BMJ Paediatrics Open

Paediatric myopia shift during the COVID-19 pandemic home quarantine: a systematic review and meta-analysis

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To cite: Abounoori M, Aghajani A, Chaibakhsh S, *et al*. Paediatric myopia shift during the COVID-19 pandemic home quarantine: a systematic review and meta-analysis. *BMJ Paediatrics Open* 2022;**6**:e001755. doi:10.1136/bmjpo-2022-001755

Received 6 November 2022
Accepted 14 December 2022

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ABSTRACT

Background Outdoor activities were restricted during the COVID-19 outbreak, although digital learning grew. Concerns have been raised about the impact of these environmental changes on myopia status. This research aimed to examine myopia shift during the COVID-19 pandemic and offer the community evidence-based data.

Methods The literature search was undertaken in PubMed, SCOPUS, Science Direct, Web of Science and Google Scholar databases on published papers before 17 May 2022. The main outcome was mean spherical equivalent refraction (SER) before, at the onset and at the end of follow-up during the COVID-19 pandemic.

Results Among 518 articles, 10 studies were included in the meta-analysis. The mean SER differences during the COVID-19 pandemic follow-up (mean follow-up time was 10 months) compared with before the pandemic was 0.15 dioptre (D) (95% CI −0.39 to 0.69, p=0.58). After age adjustment using meta-regression, the mean SER differences during the COVID-19 follow-up compared with before the pandemic was – 0.46 D (95% CI −0.59 to −0.34, p<0.001). Over the mean follow-up time during the COVID-19 pandemic, the SER mean difference was −0.55 D (95% CI −0.78 to −0.32, p<0.001), showing that the mean SER had decreased significantly during the COVID-19 pandemic. The mean SER differences in myopic patients before COVID-19 compared with during the pandemic follow-up was −0.49 D (95% CI −0.53 to −0.45, p=0.00). So the prior pandemic myopic patients became more myopic during the pandemic follow-up time.

Conclusion During home quarantine, the mean SRE shifting in paediatrics accelerated. This phenomenon should be given more attention by policymakers, eyecare experts, educators and parents.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The COVID-19 pandemic accelerated myopic progression compared with the past. This research aimed to examine myopia shift during the COVID-19 pandemic and offer the community evidence-based data.

WHAT THIS STUDY ADDS

⇒ To find out the effect of age on myopia shifting, after age adjustment, we found that the spherical equivalent refraction (SER) change towards myopia was 0.46 dioptre (D) greater during the pandemic than before.

⇒ The prior pandemic myopic patients became more myopic during the pandemic. The mean SER differences in myopic patients before COVID-19 compared with during the pandemic was −0.49 D.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Government initiatives are urgently needed to stop and manage the progression of myopia.

INTRODUCTION

The COVID-19 spread swiftly in China and throughout the globe in December 2019. Governments issued quarantine and lockdown orders. Home confinement was implemented on an unprecedented scale.[1] Due to pandemic limits and distance education, 1.1 billion children in over 140 nations were exposed to digital devices in May 2020, according to the United Nations Educational, Scientific and Cultural Organisation.[2] Learning modalities shifted from conventional offline/in-class study in schools to online learning through digital platforms due to the home confinement policies.[2] As a result of a drop in outdoor activities and increasing exposure time to digital devices, concerns regarding 'quarantine myopia' have been highlighted. Myopia is a multifaceted disorder that is impacted by risk factors such as long periods of close work and limited light exposure.[3] Factors such as increased exposure time to electronic devices (online learning via digital platforms and daily assignments), changing activity patterns, an unbalanced diet and sleep length may all impact myopia onset and progression under exceptional conditions of house confinement.[4] According to estimates, myopia is expected to afflict around half of the world's population by 2050.[5] Because of the accompanying longer screen time and house confinement, the current pandemic lockdown may speed up this assessment.[6] Furthermore, myopia is

more likely to develop into high myopia or even pathological myopia in young children, whose complications, such as macular holes and retinal detachment, could induce permanent and irreversible visual impairment.[7] Although household quarantining and school closures to combat the pandemic will not last indefinitely, the increasing adoption and reliance on digital devices, as well as behavioural changes resulting from extended home confinement, may have long-term implications for myopia progression in the population, particularly among children. This is an issue that the worldwide ophthalmology community is concerned about.[8 9]

This systematic review and meta-analysis looked at whether the COVID-19 pandemic worsened myopia in children compared with the prepandemic scenario, implying that the pandemic accelerated myopia shift in children. This research aimed to examine myopia shift before and during the COVID-19 pandemic and offer the community evidence-based data.

METHODS

This research follows the Preferred Reporting Item for Systematic Reviews and Meta-Analyses standards.[10] Also, this study has been registered in the PROSPERO database (CRD42022326138). Before the research began, all authors reviewed the study's inclusion and exclusion criteria and the keywords used to search the literature.

Inclusion and exclusion criteria

The following features were found in the papers chosen for consideration in this study: (1) case–control, cross-sectional, retrospective cohort and prospective cohort studies; (2) studies with mean spherical equivalent refraction (SER) in 2018 or 2019 and 2020 or 2021 or 2022 or mean change in SER before and during the COVID-19 pandemic as primary or secondary outcomes; (3) studies with participants under the age of 18 years old; (4) articles published before the start of the search (17 May 2022) and (5) studies that provided informative data for calculating mean differences.

Reviews, case reports, case series, conference abstracts, letters to the editor, in vitro and animal studies, duplication, and non-English papers were among the exclusion criteria.

The conventional formula of the algebraic sum of the dioptric powers of the sphere and half of the cylinder (sphere+0.5 cylinder) is used to determine the SER. The criteria for myopia were SE ≤–0.5 dioptre (D). The SER between −0.5 D and+0.5 D and more than+0.5 D were used to characterise the emmetrope and hyperopia, respectively.[11]

Patient and public involvement statement

Patients were not involved.

Searching strategies

To find possibly suitable and relevant papers published by 17 May 2022, a literature search was undertaken in PubMed, SCOPUS, Science Direct, Web of Science and Google Scholar databases. Two researchers (MA and MP) conducted the search and assessed the titles and abstracts of possible studies to exclude irrelevant articles based on the inclusion and exclusion criteria.

The following terms were included in the search: [(COVID-19) OR (COVID-19 pandemic) OR (coronavirus disease 2019) OR (novel coronavirus 2019) OR (2019-nCoV) OR (SARS-CoV 2) OR (COVID-19 outbreak)] AND [(Home Confinement) OR (Lockdown) OR (Home-isolation) OR (Social distancing) OR (Curfew) OR (home education) OR (Quarantine)] AND [(Refraction) OR (spherical equivalent) OR (refractive error) OR (refractive status)] AND [(children) OR (child) OR (young adult) OR (preschool)].

Data extraction and quality assessment

The titles and abstracts of candidate papers were evaluated by two of us (MA and MP) independently and together. They later double-checked the complete texts to decide the final inclusions. The full text of articles that were not open access was given on a request from the corresponding author. The duplicate studies were omitted using End Note software (V.8). The extracted data included the following: last author name, publication year, study design, study region, age, number of participants, study date and time, mean SER before, at the onset and at the end of follow-up during the COVID-19 pandemic, and follow-up duration. A third author (AA) was brought in to get a final agreement after discrepancies between writers were explored to remedy difficulties.

Two authors (MA and MP) independently assessed the quality of the included studies using the Newcastle-Ottawa Scale (NOS),[12] and a third author (AA) resolved any disagreements. NOS was broken down into three parts: selection, comparability and outcome. A higher score was seen as a sign of excellent quality.

The main outcomes were mean SER before, at the onset, and at the end of follow-up during the COVID-19 pandemic.

The secondary outcome was shifting in myopic patient's SER before, at the onset and at the end of follow-up during the COVID-19 pandemic.

Statistical method

Analysis was executed by STATA, V.14. A $p<0.05$ was considered significant. If I^2 heterogeneity statistic was above 50, it showed considerable heterogeneity. In this case, a random effect model with restricted maximum likelihood (RML) estimate was used to control the heterogeneity. If needed, results were reported in a forest plot. To determine the protentional risk of publication bias, Egger's test and Begg's test were performed. Significant results marked as remarkable publication bias. Also, funnel plot was illustrated.

Effect size

To quantify the difference between the pace of rising myopia before and during COVID-19, at the first step, the mean changes of SER over study time before and during COVID-19 were measured. Then, the effect size was defined as the difference between the mean changes before and during COVID-19. Enrolled studies had the essential information both before and during COVID-19. The follow-up time before and during COVID-19 in these studies was nearly the same. Still, for more accuracy, a meta-regression with RML estimates was conducted to control the effect of follow-up time. Also, the Meta-regression was repeated by including age to find the protentional effect of it on the inferences.

The studies with the eligible follow-up time were included to assess the number of SER changes over time during COVID-19. Then, the mean changes of SER based on the start and the end of the follow-up time were calculated and considered as the effect size.

RESULTS

Search results

A total of 518 relevant articles were searched according to our search strategy, 213 articles were removed because of duplication and 305 were screened. After screening the titles and abstracts, 220 studies were excluded. Eighty-five articles were reviewed, among which 49 had no relevant outcomes, 23 had study types that were not relevant and 3 had no different languages. Eventually, 10 eligible articles were included in this meta-analysis (figure 1).

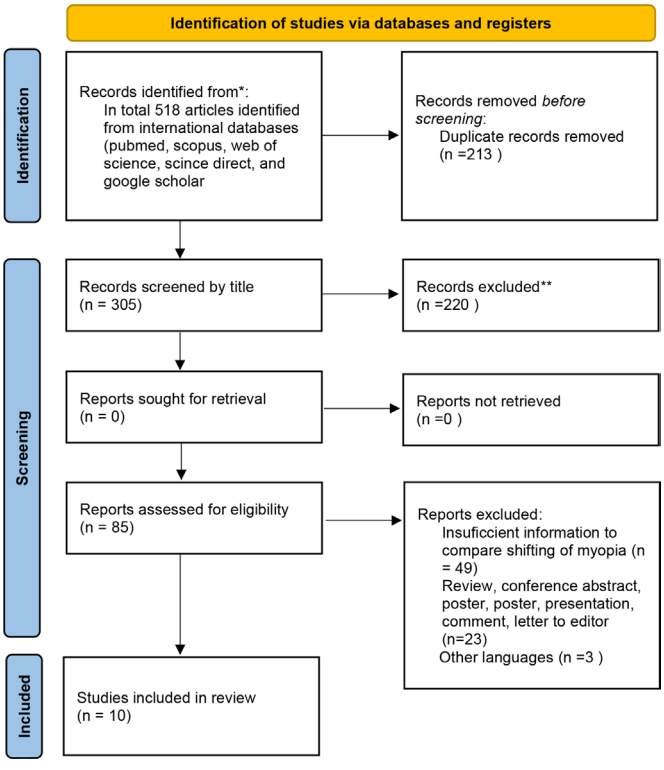

Figure 1 The PRISMA flow diagram of the study selection process. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Study characteristic

An overall of 5381 cases before the pandemic and 11 971 at the onset of follow-up during the pandemic, and 7530 cases at the end of follow-up during the pandemic were included. Of the included studies, four were from China, one was from Turkey, one was from Tibet, one was from India, one was from Spain, one was from Korea and one was from Argentina. Three studies were cross-sectional and seven studies were cohort. The main characteristics of the included 10 articles are demonstrated in table 1. NOS for cross-sectional and cohort studies scores suggested that all the studies scored 7 or higher and were of high quality.

SER means changes before and during the COVID-19 pandemic

Overall, five studies[13–17] were included to compare mean SER changes before and during the COVID-19 pandemic. The mean follow-up time was 10 months before and during the pandemia. Figure 2 shows that the during the pandemia, the SER change towards the myopia was 0.15 D (95% CI −0.39 to 0.69) greater than the SER change before the COVID-19 pandemic, which was not statistically significant (p=0.058, figure 2). Since the age of the participants in these five studies was not matched, we adjusted the effect of the age on the amount of the myopic shift in a meta-regression model to assess whether the age of the participants of this study has an effect on the primary analyses. After age adjustment using meta-regression analysis, we found that the SER change towards myopia was 0.46 D (95% CI −0.59 to −0.34) greater during the pandemic than before, which was statically significant (p≤0.001).

Mean SER changes during the COVID-19 pandemic

A total of 10 studies were included in the analysis.[6 13–21] The highest and the lowest SER changes were reported by Picotti *et al*[14] by −1.21 and Ma *et al*[16] by −0.03 D, respectively. Over the mean follow-up time during the COVID-19 pandemic (10 months), the SER mean difference was −0.55 D (95% CI −0.78 to −0.32, p<0.001), showing that the mean SER decreased significantly during the COVID-19 pandemic. To assess the effect of the baseline amount of SER on its changes over time, a meta-regression was performed. It revealed that the SER change during this period of time was significantly related to its baseline value (p<0.001). It was expected that, on average, every one unit of myopic SER resulted in greater changes in SER towards myopia by 0.07 D (the lower the baseline SER, the greater the myopic shift during the pandemia) (figure 3).

Total SER mean differences before and during the COVID-19 pandemic in myopic patients

The mean SER differences in myopic patients before COVID-19 compared with during the pandemic follow-up

Table 1 The characteristics of 10 included studies in the meta-analysis

First author	Year	Study design	Location	Age range	No of patients			Date		
					Baseline visit	Before pandemic	During pandemic	Baseline visit	Before pandemic	During pandemic
Wang[18]	2021	Cross sectional	Chongqing, China	5–18	NA	1728	1733	NA	10/19	10/20
Ma[15]	2021	Cohort	Shanghai, China	7–12	201	201	201	4/19 to 5/19	10/19 to 11/19	5/20
Mohan[6]	2021	Cohort	India	6–18	133	133	133	11/19 to 1/20	5/20 to 7/20	11/20–1/21
Ma[16]	2021	Cohort	Hebei, China	8–10	208	208	208	7/19	1/20	8/20
Aslan[17]	2021	Cross-sectional	Turkey	8–17	115	115	115	NA/18	NA/19	8/20–12/20
Zhang[19]	2021	Cohort	Hong Kong	6–8	709	709	709	12/19 to 1/20	7/20	8/20
Alvarez-Peregrina[21]	2021	Cross-sectional	Spain	5–7	NA	4227	1600	NA	9/19 to 10/19	9/20–10/20
Yang[13]	2022	Cohort	Tianjin, China	6–18	2792	2792	2792	NA/18	NA/19	NA/20
Yao[20]	2022	Cohort	Lhasa, Tibet	6–7	1853	1819	NA	10/19	11/20	7/21
Picotti[14]	2022	Cohort	Argentina	5–18	NA	39	39	9/18	10/19	12/20

N, number; NA, not addressed.

was −0.49 (95% CI −0.53 to −0.45, p=0.00). So the prior pandemic myopic patients became more myopic during the pandemic.

Sensitivity analysis and publication bias

Sensitivity analysis showed that both results were consistent after one-layer omitting study, confirming the stability and reliability of this meta-analysis. As mentioned before, the total effect size was −0.55, and by eliminating individual studies, it ranged from −0.59 to −0.47. All of them showed statistically significant results. Also, Egger's test indicated no publication bias in the studies (p=0.626).

DISCUSSION

According to this review, the mean changes of SER towards myopia were significantly accelerated in school/preschool children during the pandemic home confinement. Furthermore, the overall SER decreased significantly over the follow-up period from the COVID-19 pandemic onset (with a mean follow-up time of 10 months), showing that children became more myopic during the pandemic. On the other hand, this study shows that children with younger ages and more myopic refraction tended to decrease SER more during the pandemic.

The findings of this study were in line with the other systematic reviews on this subject. A systematic review and meta-analysis study evaluated myopia progression before and during the pandemic demonstrated significant SER progression during the COVID-19 pandemic compared with before the pandemic. Also, in another systematic review and meta-analysis comparing SER progression before and during the COVID-19 pandemic same results were demonstrated, and mean progression was reported as 0.41 D.[13 22] Compared with previous studies, this study uses cohort studies solely to evaluate the amount of myopia progression during the pandemic. On the other hand, we found that during home quarantine with a mean follow-up time of 10 months, paediatrics compared with the first month of the pandemic, became more myopic with −0.55 D shifting in SER.

Another finding of this study was the significant effect of baseline myopic refraction on the amount of myopia progression during home quarantine. Likewise, in a study in India evaluating myopic patient's SER progression before and during COVID-19, the mean annual progression was reported as 0.25 D before lockdown to 0.90 D after lockdown.[6] The same reports from Turkey (annual myopic progression of 0.71 ± 0.46 D in 2020 and 0.54±0.43 in 2019)[23] and China (−0.39±0.58 in 2019 to −0.98±0.52 in 2020)[15] reported myopia acceleration before and after COVID-19 pandemic lockdown.

The reason for myopia progression during the pandemic has been studied as well. The COVID-19 pandemic caused changes in lifestyle and behaviour. Children and teenagers no longer attend traditional schools; instead, various technologies have taken their place. Due

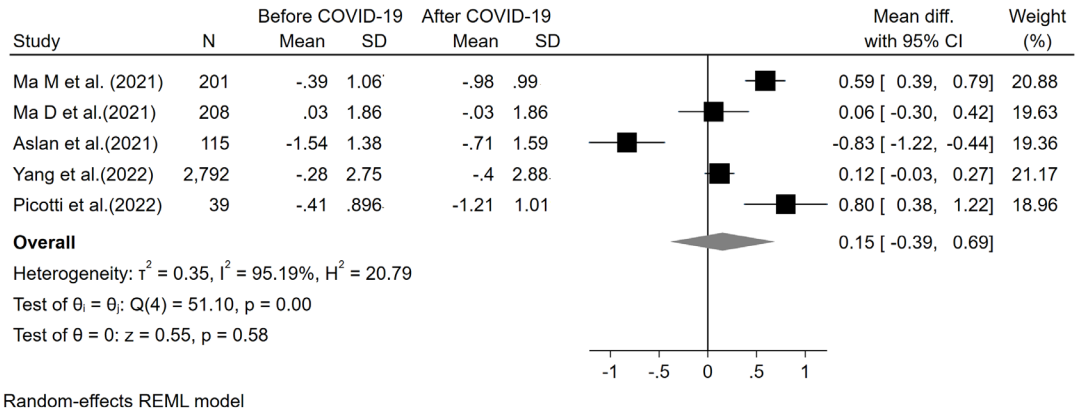

Figure 2 Forest plots for comparison of total spherical equivalent refraction before and during the COVID-19 pandemic.

to the students' distance learning and social networking, there was a drop in outside exercise and an increased usage of digital displays.[21] A study in China revealed that most children engaged in less than 2 hours of outdoor play per day and more than 3 hours per day using digital displays.[24] Also, a study on European paediatric behavioural changes in the early phases of the pandemic showed that the pattern of digital screen use and daily physical activity significantly differed before and during the COVID-19 pandemic.[25] Even though previous studies have proposed increased screen time and decreased outdoor activities as a cause for myopia progression, we could not evaluate the effect of these factors due to insufficient data on this matter.

This systematic review and meta-analysis study has some novelty compared with systematic review and meta-analysis studies published on this topic before.[13 26 27] First, the effect of age on myopia shifting was not evaluated in prior studies, and our results demonstrated that after age adjustment using meta-regression analysis, we found that the SER change towards myopia was 0.46 D greater during the pandemic than before, which was statically significant. Second, the prior studies did not evaluate myopia shifting in myopic patients, whereas our study showed that the mean SER differences in myopic patients before COVID-19 compared with during the pandemic follow-up was −0.49. So the prior pandemic myopic patients became more myopic during the pandemic follow-up time.

There were several limitations to the study. First, although the study combined large sample sizes, most of the studies represented Asian and Chinese populations. This analysis does not adequately represent other ethnic groups, which have been suggested to be more at risk of myopic shift.[28 29] This suggests that North American and Europe populations may not follow this pattern. The findings of research investigations on the COVID-19 pandemic are being updated at a quick pace, which may have an impact on the findings.

In this study, we were not able to analyse the changes in axial length, visual acuity, indoor and outdoor activity time, and digital screen time spent on myopia shifting due to insufficient data represented in included studies.

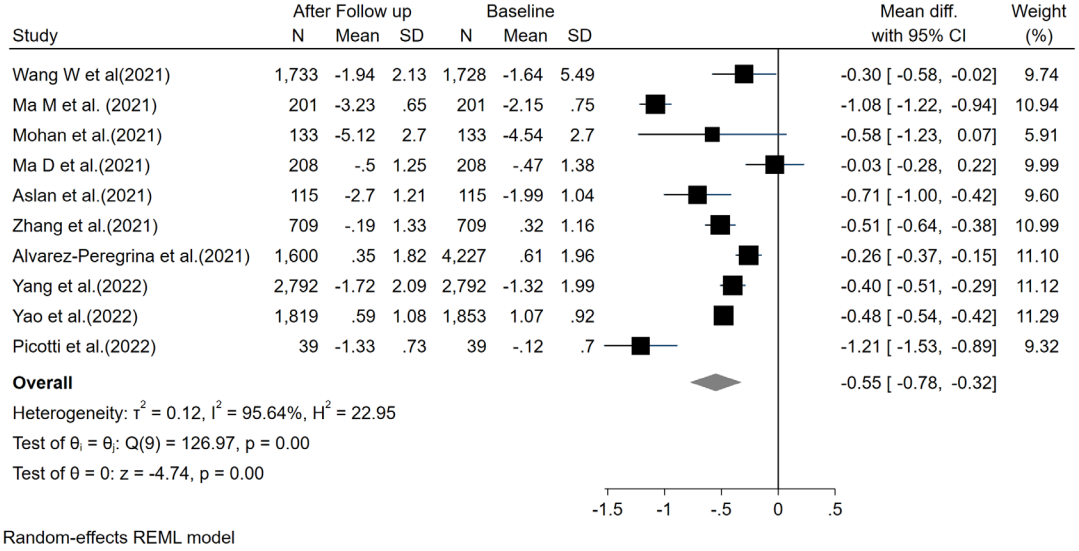

Figure 3 Forest plots of total spherical equivalent refraction during the COVID-19 pandemic.

The papers included in this meta-analysis were cohort and cross-sectional studies, with data from various countries and sample sizes ranging from 39 to 29719, resulting in publication bias and substantial heterogeneity.

CONCLUSION

A significant SER shifting towards myopia was observed during the COVID-19 pandemic. Baseline myopic refraction was associated with a more myopic shift in a paediatric population. This study could neither confirms nor opposes the effect of outdoor activity and screen time on myopia progression.

Contributors MA: conceptualisation, methodology, investigation, writing—review and editing. AA: conceptualisation, methodology, investigation, writing—review and editing. SC: conceptualisation, methodology, formal analysis, writing—review amnd editing. MB: methodology, formal analysis. MP: conceptualisation, methodology, investigation, writing—review and editing, guarantor. AP: conceptualisation, methodology, investigation, writing—review and editing, guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/disclosure-of-interest/ and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The study was approved by ethical committee of Isfahan University of Medical Sciences, Isfahan, Iran (IR.ARI.MUI.REC.1401.062).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data sets generated for this study are available at reasonable request to the corresponding author.

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