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EXCESSIVE USE OF ELECTRONIC GADGETS LEADS TO ASTIGMATISM AND OCULAR DEVIATION: A PROSPECTIVE CASE SERIES STUDY

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Abstract

Background: The study's aim was to find the association of astigmatism development with excessive screen time exposure in children aged 3-11 years. **Methods:** A prospective case-series study including six participants was conducted in Islamabad from November 2023 to May 2024. Clinical parameters, such as uncorrected and corrected visual acuity, astigmatism magnitude and orientation, exodeviation, and near point of convergence, were assessed using various tools including autorefractor, topography scan, prism cover test, and RAF rule. Analysis was performed using the Wilcoxon signed-rank test with a 95% confidence interval. **Results:** The daily mean screen time exposure of study participants was 5.50±1.90hrs (R=3-8). Astigmatism was mixed and with the rule in nature in all patients. The overall mean magnitude of astigmatism at presentation was -3.31±1.22D. The candidates were divided into two groups those who regulated their screen time to <2hrs a day along with average 90 minutes outdoor activities and those who did not regulate their screen time and outdoor activities. Participants regulating screen time to <2 hours/day and engaging in 90 minutes (about 1 and a half hours) of outdoor activities showed a significant reduction in astigmatism with a mean value of –0.67DC over a period of 3-6 months (p-value: 0.04, 0.02 respectively), while in participants having unregulated screen time led to a significant increase in astigmatism with a mean value of around –1.0DC (p-value: 0.02). The results were supported by a topographical map as well. Intermittent exotropia reduced from 14.00±2.19 to 8.75±2.78 PD after six months using convergence exercises. **Conclusion:** The results of this study point towards the association of excessive screen time with astigmatism and Exodeviation.

Keywords: Astigmatism, Exodeviation, Screen Time, VA, Electronic Gadgets.

INTRODUCTION

Astigmatism is an error of the ocular refractive system which abnormally converts the final point focus into a line focus. It is one of the most common refractive errors with an estimated prevalence of 14.9% and 40.4% in children and adults respectively [1]. In addition to the risk of meridional amblyopia, uncorrected astigmatism has severe detrimental effects on the academic performance of children [2]. Although gender, race, and preexisting refractive error has been identified as risk factors for astigmatism in children the current refractive status cannot be used to predict future presence of

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astigmatism [3],[4],[5]. This suggests some underlying factors not identified and described in detail in the literature.

With the rapid development of information technology, electronic devices have become a vital part of normal routine life including work as well as a variety of entertainment. In recent years, electronic devices use has become the most popular leisure activity in children [6]. This was further worsened during the COVID 19 pandemic because of online educational activities. A significant increase was also seen in the screen time of preschool children as well [7]. Excessive screen time has been linked with negative impact on physical and mental health such as poor dietary habits, reduced physical activities, abnormalities of sleep patterns, and ocular diseases [8].

Dry eye, pediatric computer vision syndrome, and an increased incidence of myopia are the most reported ocular issues in the post-pandemic period [9],[10]. Recently, an increased risk of astigmatism has also been reported in preschoolers who are exposed to excessive screen time [11]. To the best of our knowledge, the effect of screen time and its association with astigmatism and ocular deviation were not discussed previously. This is a massive gap in the available literature, as understanding the influence of screen time on the occurrence of astigmatism can be crucial in the development of interventions for pediatric refractive error. In this case-series study, we described the pattern of astigmatism and its associated features in preschool children in the context of screen time exposure.

PATIENTS AND METHODS

A prospective case-series was conducted for 12 eyes from 6 participants including 4 females and 2 males belonging to preschoolers (2-5 years) and middle childhood (6-11 years) using purposive sampling. The cases included those with similar complaints of ocular refraction and deviation. The major complaints were headaches, unhabitual blinking, and blurring of vision, along with intermittent exotropia. The study was conducted to rule out this unusual association of screen time exposure with astigmatism and exotropia and to see if the regulated screen time and increase in outdoor time had any effect in these selected cases. The setting for the study was the department of ophthalmology at the tertiary care hospital in Islamabad. The period for the said study was November 2023 to May 2024. All individuals who were either astigmatic of any type or had any type of ocular deviation were included in the study; however, those with any other ocular anomalies, i.e., trauma, surgery, or any other systemic abnormality, were excluded. It had been documented that all those participants had a dedicated cell phone or tablet.

The study followed the protocols established in the declaration of Helsinki and was approved by the Ethical review committee of (XXX), Malaysia and (XXX), Islamabad ref: LUC/R&D/Eth/SP/007/101 and AMC-HI-PUB-ERC/Mar23/24, respectively. Data was collected after written informed consent from the parents/ guardians of the participant.

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Study Participants

All participants underwent a complete ophthalmic examination, including cycloplegic retinoscopy with a Nietz Retinoscope (Streak) and auto-refractometer (ARK-1, NIDEK Japan), subjective refraction, ocular examination of the anterior and posterior segments, and a complete orthoptic assessment, including a prism cover test and convergence amplitude.

The topographical results were evaluated using OCT based topography instrument (OPTOPOLE REVO NX 130, Poland) for baseline and six months follow up, to rule out changes occurred in corneal curvature A family history of refractive error in parents was also obtained, along with daily screen time on dedicated gadgets, which was measured by using the data available on that equipment or reported by parents. All the patients were provided with the best refractive correction and recommended reducing the screen time to below two hours. Additionally, all participants were recommended to practice two sets of 20 pencil pushups per day [12].

The data on follow ups was obtained from all patients who reported a screen time of less than 2 hours or not and an increase of outdoor activities around 90 minutes (about 1 and a half hours). It was then verified from the data screen time record within the electronic devices (mobile phones/ tablets) and their parents/guardians. The follow-ups were done after 3 and 6 months for the spherocylindrical prescription and ocular deviation.

However, for topographical changes one follows up of around 6 months was adopted. All steps of this examination at presentation and both follow-ups were done by the principal examiner with the same instrumentation. The potential confounding factor was rubbing of the eyes. The participants were instructed to prevent rubbing. It was recommended to take regular breaks and avoid rubbing their eyes, along with reducing screen time.

Outcome Variables

The study's main results were uncorrected distance visual acuity (UDVA) recorded on an ETDRS chart, corrected distance visual acuity (CDVA), the magnitude and axis of astigmatism, the degree of exodeviation (prism diopters), and the near point of convergence (NPC) along with topographical changes. All these variables were quantitative in nature and were measured in their respective units.

Statistical Analysis

All the data was recorded and analyzed in Statistical Package for Social Sciences (SPSS) version 21. Descriptive data for quantitative variables was described in terms of mean and standard deviation. While frequencies and percentages were reported for categorical data, A Wilcoxon signed ranked test was applied as the data was not normally distributed and the sample size was small. A 95% confidence interval was observed for comparing data at different timelines.

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RESULTS

In total, 12 eyes from 6 patients were included in the study. All participants had their own dedicated smart gadgets (smart phones/tablet computers). On average, the daily screen time was 5.50±1.90, ranging from 3 to 8 hours. Mean outdoor activities was 37.5 ± 27.90 minutes at presentation. Of the six participants, 2 (33.33%) had parents with a positive history of refractive error and spectacle use. However, none of the families had a history of astigmatism.

The mean spherical refractive error (diopters) after wet auto-refraction was +2.87±0.98D on first assessment which was then verified subjectively, and patient acceptance was for +1.67±0.91D (Range= 0.50-4.00D). There was no reduction in mean values observed for spherical error in autorefractometer and retinoscopy on first and final verified prescription for 3 months (+2.87±0.98D vs 2.86±0.85D) and 6 months (2.86±0.84D vs 2.86±0.85D), respectively.

The mean cylindrical component in prescription on first assessment was -3.31±1.22D. Corrected distance visual acuity (CDVA) in log MAR showed an improvement in all individuals from 0.19±0.10 at baseline assessment to 0.12±0.08 at 6 months follow up. A mean intermittent exotropia (XT) of 14.00±2.19 prism diopters (PD) was observed initially, which later improved to 9.25±2.96 PD and 8.75±2.78 PD on 3 and 6 months follow ups, respectively (Table 1).

Table 1: Representation of mean screen time, outdoor activities, spherical refractive error, cylindrical correction (Astigmatism), exotropia, convergence, uncorrected visual acuity and corrected visual acuity (at presentation, 3 months and 6 months follow up. (N-12)

Parameter	Mean ± SD	Minimum	Maximum
Mean Screen Time (Hours)	5.50 ± 1.90	3	8
Average Outdoor activities (Minutes)	37.5 ± 27.9	15	120
Sphere Pre	2.87 ± 0.98	0.50	4.00
Sphere 1st follow up	2.86 ± 0.85	0.50	3.75
Sphere 2nd Follow up 6	2.86 ± 0.84	1.0	3.75
Astigmatism	-3.31 ± 1.22	1.50	5.50
Convergence	12.41±1.59	10.50	14.50
Convergence 1st F/Up	8.0 ± 1.89	6.0	11.00
Convergence 2nd F/Up	7.83 ± 1.83	6.00	10.50
Exotropia (PD)	14 ± 2.19	11	17
Exotropia 3 months	9.25 ± 2.96	6	13
Exotropia 6 months	14 ± 2.19	11	17
Visual Acuity Pre	1.22 ± 0.16	0.98	1.49
VA 1st F/Up	1.21 ± 0.21	0.81	1.51
VA 2nd F/Up	1.27 ± 0.13	1.09	1.51
BCVA presentation	0.19 ± 0.10	0.02	0.34
BCVA 1st F/Up	0.13 ± 0.08	0.00	0.24
BCVA 2nd F/Up	0.12 ± 0.08	0.00	0.22

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Screen time Reduction and Change in Astigmatism

Three of the total children (50%) showed a reduction of screen time to < 2 hours while it remained constant or increased in the rest of the participants [13], [14]. The Wilcoxon sign ranked test was applied separately on the cases with and without screen time control.

A statistically significant increase in astigmatism was seen (p-value .02) in individuals who did not reduce the screen time after baseline examination. Topographical presentation of a case with uncontrolled screen time showed an increase in corneal astigmatism (fig 1). Intergroup comparison showed a statistically significant difference between baseline and 6 month follow up (p-value: 0.02).

The mean cylinder increased from -2.41±0.68D at baseline to -3.41±0.73D at 6 months examination. Related results were also documented for intergroup comparison in wet retinoscopic refraction. The key point to be noted was that the astigmatism seen in all these cases was corneal, and with the rule in nature. Wilcoxon signed ranked test also showed statistical significance in group with controlled screen time as astigmatism reduced from -4.20±0.95D to -3.79±0.96D and -3.54±96D after 3 months and 6 months, respectively.

Topographical presentation of a case with controlled screen time showed an increase in corneal astigmatism (fig 2). The magnitude of intermittent exotropia and near point of convergence showed improvement in both groups. However, statistical significance was not seen in any of the groups for both findings (Table 2).

Table 2: Ocular Parameters at different timelines of the study

Parameter	Regulated Screen time group (N=6)				Intergroup* comparison	Unregulated Screen time group (N=6)			
	Refractive Astigmatism ±SD			χ^2 (p-value)		Refractive Astigmatism ±SD			χ^2 (p-value)
	Baseline	3months	6months			Baseline	3 months	6 months	
Retinoscopic Cylinder (DC)	-4.20±0.95	-3.79±0.96	-3.54±0.96	-3.85(0.04)	Baseline-6 months (0.02)	-2.41±0.68	-3.25±0.68	-3.41±0.73	11.14 (0.02)
Intermittent exotropia	15.33±1.53	11.33±2.52	11.00±2.00	5.60 (0.06)	-	12.67±2.08	7.17±1.61	6.50±0.50	5.60 (0.06)
Near point of convergence	13.17±1.89	9.33±1.75	9.33±1.26	4.91(0.09)	-	11.67±1.04	6.67±0.76	6.33±0.29	5.60 (0.06)

*All astigmatic numerical values are in minus form (Myopic Astigmatic Values)

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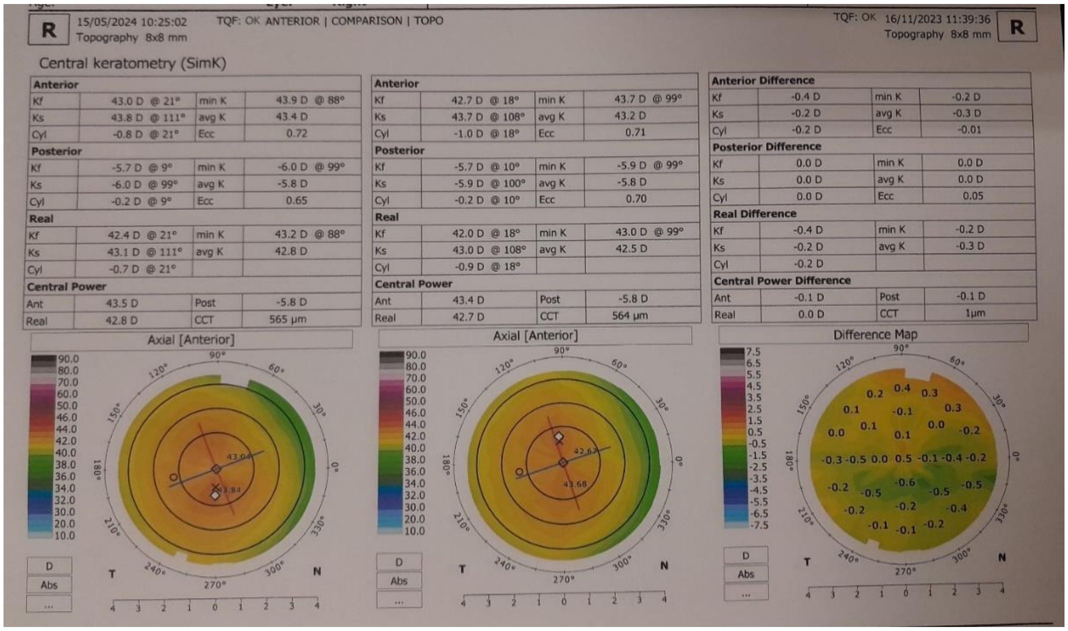

Fig 1: The topographical presentation of corneal curvature changed in participants with uncontrolled screen time. The image showed that the corneal curvature became steeper around -0.4DC within six months

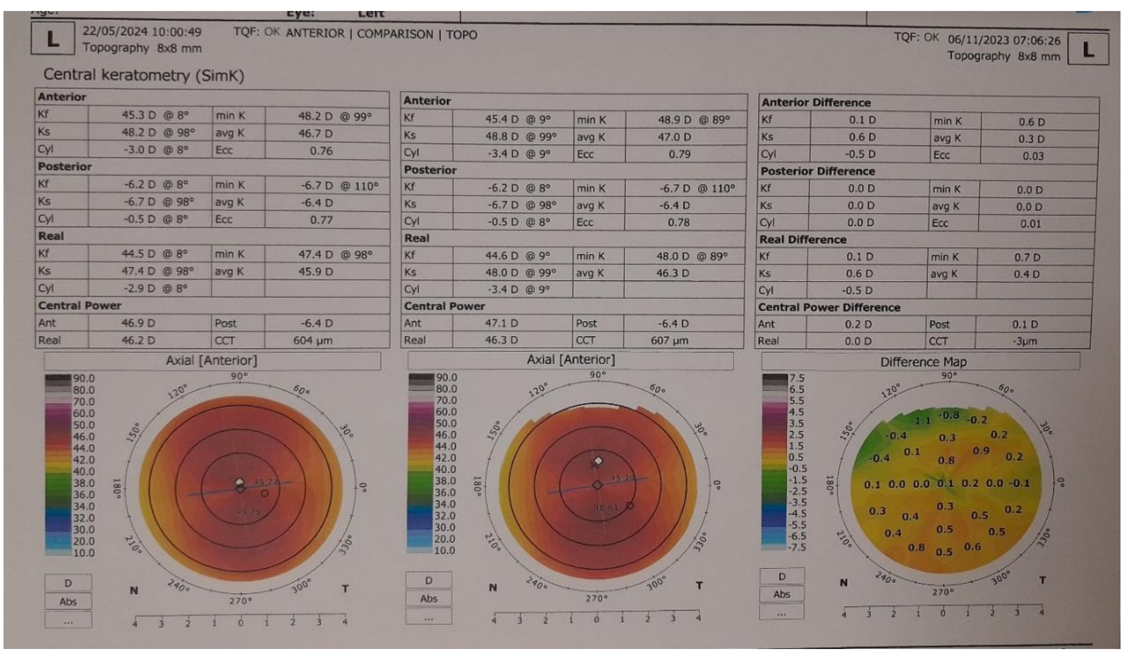

Fig 2: The topographical map of one of the cases at presentation and after six months in regulated screen time group. The image showed a reduction in corneal curvature of about -0.50DC in other words the cornea becomes flatter within 6 months

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DISCUSSION

This study showed the influence of screen exposure time on the magnitude of astigmatism in preschool children. To the best of our knowledge, this is the first study reporting the influence of screen time exposure on astigmatism and its progression. We observed that reduction in screen exposure in preschoolers can lead to a halt in progression of astigmatism within 6 months while continuous non-modulated screen exposure can lead to an increase in the magnitude of corneal, retinoscopic and prescribed astigmatism even with best correction prescribed at the baseline investigation.

A statistically significant reduction in the mean retinoscopic (0.54D) astigmatism was seen between the baseline assessment and six months follow up examination in group with controlled screen time. On the other hand, a statistically significant increase was observed in the group with unregulated screen time exposure for retinoscopic. While the decrease in magnitude of astigmatism in the controlled screen time group agrees with the reduction in prevalence and magnitude of astigmatic error reported in population-based studies, a statistically significant increase in the group with uncontrolled screen time that also exceeds the reported annual progression rate demands an alternate explanation [15],[16],[17].

An interesting finding was the comparison of components of total astigmatism which is formed by corneal astigmatism. There was a slightly higher increase in the overall representation of corneal astigmatism in the total ocular astigmatism in participants with controlled screen exposure time (6.21%) as compared to uncontrolled screen time (5.75%). The potential reason for this difference is the inhibitory effect of internal astigmatism to compensate for the higher rise in corneal curvature differences in the group with unregulated screen exposure.

A rise in screen exposure time is associated with higher corneal astigmatism which requires greater inhibitory control from internal astigmatism, leading to reduced representation of corneal component in the total astigmatism. However, further investigations are needed to explore the relationship of screen exposure with different components of astigmatism.

In addition to astigmatism, associated features of intermittent exotropia and an abnormal increase in the near point of convergence were also observed in all cases. Both features are classical signs of convergence insufficiency. Although statistically significant improvement was not observed after treatment for either, relative betterment was observed objectively and subjectively. Studies showed that convergence insufficiency in astigmatic patients was documented, and it may be associated with asthenopia however there was no significant association between them [18].

Rechichi *et.al*., also described a condition depicting a spectrum of features associated with excessive video gaming such as asthenopia along with reduction in stereopsis and labelled it as “Video Game Vision Syndrome” [19]. Since video gaming is becoming a popular hobby and even profession for the younger generation, regular eye examinations

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should be recommended to adequately manage these ocular issues. A study published recently showed that uncorrected astigmatism in children is mostly associated with exodeviation [20].

The comprehension of mechanism for continuous increase in corneal astigmatism associated with screen time exposure is essential to develop effective management plans. All the participants in this study had with the rule astigmatism which is strongly associated with the position and pressure of upper eye lid [21]. Persistent downgaze during screen exposure leads to a continuous pressure on the vertical corneal meridian leading to a steepening in curvature.

Although similar effects should be expected in adults as well; however, children are more prone to these changes because of the lower tensile strength of corneal collage fibers [22], [23]. The halting and progression of astigmatism can be logically explained based on this phenomenon. Additionally, we would like to hypothesize the regression of astigmatism based on this process. Although this study was not able to provide evidence for it; longitudinal studies are needed for investigating this proposed mechanism and its relationship with pattern of astigmatism.

Limitation and Strength of the Study

Small sample size was the major limitation of the study. Furthermore, limited instrumentation and time frame were added weaknesses too. The study highlighted the effect of early screen exposure that can be potentially associated with developing astigmatism and Exodeviation, if left untreated it can be a risk of meridional amblyopia and risk of myopia progression in future.

CONCLUSION

The study concluded that exposure of electronic gadgets in early life of development leads to astigmatism, exotropia and other ocular dimension changes. The degree of exposure is directly proportional to the risk of developing astigmatism. If left uncorrected the condition may lead towards meridional amblyopia and squint.

Data Availability Statement:

The data supporting this study's findings are available on request from the corresponding author, Mutahir Shah. The data are not publicly available due to having information that could compromise the privacy of research participants.

Author Contribution:

Conception and design, data collection, Analysis and Interpretation: Mutahir Shah

Analysis and interpretation, Drafting of the article: Nafees Ahmad

Revising it critically for intellectual content & final approval version: Satheesh Babu Natarajan

All authors agree to be accountable for all aspects of the work.

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