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A COMPARATIVE STUDY ON THE IMPACT OF BLUE LIGHT ON ACCOMMODATION AND EYE STRAIN IN CHILDREN AND ADULTS

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ABSTRACT

This comparative cross-sectional study investigated the impact of blue light exposure on accommodation and eye strain among children and adults in ophthalmic settings in DG Khan, Pakistan. A total of 150 participants (75 children, 75 adults) were assessed using structured questionnaires and clinical evaluations. Findings revealed that children experienced significantly higher prevalence of accommodative complaints, including blurred near vision (69.3%), difficulty refocusing (64.0%), and eye fatigue (74.7%), compared to adults. Sleep disturbances following screen use were also more frequent in children (80.0%) than adults (68.0%), underscoring the influence of blue light on circadian rhythm regulation. Although blue light protective measures were used by only 25.3% of participants, their effectiveness was limited, with most reporting mild or no improvement. The study concludes that children are more vulnerable to accommodative stress and digital eye strain due to anatomical and behavioral factors, highlighting the need for behavioral interventions such as regulated screen time, visual hygiene practices, and reduced evening exposure. Future research should employ larger, diverse samples and objective accommodative assessments to strengthen evidence for preventive strategies.

Keywords: *Blue light exposure, Accommodation, Digital eye strain, Children vs. adults, Circadian rhythm*

INTRODUCTION

The fast development of digital devices such as smartphones, tablets, computers, and LED screens into daily life has been increased human exposure to blue light, a high-energy visible light with wavelengths ranging from 400 to 500 nm. While blue light plays a major role in regulating circadian rhythm and alertness, excessive and prolonged exposure has raised growing concerns regarding its adverse effects on visual health, particularly accommodation and eye strain. Digital eye strain has been raised as a common public health issue affecting both children and adults, largely due to increased screen dependency for education, work, and entertainment (1).

Accommodation makes the eye to focus at distant object clearly, its obvious ability of the

accommodation (2). Accommodative ability can be disturbed by excessive near work under blue light, which can lead to symptoms such as blurred vision, difficulty refocusing, eye fatigue, and headaches. Eye strain, also known as asthenopia, can cause a group of visual and ocular symptoms including dryness, burning sensation, blurred vision, and reduced visual comfort associated with sustained visual tasks (3).

Children are noted to be particularly harmed to blue light exposure due to anatomical and physiological differences such as clearer crystalline lenses and larger pupil sizes, allowing greater transmission of blue light to the retina (4). Behavioral factors including shorter viewing distances, prolonged uninterrupted screen use, and limited awareness of visual hygiene further increases their susceptibility (5). Adults, although partially protected by age-related lens yellowing, remain at risk due to cumulative occupational and recreational screen exposure (6). The study, which is conducted at The Superior University, Lahore, aimed to comparatively assess the impact of blue light exposure on accommodation and eye strain in children and adults.

Background

Blue light exposure from digital devices has increased, meeting with a global rise in complaints related to digital eye strain. Studies have showed the major screen use is associated with accommodative fatigue, reduced blink rate, tear film instability, and visual discomfort. The eyes of children transmit up to 70–80% more blue light to the retina as compare to adults, increasing their risk of accommodative stress, myopia progression, and sleep disturbances due to melatonin suppression (7).

In adults, digital device use is linked to occupational visual fatigue and cumulative accommodative stress. Though age-related lens yellowing provides some filtration of blue light, adults still experience significant eye strain, particularly when exposed to screens for extended durations without adequate breaks. Instead of increasing awareness, evidence related to the effectiveness of blue light protective measures such as filters and glasses has been remains integrative (8).

Study Objectives and Methodology

The purpose of this study to know the impact of blue light exposure on accommodation and eye strain in children and adults and to compare symptom prevalence and severity between the two groups. A cross-sectional observational study was conducted over six months in public and private ophthalmic settings in DG Khan, Pakistan.

150 participants were included consisting of 75 children and 75 adults who regularly used digital devices. Non-probability convenience sampling was employed. Data for this research were collected by use of a structured questionnaire as including demographics, daily screen time, accommodation-related complaints, eye strain symptoms, sleep disturbances, and use of blue light protective measures. Some of the fundamental clinical assessments were also been conducted to know subjective findings. Data analysis was performed using SPSS version 21, with descriptive statistics used to summarize frequencies and percentages.

The inclusion criteria for this study were regular digital device u users of both genders reporting symptoms of eye strain or accommodative difficulty. The person who was suffering from ocular diseases was excluded in this study. Ethical approval was also obtained and the informed consent was obtained, and the participant was also focused in this study regularly.

Key Findings

Table 1: Comparison of Eye Strain and Accommodation-Related Symptoms Between Children and Adults (with p-values)

Variable	Children (n=75)	Adults (n=75)	Total (n=150)	p-value
Daily screen time >4 hours	46 (61.3%)	34 (45.3%)	80 (53.3%)	0.041
Eye fatigue	56 (74.7%)	42 (56.0%)	98 (65.3%)	0.018*
Headache	48 (64.0%)	38 (50.7%)	86 (57.3%)	0.112
Blurred near vision	52 (69.3%)	34 (45.3%)	86 (57.3%)	0.006*
Difficulty refocusing	48 (64.0%)	30 (40.0%)	78 (52.0%)	0.004*
Dry eye/burning sensation	44 (58.7%)	36 (48.0%)	80 (53.3%)	0.186
Sleep disturbance after screen use	60 (80.0%)	51 (68.0%)	111 (74.0%)	0.048*
Use of blue-light protection	16 (21.3%)	22 (29.3%)	38 (25.3%)	0.214

Accommodation-related complaints were more prevalent among children than adults. Blurred near vision, difficulty refocusing, and eye fatigue were reported more frequently in children, indicating greater accommodative stress. Increased screen time was strongly associated with moderate to severe eye strain across both groups, particularly among participants using digital devices for more than four hours per day.

Table 1: Distribution of Screen Time Among Participants

Daily Screen Time	Percentage (%)
Less than 2 hours	14.7
2–4 hours	32.0
More than 4 hours	53.3

The comparative analysis that is presented in Table focused a very clear age-related differences in both exposure patterns and symptom prevalence. The huge proportion of children nearly (61.3%) were reported daily screen use four hours as compared to adults (45.3%), which is showing higher exposure to the devices which are emitting blue light at a younger age. This increased exposure of the blue light was reflected in symptom patterns, as children consistently reported a higher frequency of accommodation-related complaints and eye strain symptoms as compared to adults

Majorly eye fatigue symptoms were commonly reported affecting 74.7% of children and 56.0% of adults, which is suggesting greater accommodative demand and reduced visual endurance in the children Similarly, blurred near vision and difficulty in refocusing which indicate accommodative stress greater in children (69.3% and 64.0%, respectively) compared to adults (45.3% and 40.0%). These findings also shows that prolonged near work under blue-light-enriched conditions places a heavier accommodative burden on younger eyes.

Headache and dry eye or burning sensation were also checked in both of groups but this was more

found among children, which were showing the presence of digital eye strain. Sleep disturbances following screen use were reported by of participants, with children (80.0%) which were greater, again more affected than adults (68.0%), underscoring the potential impact of blue light on circadian rhythm regulation in the pediatric population.

The use of blue-light protective measures that used by both groups was very low. Only 21.3% of children and 29.3% of adults were reported using blue-light filters or protective measures Overall, the table shows a strong association between increased screen time, accommodative stress, and eye strain in children than adults

Only 25.3% of participants reported using blue light protective measures. Between these screen users, 63.2% reported mild subjective improvement, while 36.8% reported no noticeable benefit. Sleep disturbances related to evening screen exposure was reported by 74% of participants, with children being more affected than adults.

Discussion

The findings of this study show a clear association between prolonged blue light exposure and increased accommodative stress and eye strain in both children and adults. However, children were found to be majorly affected and are experiences with greater symptoms. This increased can lead to greater retinal transmission of blue light, larger pupil, and also behavioral patterns such as prolonged uninterrupted screen use and closer viewing distances.

Accommodation-related disturbances has been observed in this study which are consistent with previous research indicating that sustained near work under blue-light-enriched conditions increases accommodative lag and fatigue. While adults also experienced visual discomfort, the comparatively lower severity may be partially explained by age-related lens yellowing and differences in accommodation (9,10).

Recent investigations have highlighted that prolonged exposure to blue-light-emitting devices not only affects accommodation but also contributes to oxidative stress at the retinal level. Experimental studies have demonstrated that high-energy visible light can induce photochemical damage in retinal cells, raising concerns about long-term ocular health in younger populations (11).

Moreover, epidemiological surveys have reported a strong correlation between excessive screen time and the onset of digital eye strain symptoms, including headaches, blurred vision, and difficulty in maintaining focus. These findings reinforce the need for comprehensive preventive strategies beyond optical filters or protective lenses (12).

Clinical trials assessing the efficacy of blue-light-blocking spectacles and screen filters have shown mixed results. While some participants reported subjective improvement, objective measures of accommodation and visual fatigue remained largely unchanged, suggesting that behavioral modifications remain the cornerstone of prevention (13).

In addition, pediatric studies have emphasized the role of parental guidance and institutional policies in regulating screen exposure. Structured interventions such as school-based awareness programs and digital hygiene education have proven effective in reducing both visual strain and sleep disturbances among children (14).

Finally, emerging evidence links blue light exposure to circadian rhythm disruption, particularly through suppression of melatonin secretion. This mechanism explains the higher prevalence of sleep-related complaints among children and adolescents, underscoring the broader systemic impact of digital device use on health and well-being (15).

The limited effectiveness of the blue light protective measures showed that these steps are not enough to prevent digital eye strain. Behavioral strategies also needed, which includes regular breaks, proper viewing distance, proper screen positioning, and screen-time regulation,

are also important which play major and vital role. The higher prevalence of sleep disturbances among children further focus on the impact of blue light on circadian rhythm and overall visual health.

Recommendations

To overcome the impact of blue light, major recommendations are given. Screen time should be regulated, particularly among children, which on regular breaks using strategies such as the 20-20-20 rule. Awareness programs should be implemented in schools, universities, and workplaces to promote visual hygiene and healthy screen habits. Regular eye examinations should be encouraged for early detection of accommodative dysfunction. Blue light filtering measures may be used as adjuncts but should not replace behavioral and ergonomic interventions. Additionally, reducing evening screen exposure is advised to minimize sleep disturbances, especially in children.

Limitations

The study was limited by the use of small sample size. and focus on a limited hospitals Some participants which were not interested and their lack of cooperation further restricted the data collection. Future research should involve larger, more diverse samples to enhance generalizability.

Conclusion

This study was limited by its cross-sectional design, which restricts causal inference. Reliance on self-reported symptoms may introduce recall bias, and the use of convenience sampling limits generalizability. Objective accommodative measurements were not included. Future longitudinal studies with larger, more diverse samples and objective assessment tools are recommended.

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