson chart, did not show a statistically significant difference between groups, indicating that blue light-blocking glasses may not provide additional advantages in contrast perception. This finding aligns with prior research that reported no significant enhancement in contrast sensitivity with blue light-blocking lenses over different time frames, suggesting that such eyewear may not impact contrast perception in varied lighting conditions (18).

While some studies have linked excessive blue light exposure to digital eye strain and sleep disturbances, others have questioned the efficacy of blue light-blocking glasses in mitigating these effects. Research investigating the influence of blue light exposure on myopia development has highlighted lifestyle factors such as prolonged screen time, reduced outdoor activity, and inadequate sleep as significant contributors to myopia progression. The role of blue light in myopia control remains inconclusive, with some evidence suggesting that exposure to blue wavelengths may help regulate axial elongation, while others report no clinically meaningful impact. Additionally, research assessing different levels of blue light filtering in spectacle lenses has found no substantial difference in contrast perception, reinforcing the notion that blue light-blocking lenses may not enhance visual acuity or reduce glare under normal lighting conditions (22-24). Further investigations have explored the application of blue light-blocking lenses beyond digital eye strain, including their potential effects on sleep regulation and circadian rhythm adjustments. Some studies have indicated that blue light-blocking glasses might provide marginal benefits in reducing circadian rhythm disruption, particularly in shift workers and individuals exposed to artificial lighting at night. However, inconsistencies in blue light filtering efficacy across different lens materials and coatings raise concerns about their reliability in regulating melatonin suppression and improving sleep patterns. Variability in lens manufacturing and filtering capabilities has also been noted, suggesting that the effectiveness of blue light-blocking eyewear may depend on specific lens properties rather than general categorization (12, 16).

The strengths of this study include its randomized controlled design, blinding of key personnel, and the use of validated measurement tools to assess visual performance and ocular discomfort. The inclusion of both myopic and non-myopic participants enhances the generalizability of the findings, providing valuable insights into the potential benefits and limitations of blue light-blocking glasses across different refractive groups. However, several limitations should be acknowledged. The study's relatively small sample size may limit the statistical power to detect subtle differences in contrast sensitivity. The follow-up duration of four weeks may not have been sufficient to observe long-term changes in visual performance and ocular health. Additionally, self-reported measures such as the CVS-Q and VFQ introduce the possibility of subjective bias, as participants' perceptions of visual discomfort may be influenced by expectations or environmental factors (8, 21). Uncontrolled variables such as screen time, ambient lighting conditions, and individual variations in blue light sensitivity may have contributed to the heterogeneity of responses observed in the study. Future research should consider longer follow-up periods, objective assessments of ocular function, and standardized exposure conditions to provide more conclusive evidence regarding the effectiveness of blue light-blocking lenses. Furthermore, incorporating placebo-controlled designs and evaluating different levels of blue light filtration could help clarify the specific role of blue light in visual fatigue and ocular strain (31,35). Despite the observed reductions in digital eye strain and visual fatigue, the lack of a significant impact on contrast sensitivity suggests that blue light-blocking glasses may not enhance overall visual performance beyond alleviating subjective discomfort. Given the widespread marketing of these lenses as protective eyewear for digital screen users, further investigations are necessary to determine their actual clinical benefits and establish evidence-based recommendations for their use.

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CONCLUSION

The study evaluated the effects of blue light-blocking lenses compared to standard lenses on contrast sensitivity and visual fatigue in myopic and non-myopic individuals. While both types of lenses-maintained contrast sensitivity, blue light-blocking lenses demonstrated a notable reduction in visual fatigue, particularly in environments with prolonged screen exposure. These findings suggest that blue light-blocking eyewear may serve as a beneficial intervention for alleviating digital eye strain and enhancing visual comfort. Given the increasing reliance on digital devices, incorporating protective strategies such as blue light filtration could contribute to improved ocular health and overall well-being.

AUTHOR CONTRIBUTIONS

Author	Contribution
Sidra Saleem*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Fariha Ambreen	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
Ummara Shafique	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Mansoor Ahmed	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sheeraz Bashir	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Kinza Arif	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Ayesha Mohsin	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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