

Myopia Progression in Children during COVID-19 Home Confinement in Argentina.

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Running Head: Myopia progression during COVID confinement.

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Research in context.

Myopia is now one of the leading causes of preventable visual impairment and blindness all over the world, and is increasing in prevalence in many parts of the world. Increased outdoor time slows the onset of myopia in children, but whether it also slows myopia progression is still unclear. In many parts of the world, the COVID-19 pandemic has led to school closures and home-schooling, as well as restrictions on activities outside the family home. These restrictions have produced conditions that may promote the onset and progression of myopia. The aim of this study was to compare myopia progression during COVID-19 home confinement for children in Argentina. Progression increased by 30-40% during the period that incorporated the confinement, compared to the previous year in which children probably spent part of their day outdoors. The results suggest that prolonged confinement periods enhances the progression of myopia in myopic children, potentially resulting in more severe myopia in adults. These results therefore suggest that when designing home confinement restrictions that impact on children, it is important to incorporate additional strategies that can prevent increased myopia progression and perhaps onset of myopia.

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Abstract. (186 words).

Purpose. To determine whether the progression of myopia in children is faster during school closures and home confinement during the COVID-19 pandemic.

Methods. This was a case series study collecting retrospective data of refractive error during 2019 and 2020 in consecutive myopic patients attending regular checkups for their spectacle prescription. Inclusion criteria were spherical equivalent between -0.50 and -6.00 diopters (5-18 years of age) consulting from September to December 2020. Patients receiving any treatment for arresting myopia progression were excluded. Cycloplegic spherical equivalent in both eyes was recorded for 2018, 2019 and 2020. Mean progression over the two periods 2018-2019 and 2019-2020 was calculated.

Results. At the 2020 visit after confinement, mean age of the 115 enrolled patients was 11.89 ± 3.68 years and 60.0% were girls. The mean annualized progression for the right eyes in 2019 was 0.44 ± 0.52 D and increased to 0.58 ± 0.53 D in 2020 during the period that included home confinement ($p = 0.0019$).

Conclusion. Mean annual progression rates during strict pandemic home confinement was faster than in the previous year, in contrast to the general slowing of progression as children get older.

Key words. Myopia progression, COVID-19, pandemic, confinement, school children.

Myopia is one of the leading causes of visual disability in adults, due both to lack of correction, and the development of pathological outcomes associated with high myopia.¹ Once developed, myopia continues to increase in severity during childhood, but this progression is preventable with several interventions.¹ Since the onset of incidence and perhaps myopia progression are associated with less outdoor exposure and more intense nearwork,¹⁻⁴ this study was developed to investigate whether the home confinement due to the COVID19 pandemic in Argentina, from March to August 2020, was associated with a greater progression of myopia compared to that in the previous year.

In Argentina, the academic year begins in March (Autumn) and ends at mid December (Summer). During the year 2020, children in Argentina went to school for only two weeks, since schools were closed and children were confined to their homes from March 20.⁵ Sports clubs and gyms were closed in March 2020. Children could not visit their grandparents who constituted an at risk population, and could not visit cousins or friends. Birthday parties and other familial meetings were discouraged. Children had to stay at home and study or play with siblings or parents. Children did not return to face-to-face classes for the rest of the academic year. During the 6 months from 21 March to 21 September (Autumn and Winter) children were not allowed outside to play, due to a strict government policy. After these 6 months, home confinement was progressively relaxed, allowing children to go outdoors for up to one hour per day. This is very different to what happened during the 2019 school year. In Argentina, school lasts for only 4 hours on weekdays, and most children play outside for many hours, as the climate is warm, with only 4 weeks of cold weather and with low annual rainfall. We therefore planned to collect retrospective data on refractive change in consecutive myopic patients

attending regular patient-initiated checkups after the lifting of the most severe restrictions for their spectacle prescription, to investigate possible changes in progression rate.

Material and Methods.

This was a retrospective study of a series of consecutive myopic cases obtained by ophthalmologists from different public and private services in Argentina. The data were obtained by 16 ophthalmologists who completed a very simple online Google Form questionnaire. All consecutive myopic patients (-0.50 to -6.00 diopters) between 5 and 18 years of age who requested consultations from September to December 2020 were included. The following data had to be recorded: age, gender, date of examination and spherical equivalent refraction of the prescription of both eyes in the years 2018, 2019 and 2020. There had to be at least 8 months or more between each of the three different examinations. The input spherical equivalent of each eye for each year was the subjective refraction, confirmed by cycloplegic refraction to exclude myopic spasm. Pupil dilation and cycloplegia were achieved with tropicamide or cyclopentolate, since they produce similar levels of cycloplegia in myopic patients, although not in hyperopes.⁶ Identities were maintained confidential in the database.

Refractive data for 2018 and 2019 were extracted from medical records at the time of examination in 2020. The study enrolment was scheduled during the 4 months at the end of the year 2020, in which, as patients came consecutively for new prescriptions, a subjective refraction was performed, with cycloplegic autorefractometry confirmation. Patients and their families gave verbal informed consent in which "they accepted that their prescription data would be used for statistical purposes because of the pandemic, keeping their identity confidential," following the

precepts of the Helsinki Declaration. The Ethics Committee of the Argentinian Council of Ophthalmology gave approval for this study.

The following patients were excluded: those who did not have the 3 subjective refractions confirmed by cycloplegia, those with astigmatism greater than 3 diopters, patients with a single eye, with diabetes, Down, Marfan or Stickler syndromes, or any associated eye disease (e.g.: keratoconus, cataract, retinal disease or glaucoma). Patients undergoing treatment for myopia control with diluted atropine drops or with especial lenses were also excluded. Once the information had been obtained from all the ophthalmologists, the statistical analysis was carried out with the total number of cases collected over the 4 months of recruitment.

The data were recorded in an Excel spreadsheet. Annual progressions in 2019 and 2020 were calculated as the difference in spherical equivalent between a particular year and the former. The progression was annualized taking into account the exact dates of refractive exams, dividing it by the number of days between both examinations and multiplying by 365. Mean annual progressions were calculated and Student *t*-tests were performed with these variables to identify a significant difference in progression between the two periods. A value of $p < 0.05$ was taken as the cut-off for statistical significance. The annual progressions during 2019 and 2020 are presented as means $\pm$ standard deviations. Figures were made with SPSS version 25 (IBM, USA).

Results.

During Spring 2020, when COVID-19 restrictions including home confinement were progressively relaxed, from September to December 2020, 115 consecutive patients (60% girls) filling the inclusion parameters of three cycloplegic refractions over three years, were included in

the database. At the 2020 visit after confinement, mean age was 11.89 ± 3.68 years. The mean spherical equivalent of right and left eyes in the 2020 visit was similar (-3.62 ± 1.74 D versus -3.48 ± 1.98 D, $p = 0.478$). The mean follow up for both periods was 56.02 weeks in 2019 and 61.95 weeks in 2020, statistically different (Student t test, $p < 0.001$) but probably 6 weeks difference in follow up for one year are not clinically important for progression differences. In any case, the mean annualized progression in 2019 (the year before the confinement) in both eyes was significantly lower than that in 2020 ($p = 0.028$, Table 1). Figure 1 shows how the distribution of progression rates shifted to the left in 2020.

Table 1. Mean annual progression in diopters by eye and year (SD)

	OD	OI
Progression 2019-2018	-0.44 (0.52)	-0.40 (0.51)
Progression 2020-2019	-0.58 (0.53)	-0.57 (0.59)
Percentage change	+29.91%	+43.03%

Discussion.

The present study showed that progression of myopia was significantly increased from 2019 to 2020, a period that included the COVID-19 control measures, as compared to the period 2018-2019 in which the COVID-19 home confinement was not in place. During this year, children were locked down with home-schooling and home confinement under a strict government policy established when the academic year began in March after the summer vacations. While the precise factors leading to this increased progression have not been established, it is known that higher amounts of time spent outside by children limits axial elongation and hence myopic shifts in refraction, at least in pre-myopes, and thus reductions in time outdoors may have contributed to this increase. In addition, confinement to the family home may have increased levels of nearwork, perhaps including increased use of electronic devices.

Changes of this kind could lead to increased axial elongation, and hence increased progression of myopia.

In Argentina, the strict quarantine lasted for 8 months, with home-schooling by video conference, suspension of extracurricular activities and outdoor or indoor sports, closing of gyms or recreational spaces, and home confinement. This was a particularly severe and prolonged lockdown by international standards, and thus the results may not generalize to situations in which lockdown measures were less severe, or where children were already deprived of outdoor time and exposed to severe educational pressures. It is also important to note that the prevalence of myopia in Argentina seems to be very low by international standards. Our estimates from a small survey are that at the end of primary school, the prevalence of myopia is only about 4% in Argentina, probably due to the short school day, low academic pressures and the large amount of time that children spend outdoors (Magnetto et al. *in preparation*). The change in behaviour induced by the closure of schools and home confinement is thus likely to have been large. The impact of lockdown measures in countries with high academic pressures and limited time outdoors under normal circumstances may therefore be less dramatic than seen in this study.

These results have significance in two ways. Firstly, they are relevant to the debate about whether progression of myopia, as distinct from myopic shifts in refraction in pre-myopes, is inhibited by more time outdoors. There is general agreement that increased time outdoors slows axial elongation in pre-myopes and therefore protects from the development of myopia. However, epidemiological studies have so far been unable to demonstrate regulation of progression by time outdoors. This could be due to a limited range of variation in time outdoors, since myopes tend to spend less time outdoors, and the regulation of progression has been demonstrated through seasonal variations in progression rates, with progression generally being

higher in winter than in summer. In this study, the measures taken to control covid-19 almost certainly imposed a marked change in behaviour on myopes which may have led to a significant increase in myopic progression. This adds to the evidence that progression is actively regulated by environmental factors, thus giving additional support to the idea that increased time spent outdoors would be useful in clinical and public health practice for the control of myopia progression, as well as for the control of the onset of myopia.

Secondly, these results give substance to the concerns that have been raised about the deleterious effects of COVID-19 control measures on the development of myopia in children. Our results suggest that these measures can lead to increased progression of myopia. In our sample recruited from myopic patients, we cannot address the question of whether there are effects on onset of myopia, but all the evidence available suggests that the onset of myopia is likely to be affected as well, particularly when big changes in behaviour occur. A recent school-based paper from China, which also suffered a long and severe lockdown with interrupted schooling and home confinement, has reported increases in overall myopic shifts in refraction, consistent with the speculations above, however the results are difficult to interpret because of the lack of a control group. ⁷

The likelihood of big changes occurring is greater when children were leading lives with low educational pressures and a lot of time outdoors, and lesser changes may be anticipated where children were already under myopiagenic pressures. The recruitment method we have used should be generalizable to clinical or hospital records in other countries to test this possibility.

In conclusion, we have found clinically significant increased myopia progression under cycloplegic refractions during the pandemic confinement in 2020. We are not arguing against

taking necessary measures to control the COVID-19 pandemic. However, we stress the need to develop modifications to measures that impose school closures and home confinement that can minimize effects on refractive development, particularly since some countries are entering their second or third period of lockdown, and some may be facing even more severe and prolonged lockdowns in the future.

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Author Contributions.

Carolina Picotti. Conceptualization, Methodology, Investigation, Project Administration, Formal analysis, Writing - Original Draft, Writing - Review & Editing. **Victoria Sanchez.** Conceptualization, Methodology, Investigation, Project Administration, Writing - Review & Editing. **Leonardo Fernandez Irigaray:** Conceptualization, Methodology, Investigation, Writing - Review & Editing. **Rafael Iribarren:** Conceptualization, Methodology, Formal analysis, Investigation, Project Administration, Writing - Original Draft, Writing - Review & Editing. **Ian G. Morgan.** Methodology, Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing.

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Figure 1. Distribution of percentage of subjects according to rates of annualized progression in diopters, both in 2019 (dotted line) and 2020 (full line).

