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Pseudo-Myopia and Screen Time: A Pre and Post Cycloplegic Refractive Evaluation of Children age 4–16 years

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Purpose: *to examine the magnitude of pseudo-myopia in relation to pre- and post-cycloplegic refractive status among individuals aged 4 to 16 years and to investigate the relationship of pseudo myopia and screen time in said population.* ***Material and methods.*** *Study included 66 subject's right eyes of 48 % males, 52 % females aged 4–16 with mean and standard deviation of 10.0 ± 3.40. This comparative cross-sectional study was conducted at the department of ophthalmology Tertiary Care Hospital, Islamabad. Consecutive non-randomized sampling techniques was adopted. Screen time duration in hours was measured using self-report or screen time tracking applications in smartphones. Visual acuity (VA) was measured with a standard Log MAR chart. Pre and post cycloplegic refraction with retinoscopy and Auto-refractometer were performed using Tropicamide 1 %. Paired t test was applied for pre and post cycloplegic refraction change, while Pearson correlational analysis was also calculated. Descriptive statistics were calculated using SPSS Version 21.* ***Results.*** *Average screen time was 5.6 ± 1.5 hours, outdoor activity was 50.6 ± 27.3 minutes. Pre-dilation VA improved from 0.3 ± 0.3 to 0.05 ± 0.14 log MAR post-dilation. The mean spherical equivalent refractive error in pre-dilation state was –4.1 ± 2.2 D, while in post-dilation it was 0.76 ± 0.8 D. The differences were significant ($p<0.01$). A statistically significant relationship found between screen exposure time and pseudo-myopia ($r=0.41$, $p<0.001$).* ***Conclusion.*** *Increasing screen time is associated with pseudo-myopia. Prolonged screen exposure led to increased pseudo-myopia in low myopes and hyperopes.*

Keywords: Log-MAR; pseudo-myopia; screen exposure; visual acuity
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Псевдомиопия и экранное время: оценка рефракции детей в возрасте 4–16 лет до и после циклоплегии

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Цель *работы — оценить степень псевдомиопии на основе различия между манифестной и циклоплегической рефракцией у детей в возрасте 4–16 лет и исследовать взаимосвязь псевдомиопии и экранного времени в указанной популяции.* ***Матери-***

ал и методы. *Исследование включало 66 правых глаз детей, из них 48 % мальчиков и 52 % девочек, с манифестной рефракцией (M ± SD) –10,0 ± 3,4 дптр. Сравнительное поперечное исследование проведено в отделении офтальмологии больницы третичного уровня медицинской помощи в Исламабаде. Использовались последовательные нерандомизированные методы выборки. Продолжительность экранного времени в часах измерялась с помощью самоотчета или приложений для отслеживания экранного времени в смартфонах. Острота зрения (ОЗ) измерялась с помощью стандартной таблицы Log MAR. Пре- и постциклоплегическую (с использованием тропикамида 1 %) рефракцию определяли с помощью ретиноскопии и авторефрактометрии. Для сравнительной оценки рефракции до и после циклоплегии применялся парный t-тест, а также корреляционный анализ Пирсона.* ***Результаты.*** *Среднее экранное время составляло 5,6 ± 1,5 ч, активность на открытом воздухе — 50,6 ± 27,3 мин. ОЗ, составлявшая до циклоплегии 0,3 ± 0,3, после циклоплегии улучшилась до 0,05 ± 0,14 Log MAR. Средний сферический эквивалент рефракции до расширения зрачка составлял –4,1 ± 2,2 дптр, после расширения он изменился до 0,76 ± 0,8 дптр (p < 0,01). Связь между экранным временем и псевдомиопией была статистически значимой (r = 0,41, p < 0,001).* ***Заключение.*** *Увеличение экранного времени связано с псевдомиопией. Длительное воздействие экрана вызывает усиление псевдомиопии у детей с миопией слабой степени и гиперметропией.*

Ключевые слова: Log-MAR; псевдомиопия; экранное время; острота зрения
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Pseudo-myopia is a temporary condition where the visual system shows symptoms like myopia (near-sightedness) without any actual refractive error. It is commonly associated with excessive near work and prolonged screen time, particularly in individuals who spend significant amounts of time engaged in activities that require close visual focus, such as reading or using digital devices. The term “pseudo”, derived from the Greek word “pseudes”, which signifies falsehood or error, is used to describe certain temporary manifestations of myopia that are commonly referred to as “pseudo-myopia” [1]. Nevertheless, it is important to note that pseudo-myopia should not be conflated with the concept of “secondary myopia” [2]. The latter encompasses temporary myopic shifts that can be attributed to changes in the refractive index of the lens caused by factors such as cataracts, certain medications, diabetes mellitus [3], hyperbaric oxygen therapy [4], blunt eye trauma resulting in ciliary edema, or myopia associated with systemic syndromes [5].

Overuse of the eye’s accommodating system leads to an increase in ocular refractive power, a condition known as pseudo-myopia. When viewing objects at optical infinity, the ciliary muscle does not completely relax due to either prolonged over-action or other innervation effects. The state of accommodation is not fully relaxed when an object is found at optical infinity, and this condition can be eliminated using complete cycloplegic refraction [1]. This means that as ocular accommodation is relaxed, the eye’s refractive power becomes less myopic and more hyperopic. Clinical symptoms of pseudo-myopia, may also be known as accommodative spasm, include impaired vision, image distortion, photophobia, and ocular pain. The symptoms may manifest as either regular or intermittent occurrences, affecting either one or both eyes [6]. One of the diagnostic signs of pseudo-myopia is the distinction between cycloplegic and non-cycloplegic refraction. Multiple authors have provided definitions of pseudo-myopia as a condition characterized by the sudden onset of apparent myopia, which subsequently resolves upon cycloplegic examination of the eyes [7].

The increasing prevalence of screen usage in modern society has raised concerns about the potential impact of prolonged screen time on visual health, particularly in relation to pseudo-myopia. Therefore, conducting a study to investigate the association between pseudo-myopia and screen time is crucial in understanding this medical dilemma and its implications for public health. Given the widespread use of digital devices and the potential impact of screen time on visual health, addressing the medical dilemma of pseudo-myopia and screen time has significant public health implications.

The **PURPOSE** of the study was evaluating the relationship of pseudo-myopia and excessive screen time in children aged 4–16 years. It will also highlight that why implementation of 20–20–20 rule is important to prevent and promote ocular health.

SUBJECTS AND METHODS

A comparative cross-sectional study was conducted in the Department of Ophthalmology at Tertiary Care Hospital, Islamabad. The study duration spanned four months; from January to April 2024. Consecutive non randomized sampling technique was employed to select participants. The following formula for estimating the sample size of comparing proportions before-and-after study was used.

$$N = (Z/2 \times (P1 \times (1 - P1) + P2 \times (1 - P2)) / (P2 - P1)/2$$

where: N = required sample size, Z = Z-score corresponding to the desired confidence level (e.g., for 95 % confidence, $Z \approx 1.96$), P1 = the estimated prevalence or proportion before cycloplegic refraction (in this case, 24 %, so P1 = 0.24), P2 = the estimated proportion after cycloplegic refraction and (P2 – P1) = the expected change in proportion. The calculated sample size was 12 participants, however due to the number of variables that could affect the results, such as age of participants, 66 participants were enrolled during the study duration followed the patient selection criteria. Pseudo-myopia was operationally defined as a spherical equivalent (SE) ≤ –0.50 D prior to cycloplegia, and ≥ –0.50 D following cycloplegia [8]. The study protocol received approval from the ethics committees of the Tertiary Care Hospital Islamabad under letter no: XXX-HI-PUB-ERC/June 24/13 and followed the principles set out in the Declaration of Helsinki. Informed consent was obtained from the participants as well as from their guardians in case of younger children.

Participants aged between 4–16 years were included, encompassing both genders. Their age and outdoor activities were assessed and recorded. Individuals with pre-existing eye conditions, astigmatism > –0.50 D, previous eye surgeries, head trauma, motor nerve diseases, psychiatric illnesses, or using tricyclic antidepressants/ low potency psychoanalytic drugs were excluded from the study. Moreover, all systemic and ocular conditions affecting ocular accommodation response were excluded. Screen time duration in hours was measured using self-report or screen time tracking applications in smartphones, particularly focusing on near visual activities like studying, gaming and social media use and other tasks. Priority was given to tracking applications and this was the more common method of data collection as it was utilized in 90.9 % (60/66) of the total cases. Data for screen time for the last seven days was obtained from the application and the average was utilized in this study. In the rest of the cases, the parents were asked to provide an average duration of screen time for their child during the last week. Visual acuity (VA) was evaluated using the log MAR alphabetic chart. Complete objective and subjective pre dilation refraction were conducted. The objective refraction was done through (Nidek ARK-1) autorefractor which was then confirmed by non-cycloplegic retinoscopy. This was followed by subjective refraction starting with visual acuity and then subjective verification of the prescription obtained through retinoscopy and autorefractor. Following the initial procedures, objective refraction was performed by administering tropicamide 1 % eye drops [9]. Although tropicamide 1 % is a week cycloplegic agent, however; it can be used as a weak alternative to cycloplegic drugs [10, 11]. The drops were usually given with a 5-minute interval between each dose for three times. Cycloplegia generally begins within 15 to 30 minutes after the final drop, allowing for an effective paralysis of the ciliary muscles.

The selection of tropicamide 1 % was based on its favourable characteristics, including its rapid onset of action in inducing dilatation and its prompt and brief recovery period. Moreover, it was easy to obtain informed consent for tropicamide rather than cyclopentolate because of its short-lasting effect. After 30–45 minutes of waiting time, they were followed by subsequent refractive error assessments using the autorefractor, retinoscopy, and final subjective refinement.

Descriptive statistics, such as mean and standard deviation, were calculated for pre- and post-dilation refractive errors, visual acuity, screen time, and age. The data was normally distributed so Paired t-tests were applied to compare the differences in refractive errors before and after dilation. A 95 % confidence interval was constructed to estimate the population parameter, and the p-value was calculated separately to assess the significance of the observed results. Pearson's correlation test was opted to assess the relationship of pseudo-myopia with age, outdoor exposure time, daily screen time exposure, pre and post dilation visual acuity.

RESULTS

66 patients' right eyes were included in the study. Out of these participants, 48 % (n = 32) were males and 52 % were females (n = 34). Participants' ages ranged from 4 to 16 years, with a mean age and standard deviation of 10.0 ± 3.4 years. On average, participants had a screen time of 5.6 ± 1.5 hours. In contrast, the mean time spent by participants in outside activities was 50.6 ± 27.3 minutes (Table 1). The average pre-dilation VA along with standard deviation in right eyes was about 0.30 ± 0.30 log MAR (Range = 0.00 to 0.80) which improved to 0.05 ± 0.14 log MAR after dilation. The mean refractive error (spherical equivalent) identified during dry retinoscopy (pre-dilation) and refined was –4.1 ± 2.2 DS (Range = 0.00 to –11.50 DS) while the post dilation mean refractive error was 0.76 ± 0.80 DS ranging from -3.50 to +2.00 DS (Table 1).

The paired samples t-test was applied to compare the mean difference between pre-dilation refractive error and post-dilation refractive error. The results in Table 2 showed a significant difference between the two measures ($p < 0.01$).

Table 1. Descriptive statistics showed average age, screen time, outdoor activities pre and post cycloplegic visual acuity along with pre and post cycloplegic refractive status
Таблица 1. Описательная статистика среднего возраста, экранного времени, активности на открытом воздухе, остроты зрения и рефракции до и после циклоплегии

Variable Переменная	Mean [SD] Среднее значение	Range Диапазон	
		minimum мин	maximum макс
Age, years Возраст, лет	10.0 [3.4]	4	16
Screen time, hours Экранное время, ч	5.6 [1.5]	3	8
Outdoor Exposure time, minutes Активность на открытом воздухе, мин	50.6 [27.3]	30	120
Pre-Dilation Visual Acuity (log MAR) Острота зрения до циклоплегии	0.3 [0.3]	0.0	0.8
Post-Dilation Visual Acuity (log MAR) Острота зрения после циклоплегии	0.05 [0.14]	0.0	0.7
Pre-Dilation Spherical Equivalent (DS) Сферический эквивалент рефракции до циклоплегии	–4.1 [2.2]	0.0	–11.5
Post-Dilation Spherical Equivalent (DS) Сферический эквивалент рефракции после циклоплегии	0.76 [0.8]	–3.5	+2.0

Table 2. Results of paired t-test in pre- and post-cycloplegic spherical equivalent refractive difference (D)
Таблица 2. Результаты парного t-теста различий пре- и постциклоплегического сферического эквивалента рефракции (дптр)

Variable Переменная	Mean [SD] Среднее значение		t-test (df)	p-value
	pre-dilation до циклоплегии	post-dilation после циклоплегии		
Spherical Equivalent Сферический эквивалент	–4.1 ± 2.2	0.7 ± 1.0	–16.0 (65)	< 0.01

Table 3. Correlation analysis results of related variables with magnitude of pseudo-myopia
Таблица 3. Результаты корреляционного анализа связанных переменных с величиной псевдомиопии

Variables Переменная	Correlation Coefficient (r)	p-value
Age Возраст	–0.06	0.78
Pre-dilation visual acuity Острота зрения до циклоплегии	0.09	0.48
Post-dilation visual acuity Острота зрения после циклоплегии	0.13	0.28
Daily screen time Ежедневное экранное время	0.41	< 0.001*
Outdoor Activities Активность на открытом воздухе	0.05	0.75

Note. * — correlation is significant.
Примечание. * — корреляция достоверна.

The variables of age (r = –0.04), excessive screen time (r = 0.41), and outdoor time (r = 0.05) were analysed through Pearson's correlation to assess their relationship with the magnitude of pseudo-myopia. Out of these variables only daily screen time had a statistically significant relationship. It showed a positive correlation meaning, if you use more screen time exposure, there will be a greater chance of developing pseudo-myopia (Table 3).

DISCUSSION

This study was conducted to find the magnitude of pseudo-myopia in children and to identify the relationship of screen time and outdoor exposure time with it. It highlighted that with excessive screen time is associated with pseudo myopia. The study further showed that most of the eyes (n = 57) reverted to hyperopia. The study also find that magnitude of pseudo-myopia had a strong association with screen time (r = 0.41, p-value = <0.01).

Pseudo-myopia has been identified as one of the independent risk factors for development of myopia in future [9]. It has been reported that children who manifest pseudo-myopia have a 3.03 times higher chance of developing myopia and majority of those children had axial variant of the myopia [8]. Although large evidence-based studies have not supported this theory, the concept of myopia development secondary to persistent accommodative spasm exists in the current literature. The theory goes that the extreme contraction of ciliary muscles pulls the choroid inward and forward. This leads to restriction of equatorial growth of eye decreasing the circumference of sclera which leads to more prolate changes in the eye [12]. Thus, persistent near work affects the growth pattern of eyeball which leads to development of myopia.

This study reported a significant relationship between screen time and magnitude of pseudo-myopia. This is logical as the risk of ciliary spasm increases with increase in near work. A study by Z. Lin, et al [13] showed that near work induced transient myopia is common in near work-related activities. The results of this study were relevant to our study. Our study has revealed a significant association between individuals with hyperopic refractive errors and an increased susceptibility to pseudo-myopia. This intriguing finding can be attributed to the fact that those with hyperopia tend to exert more effort in accommodating their vision for distant objects. In essence, hyperopic individuals typically must accommodate more than individuals with normal vision to bring distant objects into focus, which, over time, can lead to an over exertion of their accommodative system. Therefore, these children are more prone to pseudo-myopia as compared to myopics. Similar results have also been reported in the literature as well [14, 15]. Literature showed that rise in pseudo-myopia among individuals with hyperopic refractive errors may be attributed to a recent surge in near work activities, specifically, the increased use of electronic devices in the modern technological era [14, 16].

The current study documented that those children with pseudo-myopia had reduced visual acuity even with full correction before cycloplegia. After cycloplegia, these children showed a BCVA of 0.04 or better. Unaided distance visual acuity and the degree of myopia were closely correlated, as published by M. García-Montero, et al [1]; however, this association fails in the presence of pseudo-myopia. Accommodation-related variations in visual acuity, the retinoscopic reflex, and occasionally changes in pupil width can all be indicative of fluctuations in distance visual acuity. Literature showed that blurring of vision occurs in children with pseudo-myopia and in future it may lead to early onset or development of myopia [9]. The possible reason for the phenomena was the formation of clear and stable retinal images that may be affected by an inaccurate accommodating response in children with pseudo-myopia, leading to blurry retinal images that may encourage decrease visual acuity. Excessive accommodation due to the result of prolonged near work or excessive digital device use, occurs when an individual consistently focuses on a closer distance than the norm. This condition can lead to symptoms such as fatigue, eye strain, dizziness, headaches, difficulties in concentration, and related discomfort. It is especially relevant for schoolchildren and IT sector professionals who spend extended periods engaged in near work, studies showed [17, 18]. Studies published previously showed that children without cycloplegic refractions give overestimation of myopia and under correction of hyperopia [19–21].

The excessive tension of accommodation, especially in children and adolescents with pseudo-myopia, plays a critical role in affecting retinal defocus and altering the eye's wavefront structure. This tension is often associated with an overactive ciliary muscle, which leads to persistent contraction and changes in the lens's shape. When this happens, the lens becomes more convex, increasing its refractive power and causing a shift towards myopic defocus. This prolonged accommodative stress can result in a form of temporary myopia, or pseudo-myopia, where the eye experiences near-sightedness even when viewing distant objects. Over time, the repeated strain and changes in the lens may exacerbate the progression of true myopia, particularly during the critical development phase in children and adolescents. The wavefront aberrations caused by these changes in the lens curvature can lead to suboptimal retinal image quality, further contributing to the progression of myopia by encouraging elongation of the axial length of the eye, which is a known risk factor for myopia development [22].Thus, the interplay between excessive accommodative tension, retinal defocus, and wavefront distortions underscores the importance of early intervention in managing pseudo-myopia to prevent its progression into permanent myopia in younger populations [22, 23]. This highlights the role of cycloplegic agents like tropicamide in breaking the accommodative spasm, providing more accurate refractive measurements, and preventing further structural and functional changes in the eye.

The study had strengths as well as limitations. The targeted research question for this study had limited work to the best of our abilities. Moreover, work focused on this age group is especially scarce from the developing countries. In contrast, the study's limitations include the administration of tropicamide 1 % as a mild cycloplegic drug, a limited sample size, and the absence of randomization.

CONCLUSION

This study provides valuable insights into the magnitude of pseudo-myopia and factors associated with it in children. The most notable finding was the substantial occurrence of pseudo-myopia in the studied population, where a significant shift from myopia to hyperopia was observed after cycloplegia. Moreover, an association with increased screen time and the magnitude of pseudo-myopia was also observed. Although further studies with larger sample sizes are warranted to assess this relationship, in era of gadgets screen time in children should be regularly inquired and 20–20–20 rule should be followed.

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