

Impact of online classes and home confinement on myopia progression in children during COVID-19 pandemic: Digital eye strain among kids (DESK) study 4

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Purpose: This study was performed to compare the rate of progression of myopia before and during the COVID-19 pandemic and to assess the risk factors of hastened progression. **Methods:** All children with myopia of spherical equivalence ≤ -0.5 D with at least two prior documented refractions 6 months and 1 year before were included. The annual progression rate before COVID-19 and during COVID-19 was calculated. Annual myopia progression was categorized as no progression (0), slow progression (<1 D), and fast progression (≥ 1 D). **Results:** A total of 133 children (266 eyes) aged 6–18 years were included in the study. Mean annual myopia progression was found to be statistically significant during COVID-19 as compared with pre-COVID-19 (0.90 vs 0.25 D, $P < 0.00001$). A total of 45.9% of children showed an annual progression of ≥ 1 D during the pandemic as compared with 10.5% before the COVID-19 ($p < 0.00001$). In multivariate analysis, history of rapid progression in pre-COVID-19 era ($P = 0.002$) and sun exposure <1 h/day ($P < 0.00001$) were found to be independent risk factors for rapid myopia progression. **Conclusion:** Parents should consider risk of rapid myopia progression in children during current pandemic and children should be provided with socially distant outdoor activities to increase their sun exposure and diminish the rate of myopia progression.

Key words: Children, COVID-19 pandemic, digital eye strain, myopia, myopia progression

Community- and school-based epidemiological studies have found that near work is related to a higher prevalence and degree of myopia.^[1] It has been found that reading at a closer distance makes children more prone to myopia as well as a delay in myopia stabilization until at a very late age.^[2]

During the COVID-19 pandemic, e-learning has been the only studying option for school-aged children and has required children to adjust to online classes. To prevent the spread of infection, restrictions on social gatherings have been imposed, resulting in less outdoor activities. Major changes in daily life during the COVID-19 era have increased children's screen time and home confinement.^[3] There was a marked increase in screen time among children, as reported in several studies during this pandemic. The digital eye strain among kids (DESK) study 1 reported that the duration of digital device use during the COVID-19 era increased to 3.9 ± 1.9 h during the pandemic as compared with 1.9 ± 1.1 h prior to the COVID-19 era.^[4] Montag *et al.*^[5] reported that children's screen time increased by 4.85 h per day during the pandemic.

As a result of the prolonged use of digital devices, there may soon be an increase in ocular health-related issues such as digital eye strain, accommodation-vergence dysfunction, dry eye-related

complications, and myopia progression in children.^[6] Evidence suggests that sustained near work on digital devices and less outdoor activities are important factors in the progression of myopia.^[7,8] It has been estimated that the prevalence of myopia will increase to affect approximately 50% of the world's population by 2050.^[9] The current lockdown during the pandemic can hasten this estimation because of the accompaniment of prolonged screen time and home confinement. The term "quarantine myopia" has been coined and discussed among eye care professionals in editorials and commentaries of various platforms and journals.^[10] However, there is a lack of scientific studies comparing myopia progression before and during lockdown.

The aim of the current study was to compare the rate of progression of myopia before and during the COVID-19 pandemic and to assess the risk factors of hastened progression.

Methods

The study was conducted at a tertiary eye care center in central India. The study was approved by the institutional review board and adhered to the tenets of the Declaration of Helsinki. All consecutive children younger than 18 years of age

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presenting with myopia in the study period between November 2020 and January 2021 were eligible for the study. Inclusion criteria consisted of spherical equivalence (SE) ≤ -0.5 D under cycloplegic conditions with at least two prior documented refractions 6 months and 1 year before. Patients using atropine (0.01%) eye drops during the study period were excluded from this study. The presence of myopia related to collagen disorders, retinal dystrophies, or any previous ocular surgeries were excluded. After providing written informed consent from legal guardians or parents, all parents of eligible children received a questionnaire [Annexure 1]. The questionnaire was designed to obtain information regarding the mean daily duration of online classes, outdoor activities, playing video games, and watching television. All information was recorded both before and during the COVID-19 era lockdown. The questionnaires were completed by the parents independently with the help of the investigator.

A standardized ophthalmological examination was performed at every visit. Best-corrected visual acuity was assessed using a visual acuity chart at a distance of 6 m. The refractive error was measured with a Topcon auto refractor KR8900 (Topcon, Tokyo, Japan) and confirmed via retinoscopy with a Heine beta 200 retinoscope (Heine Optotechnik, Herrsching, Germany). Glasses were prescribed according to the standard protocols. The same devices were used during each visit. SE was calculated using the formula: SE = sphere + 1/2 cylinder. For analysis purposes, refractive errors were converted into SE. Myopia was further categorized as high (≥ -6.0 D), moderate (-3 to -5.9 D), or low (< -3.0 D).

In each patient, data regarding refractive errors were taken at three different time frames. A: at current visit (between November 2020 and January 2021), B: visit 6 months prior (May 2020 to July 2020), and C: visit 1 year prior (November 2019 to January 2020). E-learning was started at majority places around visit B, and duration between A and B constituted COVID-19 era, while duration between B and C constituted pre-COVID-19 era. The average value of refractive error from the right and left eye was taken during the final analysis of myopia progression.

The annual progression rate pre-COVID-19 was calculated by subtracting the SE at baseline (visit C) from the SE at 6 months before (visit B) for each participant and multiplying the result by 2. The progression rate during the COVID-19 era was calculated by subtracting the SE at 6 months prior (visit B) from the SE at the present time (visit A) and multiplying the result by 2. Annual myopia progression was categorized as no progression (0), slow progression (< 1 D), and fast progression (≥ 1 D).

Statistical analysis

All collected data were entered in Microsoft Excel (Microsoft Corporation, USA). Quantitative variables were presented as mean \pm standard deviation, while qualitative variables were presented as numbers and percentages. Proportions were calculated, and data before and during the COVID-19 era were compared using Fisher's exact test. Biometric measurements of the eyes were analyzed using the Mann-Whitney *U* nonparametric test. Statistical significance was set at $P < 0.05$.

The potential risk factors for myopia progression would be the same for both eyes in a subject. Considering only one eye for the analysis may result into selection bias and waste of data. Hence, we first analyzed correlation of refractive error

between the right and left eyes of the same subject. Pearson correlation coefficient analysis revealed a strong positive correlation (R -value > 0.8) for refractive error among eyes at all visits. Subsequently, we took average value of refractive error from the right and left eye in a subject for further analysis. The risk of rapid progression of myopia (≥ 1 D) was estimated using regression analysis. Multivariate and bivariate logistic regression analysis was used to determine the risk of myopia progression with age, sex, positive family history, high baseline myopia of ≥ 6 D, history of rapid progression prior to COVID-19 lockdown, duration of screen time, duration of online classes, time spent for watching television and playing video games, and sun exposure. All statistical tests were performed using IBM SPSS Statistics for Windows, version 21.0. (IBM Corp., Armonk, NY, USA).

Results

A total of 133 children (266 eyes) aged 6–18 years were included in the study. There were 81 boys (60.9%) and 52 girls (39.1%). In total, 67.7% ($n = 90$) of the children attended online classes, mostly on smartphones. Table 1 shows the demographics and baseline characteristics of the children included in the study.

Mean SE error was -4.54 ± 2.70 D before the COVID-19 pandemic and increased to -5.12 ± 2.70 D during the pandemic. Table 2 presents comparison of variables during the pre-COVID-19 and COVID-19 eras. Outdoor playing was completely restricted for all children during the pandemic. There was a marked reduction in sun exposure ($P < 0.00001$) and an increase in the duration of mobile game playing ($P < 0.0001$) during COVID-19 period. Children's online class activities were not compared in our study because there were no online classes before the COVID-19 pandemic.

The number of children who used smartphones for video games less than 1 h per day decreased from 60 (45.11%) to 22 (16.54%), while those who used smartphones for 1–2 h per day increased from 70 (52.63%) to 91 (68.42%), and those who used smartphones for over 2 h per day increased from 3 (2.3%) to 20 (15.1%).

When comparing the data of myopia progression before and during the COVID-19 pandemic, 62.4% of the children showed progression during the pandemic as compared with 45.9% before the pandemic ($P = 0.006$). Mean annual myopia progression was found to be statistically significant during COVID-19 as compared with pre-COVID-19 period (0.90 vs 0.25 D, $P < 0.00001$). Table 3 presents the mean progression of myopia before and during lockdown. A total of 45.9% of children showed an annual progression of ≥ 1 D during the pandemic as compared with 10.5% before the COVID-19 pandemic ($P < 0.00001$). There were 10 patients with significant anisomyopia (difference of ≥ 1.5 D) in our study. Mean increase in myopic error in eye having greater error was 0.83 D, while the same in eye with lesser error was 0.75 D ($P = 0.82$). This indicates that anisometropia did not have any influence on the progression of refractive error.

All risk factors of myopia progression of ≥ 1 D according to the regression analysis are presented in Table 4. Bivariate analysis showed that prior history of rapid progression, reduced sun exposure, and excessive mobile usage were associated with rapid myopia progression. In multivariate

Table 1: Baseline information and details of online classes

Variables	Number (%)
Patients included	266 eyes of 133 children
Mean±SD (range), age of subjects in years	13.38±3.29 (6-18)
Number of patients in different age groups	
<10 years	27 (20.3)
10-14 years	50 (37.6)
≥ 15 years	56 (42.1)
Gender	
Male	81 (60.9)
Female	52 (39.1)
History of myopia in parents/sibling	18 (13.5)
Mean±SD (range), age at child started wearing glasses (years)	9.39±3.3 (1-18)
Number of children attending online classes	90 (67.7)
Mean±SD (range), duration of online classes (h/day)	2.9±1.67 (1-5)
<4 h/day	62 (68.9)
≥ 4 h/day	28 (31.1)
Device used for online classes	
Smart phone	87 (96.7)
Desktop	1 (1.1)
Both smartphone and desktop	2 (2.2)
Duration of single online class	
≥ 45 min	59 (65.6)
<45 min	31 (34.4)

Table 2: Comparison of factors before and during COVID-19 period

	Pre-COVID-19 baseline, n (%)	During COVID-19 current, n (%)	P
Mean±SD myopia: SE (D)	-4.54±2.70	-5.12±2.70	
Low myopia (-0.5 to -2.9 D)	42 (31.6)	27 (20.3)	0.035
Moderate myopia (-3.0 to -5.9 D)	51 (38.3)	59 (44.4)	0.319
High myopia (≥ -6.0 D)	40 (30.1)	47 (35.3)	0.360
Outdoor playing			
<1 h/day	5 (3.8)	133 (100)	-
1-2 h/day	50 (37.6)	0	
≥ 2 h/day	78 (58.6)	0	
Sun exposure			<0.00001
<1 h/day	6 (4.5)	99 (74.4)	
1-2 h/day	13 (9.8)	28 (21.1)	
≥ 2 h/day	114 (85.7)	6 (4.5)	
Mobile use for games			<0.00001
<1 h/day	60 (45.1)	22 (16.5)	
1-2 h/day	70 (52.6)	91 (68.4)	
≥ 2 h/day	3 (2.3)	20 (15.1)	
Television use			0.00006
<1 h/day	5 (3.8)	10 (7.5)	
1-2 h/day	98 (73.7)	63 (47.4)	
≥ 2 h/day	30 (22.5)	60 (45.1)	

SE=spherical equivalent

Table 3: Myopia progression

	Before lockdown	After lockdown	P
Myopia progression, n (%)	61 (45.9)	83 (62.4)	0.006
Mean myopia progression in D, Standard error	0.12±0.18 (0-1) 0.01	0.45±0.48 (0-3) 0.04	<0.00001
Mean annual progression (D)	0.25	0.90	<0.00001
≥ 1 D annual progression, n (%)	14 (10.5)	61 (45.9)	<0.00001

D=dioptr

Table 4: Multivariate logistic regression analysis of risk factors for rapid myopia progression during COVID-19 lockdown period

Risk factor for >1 D myopia progression	Odds ratio	Bivariate, P	Multivariate, P
Age >10 years	2.37	0.057	0.57
Male gender	1.26	0.50	-
Family history of myopia	1.21	0.70	-
Baseline high myopia	0.62	0.204	-
History of rapid progression prior to COVID-19	8.57	0.001	0.002
Online classes \geq 4 h/day	0.85	0.71	-
Duration of single online class \geq 45 min	0.99	0.98	-
Sun exposure <1 h/day	23.01	<0.00001	<0.00001
Mobile use for video games \geq 1 h/day	3.46	0.01	0.50
Watching television \geq 2 h/day	1.73	0.11	0.18

D=dioptr

analysis, history of rapid progression in the pre-COVID-19 era ($P = 0.002$) and sun exposure <1 h per day ($P < 0.00001$) were found to be independent risk factors for rapid myopia progression of ≥ 1 D.

Discussion

The COVID-19 pandemic in 2020 has led to the complete closure of schools and playgrounds, and restrictions on social gatherings and outdoor activities, a state termed as "lockdown." In India, complete lockdown was announced in the last week of March 2020 and continued for almost a year because of lockdown, school-aged children were confined to their homes from April to October 2020, and e-learning in the form of online classes began. Therefore, there was an increase in children's screen time and indoor activities, as well as a decrease in their outdoor activities.^[11]

During the COVID-19 pandemic, there was a marked increase in screen time among children, with one study reporting that it increased by about 30 h/week.^[4,5] Because of restricted outdoor activity during the pandemic, children used their smartphones for extended hours to play video games and browse the Internet during leisure time. A similar finding was reported by Sun *et al.*^[12] in China during the COVID-19 pandemic. Studies have also reported that fourth-to sixth-grade children use smartphones frequently for online learning and social media.^[12,13] In our study, 96.7% of children were using smartphones to attend online classes, which was found as a risk factor for the progression of myopia.

The mean annual progression of myopia in our cohort was 0.90 D during the COVID-19 pandemic. When analyzing the risk factors of rapid progression ≥ 1 D/year, modifiable risk factors that were found to be significant were sun exposure <1 h/day and smartphone use for video games ≥ 1 h/day. A study by Chang *et al.*^[14] found that there was accelerated myopic progression during the COVID-19 pandemic lockdown in children and teenagers. Home confinement during the COVID-19 pandemic appeared to be associated with a significant myopic shift for children aged 6–8 years old according to 2020 school-based photoscreenings conducted in 10 elementary schools in Feicheng, China.^[15] Compared with these, much less annual progression of myopia was reported in some studies of pre-COVID-19 era.^[16,17]

Decreased outdoor activity is a significant risk factor for a higher incidence of myopia in children.^[18] In our study, home confinement in the form of less sun exposure was found to be the most important risk factor for the rapid progression of myopia during the COVID-19 pandemic. Data have shown that time spent outdoors had a protective effect on myopia progression in children.^[19,20] Wu *et al.*^[21] found a 54% lower risk of myopia progression in children who spent ≥ 11 h per week outdoors.

In bivariate analysis, video game playing on smartphones ≥ 1 h per day was also found to be a significant risk factor for rapid annual myopia progression during the COVID-19 pandemic (OR = 3.46, $P = 0.01$). As a consequence of lockdown, most children spent their time indoors, leading to video game playing on smartphones and in turn to the overstimulation of accommodation, which increases the risk of myopia.^[22]

Rapid progression of myopia was found more in children older than 10 year of age, this difference almost reached statistical significance in bivariate analysis (0.057). It might be possible that older children spent more time on mobile for education and or leisure purposes than younger children. Contrary to this, Wang *et al.*^[15] found that the progression of myopia appeared to be two times higher for children less than 8 years of age. They hypothesized that younger children may be more sensitive to environmental changes than older children. However, they used photo screening rather than cycloplegic refraction method.

Among nonmodifiable risk factors, children with a history of rapid progression of myopia before COVID-19 had a marked increase in SE during the COVID-19 pandemic (OR = 8.57; $P = 0.001$). The mean annual progression during the pandemic in these children (rapid progressor) was almost two times higher than that prior to COVID-19 (mean annual progression = 2.2 D vs. 1.1 D). This finding also indicates that modifiable risk factors that mostly changed during the COVID-19 pandemic negatively affected the rate of myopia progression in school-going children.

Major limitations of our study include the small sample size and the hospital setting, which does not reflect the real burden and risk of the community. It is the first of its kind to compare progression in the same cohort before and during the COVID-19 pandemic.

Conclusion

To conclude, parents and teachers should consider myopia progression in school-aged children and children should be provided with socially distant outdoor activities to increase their sun exposure and diminish the rate of myopia progression.

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Conflicts of interest

There are no conflicts of interest.

References

1. Wong L, Coggon D, Cruddas M, Hwang CH. Education, reading, and familial tendency as risk factors for myopia in Hong Kong fishermen. *J Epidemiol Community Health* 1993;47:50-3.
2. Hepsen IF, Evereklioglu C, Bayramlar H. The effect of reading and near-work on the development of myopia in emmetropic boys: A prospective, controlled, three-year follow-up study. *Vision Res* 2001;41:2511-20.
3. Available from: <https://www.unicef.org/press-releases/dont-let-children-be-hidden-victims-covid-19-pandemic>. [Last accessed on 2021 Nov 29].
4. Mohan A, Sen P, Shah C, Jain E, Jain S. Prevalence and risk factor assessment of digital eye strain among children using online E-learning during the COVID-19 pandemic: Digital eye strain among kids. *Indian J. Ophthalmol* 2021;69:140-4.
5. Montag C, Elhai JD. Discussing digital technology overuse in children and adolescents during the COVID-19 pandemic and beyond: On the importance of considering affective neuroscience theory. *Addict Behav Rep* 2020;12:100313.
6. Portello JK, Rosenfield M, Bababekova Y, Estrada JM, Leon A. Computer-related visual symptoms in office workers. *Ophthalmic Physiol Opt* 2012;32:375-82.
7. Ip JM, Saw SM, Rose KA, Morgan IG, Kifley A, Wang JJ, *et al.* Role of near work in myopia: Findings in a sample of Australian school children. *Invest Ophthalmol Vis Sci* 2008;49:2903-10.
8. Scheiman M, Zhang Q, Gwiazda J, Hyman L, Harb E, Weissberg E, *et al.* Visual activity and its association with myopia stabilisation. *Ophthalmic Physiol Opt* 2014;34:353-61.
9. Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, *et al.* Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. *Ophthalmology* 2016;123:1036-42.
10. Pellegrini M, Bernabei F, Scorcia V, Giannaccare G. May home confinement during the COVID-19 outbreak worsen the global burden of myopia?. *Graefes Arch Clin Exp Ophthalmol* 2020;258:2069-70.
11. Available from: https://en.wikipedia.org/wiki/COVID-19_lockdown_in_India. [Last accessed on 2021 Nov 29].
12. Sun Y, Li Y, Bao Y, Meng S, Sun Y, Schumann G, *et al.* Brief Report: Increased addictive internet and substance use behavior during the COVID-19 pandemic in China. *Am J Addict* 2020;29:268-70.
13. Lee EJ, Kim HS. Gender differences in smartphone addiction behaviors associated with parent-child bonding, parent child communication, and parental mediation among Korean elementary school students. *J Addict Nurs* 2018;29:244-54.
14. Chang P, Zhang B, Lin L, Chen R, Chen S, Zhao Y, *et al.* Comparison of the myopic progression before, during and after COVID-19 lockdown. *Ophthalmology* 2021;128:1655-7.
15. Wang J, Li Y, Musch DC, Wei N, Qi X, Ding G, *et al.* Progression of myopia in school-aged children after COVID-19 home confinement. *JAMA Ophthalmol* 2021;139:293-300.
16. Fan DSP, Lam DSC, Lam RF, Lau JTF, Chong KS, Cheung EYY, *et al.* Prevalence, incidence, and progression of myopia of school children in Hong Kong. *Invest Ophthalmol Vis Sci* 2004;45:1071-5.
17. Zadnik K, Mutti DO, Friedman NE, Adams AJ. Initial cross-sectional results from the Orinda longitudinal study of myopia. *Optom Vis Sci* 1993;70:750-8.
18. Wang G, Zhang Y, Zhao J, Zhang J, Jiang F. Mitigate the effects of home confinement on children during the COVID-19 outbreak. *Lancet* 2020;395:945-7.
19. Jones LA, Sinnott LT, Mutti DO, Mitchell GL, Moeschberger ML, Zadnik K. Parental history of myopia, sports and outdoor activities and future myopia. *Invest Ophthalmol Vis Sci* 2007;48:3524-2.
20. Khader YS, Batayha WQ, Abdul-Aziz SM, Al-Shiekh-Khalil MI. Prevalence and risk indicators of myopia among school children in Amman, Jordan. *East Mediterr Health J* 2006;12:434-9.
21. Wu PC, Chen CT, Lin KK. Myopia prevention and outdoor light intensity in a school-based cluster randomized trial. *Ophthalmology* 2018;125:1239-50.
22. Navel V, Beze S, Dutheil F. COVID-19, sweat, tears... and myopia?. *Clin Exp Optom* 2020;103:555.

Annexure 1

Myopia progression in children (Digital eye strain in kids study-4) Questionnaire

Name

Age in years

Sex

Family history of myopia

In which class child is studying

At what age child had started wearing glasses

Is child attending online classes?

How many hours child is attending online classes?

Which device child is using for online classes?

What is average duration of single online class?

What is average distance of digital device from eye during online classes

Indicate duration of hours **During lockdown** **Before lockdown**

Outdoor playing

Sun exposure

Online classes

Videogame

Watching TV

School hours

other activity on smartphone

Glass power in SE **Right eye** **Left eye**

At present

6 months before

1 year before

1.5 year before

2 year before