Special Focus, Pediatric Ophthalmology, Original Article

Steep increase in myopia among public school-going children in South India after COVID-19 home confinement

Krishnamurthy Saara, Saravanan Swetha, Rangavittal Subhiksha, Murali Amirthaa, Narayanan Anuradha

Purpose: Novel coronavirus has brought huge changes in lifestyle, especially among children. Reports indicate that the prevalence of refractive errors among children has increased due to home confinement. Hence, this study was done to understand the current status of refractive errors among children from public schools in southern India. **Methods:** This cross-sectional study was conducted as part of school eye screening conducted between September and October 2021. Children between 14 and 17 years of age from public schools underwent a three-phased comprehensive eye examination. Children identified with refractive errors and an equal proportion of children without any refractive errors underwent a survey on outdoor activities. Prevalence estimates and 95% confidence interval were calculated. Chi-square tests and regression analysis were used to understand the association between refractive error and other variables. **Results:** From the data of 3,850 (90.69%) children, the prevalence of vision impairment, refractive errors, and myopia in at least one eye was found to be 12.83% (n = 494), 21.51% (n = 828), and 19.53% (n = 752), respectively. The average myopic spherical equivalent error was found to be -2.17 ± 1.11D (range:-0.50 D to -14.00 D). Almost 96.82% of girls had less than 3 h of outdoor activities. Refractive errors were 7.42 and 2.77 times more (95% CI: 3.51-15.70), $P < 0.001$) among children who had outdoor activities less than 3 h per day and sleep less than 7 h per day. **Conclusion:** Comparing to previous studies from North Indian and South Indian public schools, this study reports a three- to six-fold rise in myopia post-home confinement among public school children from India.

Key words: COVID-19, home confinement, myopia, refractive errors, school children

Access this article online

Website: www.ijo.in

DOI: 10.4103/ijo.IJO_40_22

Quick Response Code:

The outbreak of the novel coronavirus in December 2019 brought about a nationwide lockdown in India from March 2020.[1] Like all other countries, school children in India were also confined to their homes and shifted to the online mode of education.[2] Reduced outdoor activities and increased screen time have already been attributed to the exponential increase of myopia in children.[3-6] In the pre-COVID era, the prevalence of vision impairment was found to vary between 2.05 and 13.6 per thousand children and refractive error was 10.8% in Indian children.[7,8] Recent studies conducted in China have reported that the prevalence of myopia has increased 1.4 – 3 times following home confinement.[9-11] Such an increase in prevalence has also been reported in other studies conducted in India and Spain.[12,13] But the studies from India that report the current rate of vision impairment or refractive errors among children are sparse. With the rising concerns on whether the lockdown has worsened the burden of refractive error in children, this study aimed to understand the current rate of prevalence of refractive error among school-going children in South India. The study also profiled the hours of outdoor activities, screen time, and sleep duration of these children.

Methods

Study setting and sample

This cross-sectional school-based screening and eye examination was conducted between September and October 2021 in the South Indian state of Tamil Nadu. Schools started functioning following COVID-19 relaxations for classes 9 – 12 from September 1, 2021.[14] The study followed the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of the Vision Research Foundation, Chennai, India. The permission for the conduct of the screening was obtained from the State Department of Health and consent for screening was obtained from school authorities. Informed consent was obtained from the parents of children who needed further management. Five public schools from two districts that gave consent for the screening were included in the study. The two districts were Chennai, the capital city of Tamil Nadu and Kanchipuram, an adjacent district.

Screening protocol

All the children present in the schools underwent a comprehensive screening[15] and examination within the

Elite School of Optometry, Unit of Medical Research Foundation, Chennai, Tamil Nadu, India

Correspondence to: Dr. Narayanan Anuradha, Principal – Elite School of Optometry, 8, G S T Road, St Thomas Mount, Chennai - 600 016, Tamil Nadu, India. E-mail: anun@snmail.org

Received: 08-Jan-2022 Revision: 21-Feb-2022
Accepted: 10-May-2022 Published: 29-Jul-2022

Cite this article as: Saara K, Swetha S, Subhiksha R, Amirthaa M, Anuradha N. Steep increase in myopia among public school-going children in South India after COVID-19 home confinement. Indian J Ophthalmol 2022;70:3040-4.

school premises following recommended COVID guidelines. The screening model had three phases. The first phase of the screening was conducted by optometry interns which included basic vision testing using pocket vision screener,[16] screening for refractive errors and/or ocular misalignment using the Welch Allyn ® Spot ® Vision Screener[17] and screening for external and anterior segment abnormalities with a torchlight. Children who were unable to read the optotype in the pocket vision screener (Snellen equivalent 6/9) and/or children who were identified with refractive error using the auto-refractor, and children who were previous spectacle users were examined in the second phase for the refractive correction. This phase was managed by optometrists and comprised of detailed eye examination including vision testing with an internally illuminated log MAR chart, objective refraction using retinoscopy, and subjective acceptance. Spectacles were provided free of cost to children identified with refractive errors. The children whose vision did not improve after refraction and/or were found to have other ocular conditions were examined by optometrists in the third phase to find a cause for failed vision screening.

Survey

Besides the screening, a survey was administered directly to the children using a semi-structured questionnaire to understand the hours of outdoor activity, screen exposure, and sleep patterns before and during the pandemic. Based on the myopia profile developed by Gifford,[18] a slightly modified set of questions were used to gather information about the activities.[13] The time spent on outdoor activities was classified as low (less than 3 h/day) and high (more than 3 h/day). Concerning the screen time, it was classified as low (less than 4 h/day) and high (more than 4 h/day). Apart from the time, details regarding the two activities were also collected. The duration of sleep was classified into less than and more than 7 h/day. The questionnaire was administered by trained interviewers to all the children identified with refractive errors and/or requiring a change in spectacle prescription. An equal proportion of randomly chosen children without any refractive errors from the five different schools also underwent the survey.

Definitions

Vision impairment was defined as visual acuity less than 0.20 logMAR in at least one eye.[19] Prevalence of vision impairment was calculated based on the presenting visual acuity at the personal level. Spherical equivalent was used to report the mean values of refractive error. Mild myopia was defined as spherical equivalent less than -0.50DS and high myopia was defined as spherical equivalent less than -5.00DS.[20] Spherical equivalent refractive errors between -0.50DS and +1.00DS were defined as 'other refractive errors' and spherical equivalent refractive errors greater than or equal to +1.00DS were defined as hyperopia.[15]

Data management and analysis

Data were entered in Spreadsheets (Google Inc, Mountain View, CA, USA) and retrieved in Microsoft Office Excel. Data were cleaned, coded, and used further for analysis. All statistical analyses were performed using SPSS version 20.0 (IBM Corp, Armonk, NY, USA). Prevalence estimates and 95% confidence interval were calculated. Chi-square tests and regression analysis were used to understand the association between refractive error and other variables.

Results

Totally 4,245 children were enrolled in the vision screening program from the five schools, among which 3,855 (90.81%) were present on the day of screening. The data of 5 (0.11%) were excluded due to incomplete information and the remaining data of 3,850 (90.69%) children were taken for analysis. There were 3,132 (81.35%) children from urban locations and 718 (18.64%) children from rural locations. Of 3,850 children, 3,231 (83.92%) were girls and 619 (16.07%) were boys. The average age of the children was 15.08 ± 1.23 years. There were 494 children with 'presenting visual acuity' (with a habitual correction or unaided) less than 0.20 logMAR in at least one eye. Of which, 479 (96.96%) children had vision impairment due to refractive errors and 15 (3.04%) children due to other ocular conditions that needed further evaluation at the base hospital for diagnosis and management. Of the total children screened, there were 337 (8.75%) previous spectacle users and 69 (20.47%) of them were found to have vision impairment.

The overall prevalence of refractive errors was found to be 21.51% (n = 828). The prevalence of myopia, hyperopia, and other refractive errors was found to be 19.53% (n = 752), 6 (0.16%), and 70 (1.82%), respectively. Table 1 represents the status of vision impairment and refractive errors.

Among the 752 children with myopia, 719 (18.68%) had mild myopia and 33 (0.86%) had high myopia. Among these children, 296 (7.69%) were already using spectacles, of which 68 (1.77%) were not optimally corrected. There were 441 (11.45%) and 13 (0.34%) children who were found to have vision impairment in at least one eye among mild and high myopes, respectively.

The average myopic spherical and spherical equivalent error was found to be –2.08 ± 1.68D (range: -0.50D to -13.50D) and -2.17 ± 1.11D (range: -0.50D to -14.00D), respectively. The prevalence of myopia was 1.66 times (95% confidence interval (CI): 1.26 – 2.20, $P < 0.001$) more among children from urban region (21.55%), 2.00 times (95% (CI): 1.47 – 2.74, $P < 0.001$) more among girls (21.48%) and 1.17 times (95% (CI): 1.01 – 1.38, $P = 0.045$) more among children from higher secondary grades (21.17%) when compared to children from rural regions (10.72%) boys (9.37%) and high school grade (16.43%), respectively. The magnitude of myopia among girls in grade 9 was -2.04D (range: -0.50D to -14.00D) and remained almost similar till grade 12 (-2.19D range: -0.50D to -10.75D). While among boys there was a 0.75D change in magnitude from grade 9 (-1.34D range: -0.50D to -3.25D) to grade 12 (-2.13D range: -0.75 to -4.13) with peak magnitude of -2.40D (range: -0.50D to -8.00D) among grade 11 boys. Fig. 1 represents the trend of myopia across class grades. Prescribing spectacles could improve vision up to 6/9.5 or above among 458 children (11.89%); 18 (0.46%) children had vision impairment in at least one eye and the best-corrected visual acuity was not available for 5 (0.12%) children.

A survey on outdoor activities, screen exposure, and sleeping pattern was conducted among 1,134 children, of which 564 (49.73%) children had refractive errors. Almost 96.82 and 30.85% of girls had less than 3 h of outdoor activities and less than 7 h of sleep, respectively. While among boys, 65.02 and 3.29% had less than 3 h of outdoor activities and less than 7 h of

Table 1: Status of vision impairment and refractive errors

Demographics (No screened)	Children presenting with vision impairment in at least one eye *n* (%)	Children already using spectacles *n* (%)	Children with vision impairment with existing spectacle correction *n* (%)	Prevalence of refractive errors in at least one eye *n* (%)	Prevalence of myopia in at least one eye *n* (%)	ODD's Ratio for Myopia (95%CI)	*P*
Total (3850)	494 (12.83%)	337 (8.75%)	69 (1.79%)	828 (21.5%)	752 (19.53%)		
Class grades							
High school (1904)	230 (12.08%)	139 (7.30%)	37 (1.94%)	373 (19.59%)	340 (17.85%)	1	
Higher Secondary school (1946)	264 (13.56%)	198 (10.17%)	32 (1.64%)	455 (23.38%)	412 (21.17%)	1.17 (1.01 - 1.38)	0.045
Location							
Rural (718)	52 (7.24%)	23 (3.20%)	3 (0.41%)	81 (11.28%)	77 (10.72%)	1	
Urban (3132)	442 (14.11%)	314 (10.02%)	66 (2.10%)	747 (23.85%)	675 (21.55%)	1.66 (1.26 - 2.20)	<0.001
Gender							
Boys (619)	46 (7.43%)	14 (2.26%)	3 (0.48%)	64 (10.33%)	58 (9.37%)	1	
Girls (3231)	448 (13.86%)	323 (9.99%)	66 (2.04%)	764 (23.64%)	694 (21.48%)	2.00 (1.47 - 2.74)	<0.001

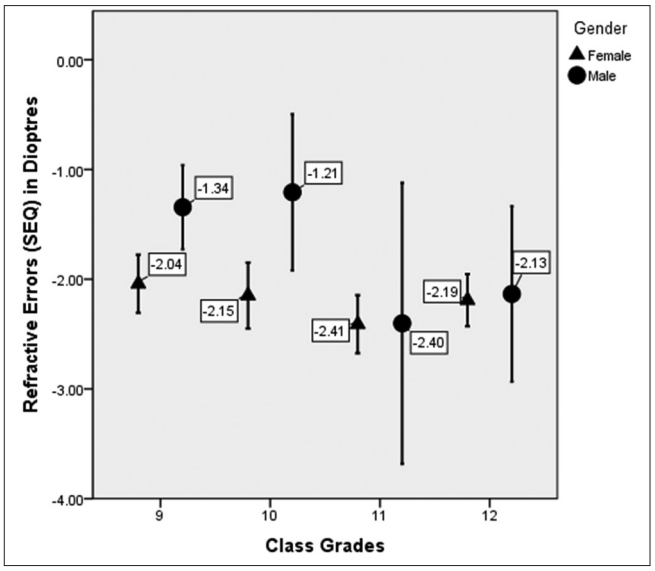

Figure 1: Trend of myopic refractive errors among girls and boys

sleep, respectively. Only 7.68% of boys had exposure to gadgets for more than 4 h per day when compared to 14.49% of girls.

Refractive errors were 7.42 times more (odds ratio (OR): 7.42 (3.51-15.70), $P < 0.001$) among children who had outdoor activities for less than 3 h per day when compared to children who had outdoor activities for more than 3 h per day. Sleeping patterns of less than 7 h per day (OR: 2.77 (95% CI: 2.77 (2.03-3.79), $P < 0.001$) were associated with myopia when compared to sleeping more than 7 h per day. Exposure to digital screens did not show any association with myopia ($P = 0.19$). Table 2 represents the risk factors associated with refractive errors.

Discussion

The study reports the increase in the proportion of vision impairment and refractive errors among 3,850 school children from southern India post home confinement due to the global pandemic compared to the previously reported literature. The children belong to the public schools from both urban and rural areas.

The study reports a higher proportion of vision impairment (12.83%) among the public school children when compared to all the other studies from India that report vision impairment among urban children (4.9%), rural children (2.6%), and children from private schools (5.8%).[21-23] The proportion of vision impairment reported in the current study was nearly two times higher when compared to the recent report on vision impairment (5.7%) among children from the public schools in the same location.[15] Almost 97% of those with vision impairment were identified with refractive errors, of which 96% of the vision impairment was corrected with spectacles. Though the proportion of children wearing spectacle correction in the current study was higher when compared to reports from urban and rural regions and SN-SEES, the need for refractive correction was also high.[15,21,22] This strongly emphasizes the need for resumption of delivery of refractive services through school eye screening programs in the same capacity as in pre-COVID times.

Table 2: Association with refractive errors among children involved in the survey

Risk factors	Children without refractive errors *n* (%)	Children with refractive errors *n* (%)	Odds Ratio (95%CI)	*P*
Total	570 (50.26%)	564 (49.73%)		
Class grades				
High school	287 (25.3%)	194 (17.1%)	1	
Higher Secondary school	283 (24.95%)	370 (32.62%)	1.54 (1.18-2.01)	0.002
Location				
Rural	98 (8.64%)	9 (0.79%)	1	
Urban	472 (41.62%)	555 (48.94%)	1.20 (0.74-1.95)	0.45
Gender				
Boys	187 (16.49%)	36 (3.17%)	1	
Girls	383 (33.77%)	528 (46.56%)	4.23 (2.64-6.78)	<0.001
Hours of outdoor activity				
More than 3 hours	98 (8.64%)	9 (0.79%)	1	
Less than 3 hours	472 (41.62%)	555 (48.94%)	7.42 (3.51-15.70)	<0.001
Hours of Exposure to gadgets				
Less than 4 hours	104 (9.17%)	98 (8.64%)	1	
More than 4 hours	466 (41.09%)	466 (41.09%)	1.27 (0.88-1.82)	0.19
Hours of sleep				
More than 7 hours	479 (42.23%)	344 (30.33%)	1	
Less than 7 hours	91 (8.02%)	220 (19.4%)	2.77 (2.03-3.79)	<0.001

The prevalence of refractive errors in the current study was found to be 21%, of which 91% of children were identified with myopic refractive error. So far, the prevalence of refractive errors ranges between 2 and 10% among school-going children from India.[7,8,15,21-23] The highest proportion of myopia reported among public school-going children from the North Indian urban region was 7% and the South Indian region was 3.6%.[13,20] This sudden three-fold increase in the proportion of myopia among public school children raises concern.

Differences have existed in the prevalence of refractive errors between children from the public and private schools earlier with the prevalence of myopia of almost 17% among urban private schools.[23] Students from these schools had more exposure to gadgets through online education, and hence, a possibility of a further increase in the prevalence could be expected among private school-going children. The temporal trends and prediction model of myopia showed that by the year 2050, the prevalence of myopia will increase up to 48% among children between 5 and 15 years.[24] The data utilized for the prediction includes children from urban regions.[25] Considering the increase in the refractive errors from this study, especially among children from the public schools, the alarming rise of 50% of children becoming myopic might happen earlier than 2050.

The magnitude of myopia reported in the current study is greater than -2.00D which is almost 0.75D more than that already reported from the similar aged public school-going children.[15] The change in the magnitude of spherical equivalent RE between classes 9 and 12 was found to be only 0.13D among girls, while among boys, the magnitude has shown nearly 1.00D change. The same set of children was not followed up to understand the association of outdoor activities with the change in magnitude. But 23.16% of girls were 'previous spectacle users' compared to the 3.14% of boys and the association between 'previous spectacle use' and change in magnitude needs further exploration.

The results from the survey showed that girls had almost double the exposure to gadgets compared to boys and almost none of the girls had any outdoor activity added to their lesser sleep hours. The current study also reports outdoor activities and lesser hours of sleep as a major risk factor for the development of refractive errors and exposure to gadgets did not show any significant association. Girls, especially from public schools, spend more hours on household chores than boys and this home confinement has reduced the outdoor activities of these children.[25] Evidence also reports that even if there is a higher amount of near work, increasing outdoor activities will have positive effects on decreasing myopia incidence and progression.[26] This effect should be explored further, especially among this age group, to understand and plan interventions immediately after the resumption of schools.

Though the study team performed both auto-refraction and objective refraction using retinoscopy, the results were obtained from non-cycloplegic refraction as per the government regulations that prohibit the use of any eye drops on the school premises.

Conclusion

The study reports a higher prevalence of vision impairment and refractive errors among public school-going children from Tamil Nadu, India. This rapid rise in myopia and refractive errors are major public health issues and need immediate attention.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. 1.3 billion People. A 21-day lockdown. Can India curb the coronavirus?. Science.org. 2021. Available from: https://www.science.org/content/article/13-billion-people-21-day-lockdown-can-india-curb-coronavirus. [Last accessed on 2021 Nov 20].
2. COVID-19: Schools for more than 168 million children globally have been completely closed for almost a full year, says UNICEF. Unicef.org. 2021. Available from: https://www.unicef.org/india/press-releases/covid-19-schools-more-168-million-children-globally-have-been-completely-closed. [Last accessed on 2021 Nov 20].
3. Deng L, Pang Y. Effect of outdoor activities in myopia control: Meta-analysis of clinical studies. Optom Vis Sci 2019;96:276-82.
4. Enthoven CA, Tideman JWL, Polling JR, Yang-Huang J, Raat H, Klaver CCW. The impact of computer use on myopia development in childhood: The Generation R study. Prev Med 2020;132:105988. doi: 10.1016/j.ypmed. 2020.105988
5. Liu X, Naduvilath T, Wang J, Xiong S, He X, Xu, X, *et al*. Sleeping late is a risk factor for myopia development among school-aged children in China. Sci Rep 2020;10:17194. doi: 10.1038/s41598-020-74348-7.
6. Wen L, Cao Y, Cheng Q, Li X, Pan L, Li L, *et al*. Objectively measured near work, outdoor exposure and myopia in children. Br J Ophthalmol 2020;104:1542-7.
7. Wadhwani M, Vashist P, Singh S, Gupta V, Gupta N, Saxena R. Prevalence and causes of childhood blindness in India: A systematic review. Indian J Ophthalmol 2020;68:311-5.
8. Sheeladevi S, Seelam B, Nukella PB, Modi A, Ali R, Keay L. Prevalence of refractive errors in children in India: A systematic review. Clin Exp Optom 2018;101:495-503.
9. Wang J, Li Y, Musch D, 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.
10. Hu Y, Zhao F, Ding X, Zhang S, Li Z, Guo Y, *et al*. Rates of myopia development in young Chinese school children during the outbreak of COVID-19. JAMA Ophthalmol 2021;139:1115-21.
11. Liu J, Chen Q, Dang J. Understanding risks of refractive error among Chinese children amidst pandemic disruptions: Results from a rapid survey. BMC Ophthalmol 2021;21:370.
12. Saxena R, Gupta V, Prasad P, Bhardwaj A, Vashist P. Prevalence of myopia and its risk factors in rural school children in North India: The North India myopia rural study (NIM-R Study). Eye (Lond) 2021. doi: 10.1038/s41433-021-01797-3.
13. Alvarez-Peregrina C, Martinez-Perez C, Villa-Collar C, Andreu-Vázquez C, Ruiz-Pomeda A, Sánchez-Tena MÁ. Impact of COVID-19 home confinement in children's refractive errors. Int J Environ Res Public Health 2021;18:5347. doi: 10.3390/ijerph 18105347.
14. Tamil Nadu schools to reopen for classes 9 to 12 from September 1. The Hindu 2021. Available from: https://www.thehindu.com/news/national/tamil-nadu/schools-for-classes-9-12-colleges-to-reopen-from-sept-1-in-tn/article36033498.ece. [Last accessed on 2021 Nov 20].
15. Narayanan A, Krishnamurthy S, Kumar RK. Status of eye health among school children in South India – Sankara Nethralaya School Children Eye Examination Study (SN-SEES). Ophthalmic Epidemiol 2021;28:349-58.
16. Raja M, Ramamurthy D, Srinivasan K, Varadharajan LS. Development of pocket vision screener and its effectiveness at screening visual acuity deficits. Indian J Ophthalmol 2014;62:1152-5.
17. Spot™ Vision Screener. Wellch Allyn. Available from: https://www.welchallyn.com/content/welchallyn/emeai/in/products/categories/physical-exam/eye-exam/vision-screeners/spot-vision-screener.html. [Last accessed on 2021 Nov 20].
18. Myopia Risk Assessment Download | Myopia Profile. Myopia Profile. 2021. Available from: https://www.myopiaprofile.com/product/myopia-risk-assessment/. [Last accessed on 2021 Nov 20].
19. School Eye Health Guidelines-The International Agency for the Prevention of Blindness. The International Agency for the Prevention of Blindness. 2021. Available from: https://www.iapb.org/learn/resources/school-eye-health-guidelines/. [Last accessed on 2021 Nov 20].
20. Flitcroft DI, He M, Jonas JB, Jong M, Naidoo K, Ohno-Matsui K, *et al*. IMI-defining and classifying myopia: A proposed set of standards for clinical and epidemiologic studies. Invest Ophthalmol Vis Sci 2019;60:M20-30.
21. Dandona R, Dandona L, Srinivas M, Sahare P, Narsaiah S, Muñoz SR, *et al*. Refractive error in children in a rural population in India. Invest Ophthalmol Vis Sci 2002;43:615-22.
22. Murthy GV, Gupta SK, Ellwein LB, Muñoz SR, Pokharel GP, Sanga L, *et al*. Refractive error in children in an urban population in New Delhi. Invest Ophthalmol Vis Sci 2002;43:623-31.
23. Saxena R, Vashist P, Tandon R, Pandey RM, Bhardaway A, Menon V, *et al*. Prevalence of myopia and its risk factors in urban school children in Delhi: The North India Myopia Study (NIM Study). PLoS One 2015;10:e0117349.
24. Priscilla JJ, Verkicharla PK. Time trends on the prevalence of myopia in India–A prediction model for 2050. Ophthalmic Physiol Opt 2021;41:466-74.
25. Raskind IG, Patil SS, Tandon N, Thummalapally S, Kramer MR, Cunningham SA. Household chores or play outdoors? The intersecting influence of gender and school type on physical activity among Indian adolescents. Health Educ Behav 2020;47:682-91.
26. Pärssinen O, Kauppinen M. Associations of near work time, watching TV, outdoors time, and parents' myopia with myopia among school children based on 38-year-old historical data. Acta Ophthalmol 2021;100:e430-8.