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Slowing of Greater Axial Length Elongation Stemming from the Coronavirus Disease 2019 Pandemic with Increasing Time Outdoors: The Tokyo Myopia Study

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Purpose: To investigate the changes in axial length (AL) elongation and other ocular parameters before and during the coronavirus disease 2019 pandemic.

Design: A longitudinal school-based study.

Participants: Public elementary schoolchildren in Tokyo (grades 1–6; age, 6–12 years) participated in this study from 2018 to 2021.

Methods: All participants underwent eye examinations and provided written consent to measurements of the noncycloplegic refraction and ocular biometry including AL, among others. The students' parents also completed a questionnaire about the students' lifestyles. We included the right eye in our analysis and compared the changes in the ocular parameters among the periods using a linear mixed-effects model for repeated measures and examined the univariate and step-wise multiple regression analyses to evaluate the associations between myopia and other covariates.

Main Outcome Measures: Changes in AL elongation and other ocular parameters from 2018 to 2019 (prepandemic), that of 2019 to 2020 (immediately after the pandemic onset), and that of 2020 to 2021 (during the pandemic).

Results: A total of 578 students before the pandemic period, 432 immediately after the pandemic onset, and 457 during the pandemic period were evaluated. The changes in the ALs and spherical equivalents (SEs) a year before, immediately after onset, and during the pandemic were 0.31 mm/−0.20 diopter, 0.38 mm/−0.27 diopter, and 0.28 mm/−0.47 diopter, respectively (ALs, $P < 0.001$; SEs, $P = 0.014$). The results of the questionnaire showed that time spent outdoors daily had changed during the 3 years to 79, 63, and 77 minutes/day, respectively ($P < 0.001$). Time spent using smartphones or tablets increased year by year to 41, 52, and 62 minutes/day ($P < 0.001$). The greatest AL elongation occurred during the period when the shortest amount of time was spent outdoors during the 3 years.

Conclusions: These results suggested that the school closures and decreasing time spent outdoors might have caused greater AL elongation among schoolchildren in Tokyo; however, it is possible that, although the time spent in near work still increased, the return to the time spent outdoors to the prepandemic levels may have affected the slowing of AL elongation after lockdown.

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Supplemental material available at www.ophthalmologyscience.org.

Myopia has been increasing dramatically over the past few decades, especially in East Asia,[1,2] and has become a major health issue worldwide.[3,4] We reported that the prevalence of myopia has been high among children, including preschool children, in Tokyo.[5,6] Regarding factors related to myopia, the time spent outdoors has been recognized recently as protective against myopia,[7–10] and near-work activities have been identified as risk factors for myopia.[9–12]

Since the onset of the coronavirus disease 2019 at the end of 2019, the virus spread rapidly worldwide. Most governments around the world temporarily closed educational institutions to contain the viral spread. According to the United Nations Educational, Scientific and Cultural Organization,

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schools in > 160 countries closed temporarily as a result, which is equivalent to > 85% of the world's student population.[13] In response to the pandemic, the Tokyo Metropolitan Government closed the public school system from March to the end of May as an emergency measure. Approximately 86% of all kindergartens, elementary schools, junior high schools, and high schools including public, private, and national schools in Japan, were closed for approximately 3 months.[14] As a result, lifestyle changes (age, 6−17 years) due to the pandemic were reviewed,[15] including increased screen time and decreased outdoor time. Thus, children were required to remain at home and engage in near work: reading books, watching television, playing videogames, or using personal computers, tablets, and smartphones without outdoor activities. Since we hypothesized that increasing time spent indoors and less time outdoors due to the pandemic may have elongated axial length (AL), affecting the increase in myopia prevalence in children, we assessed changes in AL elongation and other ocular parameters before and after the coronavirus disease 2019 pandemic.

Methods

Study Design and Study Populations

This study was performed annually in July on children at a public elementary school in Tokyo (grades 1−6; age, 6−12 years) from 2018 to 2021. The Keio University School of Medicine Ethics Committee (approval number, 20160349) approved this longitudinal, school-based study. The parents of all students provided informed written consent before the start of the study in accordance with the Declaration of Helsinki. The detailed inclusion and exclusion procedures are described in the flowcharts (Figs S1−S3, available at www.ophthalmologyscience.org). Students without serious eye diseases or missing data were included for analyses. Children treated with orthokeratology or atropine, which are also considered as treatments to suppress AL elongation, were excluded according to previous reports.[5,6,16] The same students were not tracked; approximately 120 new students were added annually due to enrollment or change in schools, and approximately 120 students were removed from the analysis target due to graduation.

Measures

The details of the current study have been previously reported.[5] The children's height and weight were measured, and the body mass index was calculated. All participants underwent eye examinations that included measurement of AL, corneal thickness, anterior chamber depth, lens thickness, and corneal radius curvature using the IOLMaster 700 (Carl Zeiss Meditec AG). The AL was measured 10 times, and the averaged value was used. The noncycloplegic refraction also was measured with the HOYA iTrace Surgical Workstation (Tracey Technologies). The spherical equivalent (SE), vitreous chamber depth, corneal power, and the AL-corneal radius curvature ratio (AL/CR) were calculated. The SE was calculated by adding the cylinder degrees divided by half to the spherical degrees; the vitreous chamber depth was defined as the AL minus the corneal thickness, anterior chamber depth, and lens thickness; the corneal power was the average of the flat and steep K; and the AL/CR was the AL divided by the averaged corneal curvature.

The students and their parents also completed the questionnaire that we used previously[5] to record the time spent outdoors, on near work, sleeping, using digital devices including computers/smartphones/tablets/handheld game consoles/reading or studying, symptoms or previous diagnosis of dry eye disease,[17,18] and parental history of myopia.

Statistical Analyses

We included the right eye in our analysis and calculated the AL elongation and changes in the SE and the AL/CR ratio over a year. We compared these changes between each year and period, i.e., from 2018 to 2021 and 2018 to 2019 (before the pandemic), 2019 to 2020 (immediately after the pandemic onset), and 2020 to 2021 (during the pandemic). Students who graduated or relocated in the respective year and students who enrolled in 2021 were not included in the analysis for the respective period (Figs S1−S3). The repeated-measures outcomes were analyzed with a linear mixed-effects model for repeated measures that included the time period of measurement and age as covariates, and the subjects as a random effect. Furthermore, in this model, all measurements obtained from the 3 periods were used and entered as repeated effects. The covariance structure was a completely general (i.e., unstructured) covariance matrix. The results were reported as the least-squares means with the 95% confidence interval at each time point. We excluded the results of time spent outdoors and time spent engaged in near work in 2018 because we evaluated those with different questions that year.

We also examined the associations between AL elongation, changes in the SE, and changes in the AL/CR ratio and other parameters including age, gender, body mass index, time spent outdoors, time spent engaged in near work, reading distance, sleep time, dry eye disease, and the number of parents with myopia by univariate and step-wise multiple regression analysis. The number of parents with myopia was analyzed with data on 3 categories: both parents were myopic, 1 parent was myopic, and both parents were not myopic, which were converted to dummy variables during multivariate analysis as we previously reported.[5] All statistical analyses were performed using a statistical analysis software (SPSS for Windows, version 27.0, IBM-SPSS). All P values were 2-sided and considered significant if they were < 0.05.

Results

The total numbers of students, including those who underwent repeated measurements, were 714, 707, 569, and 692 in 2018, 2019, 2020, and 2021, respectively. The characteristics of the total number of students, including those who underwent repeated measurements and the results of the mixed-effects model fitted to age for repeated measurements, are shown for each year (Table 1). Although the mean baseline SEs did not differ significantly, the ALs differed significantly each year ($P < 0.001$). Among the other ocular parameters, the AL/CR ratio, anterior chamber depth, lens thickness, and vitreous chamber depth differed significantly each year. Based on the questionnaire, the times spent outdoors before, immediately after the pandemic onset, and during the pandemic were 79, 63, and 77 minutes/day, respectively, by the mixed-effects model with age ($P < 0.001$); the time spent outdoors immediately after the pandemic onset decreased significantly compared with that of the prepandemic and postpandemic values (Fig 4). The times spent using a smartphone or tablet before, immediately after onset, and

Table 1. Characteristics of the Participants and Results of the Mixed-Effects Model Fitted to Age for Repeated Measurements

	2018 (n = 714)			2019 (n = 707)			2020 (n = 569)			2021 (n = 692)			
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		***P* Value**
Age (yrs)	8.4	-	-	8.5	-	-	8.3	-	-	8.4	-	-	0.487
Boys (%)	49.9	-	-	50.1	-	-	50.6	-	-	52.2	-	-	0.721
Height (cm)	131.6	131.2	132.0	131.6	131.2	132.0	133.7	133.3	134.2	132.3	131.8	132.7	**< 0.001**
Weight (kg)	29.0	28.7	29.3	29.1	28.8	29.5	30.8	30.3	31.2	29.7	29.2	30.2	**< 0.001**
BMI (kg/m^2)	16.4	16.3	16.6	16.5	16.4	16.6	16.9	16.7	17.0	16.6	16.5	16.8	**< 0.001**
Spherical equivalent (D)	−1.79	−1.90	−1.68	−1.76	−1.89	−1.63	−1.76	−1.90	−1.63	−1.91	−2.05	−1.78	0.137
Axial length (mm)	23.47	23.41	23.54	23.50	23.43	23.56	23.60	23.53	23.67	23.63	23.55	23.71	**< 0.001**
Axial length/corneal curvature radius ratio	3.02	3.02	3.03	3.02	3.01	3.03	3.04	3.03	3.05	3.04	3.03	3.05	**< 0.001**
Corneal curvature radius	7.78	7.76	7.79	7.77	7.76	7.79	7.77	7.75	7.79	7.77	7.75	7.79	0.889
Central corneal thickness (mm)	0.55	0.54	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.54	0.55	0.067
Anterior chamber depth (mm)	3.08	3.06	3.10	3.05	3.03	3.07	3.09	3.07	3.10	3.07	3.05	3.09	**< 0.001**
Lens thickness (mm)	3.44	3.42	3.45	3.46	3.44	3.47	3.43	3.41	3.46	3.45	3.44	3.46	**< 0.001**
Vitreous chamber depth (mm)	16.41	16.35	16.47	16.44	16.38	16.51	16.53	16.46	16.61	16.57	16.50	16.65	**< 0.001**
Time spent in outdoor activity (min/day)	-	-	-	78.75	74.07	83.43	63.00	58.10	67.90	76.90	72.31	81.28	**< 0.001**
Time spent watching TV (min/day)	93.68	88.74	98.62	88.30	83.67	92.93	98.27	92.55	103.98	84.55	79.82	89.28	**< 0.001**
Time spent using smartphone/tablet (min/day)	37.88	34.33	41.42	40.51	36.88	44.13	52.46	48.08	56.83	62.00	56.41	67.59	**< 0.001**
Time spent using computer (min/day)	4.12	3.05	5.35	3.11	2.22	4.00	11.27	8.03	14.52	8.55	6.47	10.63	**< 0.001**
Time spent reading/studying (min/day)	128.81	119.09	138.52	71.30	66.90	75.70	76.54	71.90	81.18	70.51	66.36	74.66	**< 0.001**
Reading distance (cm)	25.93	25.40	26.47	25.78	25.23	26.32	26.13	25.53	26.73	25.46	24.89	26.03	0.349
Time spent sleeping (min/day)	520.59	517.77	523.41	521.63	518.49	524.77	515.94	512.51	519.36	518.11	514.98	521.25	**0.033**
Dry eye disease (%)	7.6	-	-	6.7	-	-	7.4	-	-	7.1	-	-	0.909
Number of myopic parents = 0 (%)	14.1	-	-	15.5	-	-	15.3	-	-	15.3	-	-	0.938
Number of parents = 1 (%)	48.3	-	-	34.6	-	-	36.2	-	-	33.4	-	-	**< 0.001**
Number of myopic parents = 2 (%)	37.4	-	-	49.9	-	-	48.5	-	-	51.3	-	-	**< 0.001**

BMI = body mass index; CI = confidence interval; D = diopters; TV = television.
All *P* values are 2-sided, and if < 0.05, the value is considered significant and is listed in bold.

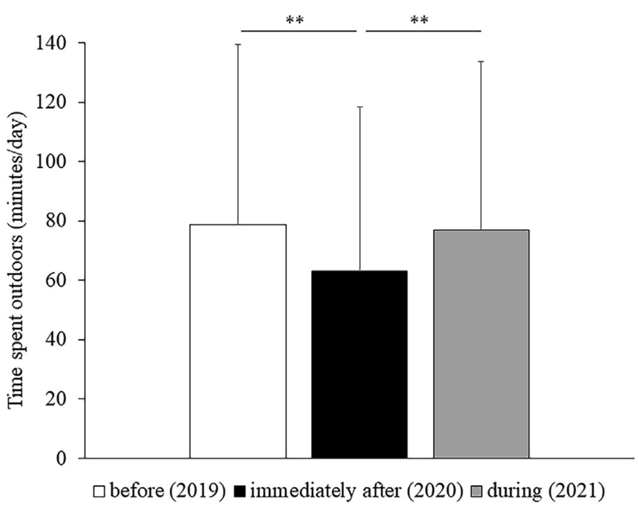

Figure 4. The changes in the time spent outdoors. The times spent outdoors before, immediately after the pandemic onset, and during the pandemic were 79, 63, and 77 minutes/day, respectively, using a mixed-effects model with Bonferroni correction ($P < 0.001$; $^{**}P < 0.01$). Before = before the pandemic; immediately after = immediately after the pandemic onset; during = during the pandemic.

during the pandemic were 41, 52, and 62 minutes/day, respectively ($P < 0.001$). The time spent using smartphones or tablets increased significantly each year (Fig S5, available at www.ophthalmologyscience.org).

The following numbers of students were evaluated: 578 students before the pandemic, 432 immediately after the pandemic onset, and 457 during the pandemic, and the changes in ocular biometry during each period and the results of the mixed-effects model fitted to age for repeated measurements are shown in Table 2. The changes in the ALs before, immediately after onset, and during the pandemic were 0.31, 0.38, and 0.28 mm/year, respectively, and the mixed-effects model with age showed a significant difference ($P < 0.001$). Axial length elongation was greater immediately after the pandemic onset than before the pandemic, and the changes in the AL decreased significantly during the pandemic compared with those immediately after the pandemic onset (Fig 6). The AL elongation values in each age group are shown in Figure S7 (available at www.ophthalmologyscience.org). When all ages were considered, the AL elongation was greater immediately after the pandemic onset than before the pandemic, and the changes in the AL decreased significantly during the pandemic compared with immediately after the pandemic onset in children aged 9 years. The changes in the SEs during each period were −0.20, −0.27, and −0.47 diopters/year, respectively ($P = 0.014$). The changes in the SEs during the pandemic were significantly more myopic compared with those before the pandemic (Fig S8, available at www.ophthalmologyscience.org). The changes in the SEs in each age group are shown in Figure S9 (available at www.ophthalmologyscience.org). The SEs were more myopic during the pandemic than immediately after the pandemic onset in children aged 6 years. Figure S10 (available at www.ophthalmologyscience.org) shows the changes in the AL/CR during each period. The changes in the AL/CR before, immediately after the pandemic onset, and during the pandemic were 0.04, 0.05, and 0.04 per year, respectively ($P < 0.001$).

Table 3 shows the results of univariate and multiple regression analyses performed to estimate the association between changes in the AL and other variables with adjustment for covariates including age, sex, baseline AL, and number of myopic parents. The reason that the number of subjects in the regression analysis was smaller than the number of subjects in the flowchart is that those who did not respond to all of the questionnaires used in the regression analysis were excluded from the analysis. The results indicated that greater AL elongation before the pandemic was significantly associated with younger age (coefficient $\beta = -0.052$; $P < 0.001$), longer baseline AL ($\beta = 0.073$; $P < 0.001$), less time spent outdoors ($\beta = -0.000342$; $P = 0.022$), less time watching TV ($\beta = -0.001$; $P = 0.001$), and shorter reading distance ($\beta = -0.003$; $P = 0.041$). The results of multiple regression analysis immediately after the pandemic onset showed that AL elongation was significantly associated with younger age (coefficient $\beta = -0.070$; $P < 0.001$), longer baseline AL ($\beta = 0.078$; $P < 0.001$), more time reading or studying ($\beta = 0.001$; $P = 0.002$), and having 2 myopic parents ($\beta = 0.048$; $P = 0.048$). The results also showed that greater AL elongation during the pandemic was significantly associated with younger age

Table 2. Changes in Ocular Biometry and Results of the Mixed-Effects Model Fitted to Age for Repeated Measurements

	2018−2019 (n = 578)			2019−2020 (n = 432)			2020−2021 (n = 457)			
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		**P Value**
Spherical equivalent (D)	−0.20	−0.32	−0.08	−0.27	−0.40	−0.14	−0.47	−0.61	−0.33	**0.014**
Axial length (mm)	0.31	0.29	0.32	0.38	0.35	0.40	0.28	0.18	0.38	**< 0.001**
Axial length/corneal curvature radius ratio	0.04	0.04	0.04	0.05	0.04	0.05	0.04	0.03	0.04	**< 0.001**
Corneal curvature radius (mm)	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.02	0.810
Central corneal thickness (mm)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	**< 0.001**
Anterior chamber depth (mm)	0.03	0.02	0.04	0.09	0.08	0.10	0.04	0.03	0.05	**< 0.001**
Lens thickness (mm)	−0.01	−0.02	−0.01	−0.08	−0.09	−0.06	−0.02	−0.03	−0.01	**< 0.001**
Vitreous chamber depth (mm)	0.29	0.27	0.31	0.36	0.34	0.38	0.28	0.26	0.31	**< 0.001**

CI = confidence interval; D = diopters.
All *P* values are 2-sided, and if < 0.05, the value is considered significant and is listed in bold.

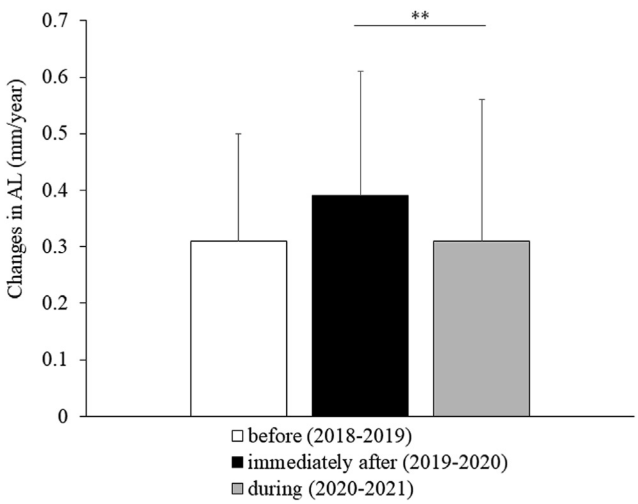

Figure 6. The changes in the axial length (AL) elongation. The changes in the ALs before, immediately after onset, and during the pandemic were 0.31, 0.38, and 0.28 mm/year, respectively, using a mixed-effects model with Bonferroni correction ($P < 0.001$; **$P < 0.01$). Before = before the pandemic; immediately after = immediately after the pandemic onset; during = during the pandemic.

(coefficient $\beta = -0.057$; $P < 0.001$), longer baseline AL at baseline ($\beta = 0.077$; $P < 0.001$), and more time reading or studying ($\beta = 0.001$; $P = 0.026$).

Tables S4 and S5 (available at www.ophthalmologyscience.org) show the results of univariate and multiple regression analyses, respectively, performed to estimate the association between the changes in the SE, AL/CR, and other variables.

Discussion

This study showed that the 3-month school closure caused more AL elongation among schoolchildren, the time spent doing near work increased significantly, and the time spent outdoors tended to decrease during school closure. However, we also found that while the time engaged in near work continued to increase, the time spent outdoors returned to the same level as before the pandemic, which may have contributed to the slowing of AL elongation.

Previous reports,[16,19,20] which evaluated the differences in AL elongation between before and after the lockdown, showed that the pandemic resulted in both decreased time spent outdoors and increased time spent engaged in near work based on questionnaire responses, and AL elongation progressed among children. Zhang et al[19] compared AL elongation before and after the lockdown in 1793 subjects aged 6 to 8 years in Hong Kong. Although no significant difference was specified, they found that the monthly prepandemic AL elongation was 0.024 mm, whereas the monthly postpandemic AL elongation was 0.036 mm, indicating a trend toward elongation. However, Ma et al[16,20] compared AL elongation before and after the lockdown in 208 subjects aged 8 to 10 years in China where the school was closed from January 2020 to August 2020, and found no significant difference. A meta-analysis[21] of 10 previous reports from China, Turkey, Spain, and South Korea also reported no significant difference in AL before and after the lockdown. However, the present study found that AL elongation increased significantly before and after the lockdown.

The current study evaluated ocular parameters, including the AL, and lifestyle factors, including the time spent outdoors and time engaged in near work, not only immediately after the pandemic onset but also continuously in 2021, and previous studies have reported decreased outdoor activity time and increased time using digital devices due to the pandemic. The results showed that time spent outdoors decreased significantly immediately after the pandemic onset and significantly increased or returned to the prepandemic level 1 year after the pandemic, while the time using digital devices increased significantly each year after the pandemic. The trend of AL elongation slowed in 2021, suggesting that the recovery of time spent outdoors may have stopped the AL elongation. A previous randomized clinical trial[22] reported that the addition of 40 minutes of outdoor activity at school compared with the usual activity resulted in a reduced incidence rate of myopia over the next 3 years. In this study, the increase or decrease in outdoor activity time reported in the questionnaire during each period was approximately 15 minutes (approximately 24%) but still may have affected the degree of AL elongation. The duration of digital devices use did not yet affect the AL elongation because the study was conducted among elementary school students and the duration of digital devices use was approximately 60 minutes daily, but it should be noted that it may have an effect if it continues to increase in the future, because Harrington et al[23] reported that time spent on digital devices was related to an increased prevalence of myopia, especially when digital screen time exceeded 3 hours daily. The results of multivariate analysis showed that other previously reported factors such as age, baseline AL, family history of myopia, and reading distance affected AL elongation. The results of multivariate analysis before the pandemic showed that the time spent outdoors, which was significantly associated with shorter AL elongation, was not significant during the pandemic; instead, longer time spent reading and studying became significantly associated with greater AL elongation immediately after the pandemic onset and during the pandemic. However, the overall trend showed that the decrease in AL elongation was linked to the recovery of time spent outdoors, suggesting that AL elongation may slow if outdoor activity time, which temporarily decreased immediately after the pandemic onset, continues to increase and the time spent reading and studying decreases.

Regarding refraction, previous reports[24–27] (using non-cycloplegic or cycloplegic refraction) found that children became significantly more myopic immediately after the pandemic onset. However, in the present study, no significant difference was observed between the prepandemic and the immediate postpandemic periods, and the children in Tokyo were significantly more myopic in 2021, > 1 year

Table 3. Results of Simple Correlation and Multiple Regression Analysis between Changes in AL and Variables

Variable	Before the Pandemic (2018–2019)				Immediately after the Pandemic Onset (2019–2020)				During the Pandemic (2020–2021)			
	Univariate Analysis (n = 375)		*Multivariate Analysis (n = 375)*		*Univariate Analysis (n = 292)*		*Multivariate Analysis (n = 292)*		*Univariate Analysis (n = 266)*		*Multivariate Analysis (n = 266)*	
	Correlation Coefficient	*P Value*	*Coefficient*	*P Value*	*Correlation Coefficient*	*P Value*	*Coefficient*	*P Value*	*Correlation Coefficient*	*P Value*	*Coefficient*	*P Value*
Age, years	-0.247	< 0.001*	-0.052	**< 0.001**	-0.226	< 0.001*	-0.070	**< 0.001**	-0.156	0.005*	-0.057	**< 0.001**
Sex (boy = 1, girl = 0)	0.002	0.487			0.082	0.082			0.056	0.179		
Axial length, mm (baseline)	0.233	< 0.001*	0.073	**< 0.001**	0.259	< 0.001*	0.078	**< 0.001**	0.252	< 0.001*	0.077	**< 0.001**
Time in outdoor activity, min/day	-0.140	0.003*	-0.000342	**0.022**	0.006	0.458			-0.065	0.147		
Time watching TV, min/day	-0.221	< 0.001*	-0.001	**0.001**	-0.100	0.045*			-0.082	0.091		
Time using smartphone/tablet, min/day	-0.151	0.002*			-0.171	0.002*			-0.072	0.120		
Time using computer, min/day	-0.060	0.125			-0.046	0.216			-0.103	0.047*		
Time reading/studying, min/day	0.075	0.073			0.078	0.092	0.001	**0.002**	0.086	0.081	0.001	**0.026**
Reading distance, cm	-0.117	0.011*	-0.003	**0.041**	-0.059	0.159			-0.074	0.115		
Sleeping time, min/day	0.056	0.138			0.022	0.351			-0.003	0.483		
Dry eye disease (yes = 1, no = 0)	0.033	0.261			-0.009	0.437			-0.036	0.277		
No. parents = 0	-0.057	0.136			-0.101	0.043*			-0.033	0.296		
No. parents = 1	0.146	0.002*			-0.163	0.003*			-0.166	0.003*		
No. parents = 2	-0.113	0.014*			0.226	< 0.001*	0.048	**0.048**	0.179	0.002*		

TV = television.
All *P* values are two-sided, and if < 0.05, the value is considered significant and is listed in bold.
*Significant correlation by the Pearson correlation test.

after the pandemic, compared with the prepandemic period. A previous study[28] reported that AL elongation preceded the onset of myopia (under cycloplegic refraction < -0.5 diopters) by 1 year in 7- to 15-year-olds, suggesting that AL elongation immediately after the pandemic onset may have manifested as myopia 1 year after the onset. It is also possible that the AL elongation immediately after the pandemic onset became manifest as myopia 1 year later. In addition, regarding the amount of change in the ocular parameters before and immediately after the pandemic onset, those that changed significantly were corneal thickness, lens thickness, and vitreous chamber depth, with corneal and lens thickness becoming significantly thinner immediately after the pandemic onset, and the vitreous chamber depth becoming significantly longer. It is possible that thinner lenses might have compensated for AL elongation and vitreous chamber depth during the pandemic. In a multivariate analysis to examine factors related to the change in the SE, longer reading/studying times and shorter reading distance were associated with myopia during the pandemic; therefore, attention should be paid to the near-work environment.

The current study had some limitations. First, though cycloplegic autorefraction is the standard based on a white paper presented by the International Myopia Institute,[29] we did not use cycloplegics because we measured the ocular parameters during class. Second, there was recall bias because the lifestyle data were collected from a questionnaire. Another limitation was that the students in only one Tokyo school were evaluated.

In conclusion, this study evaluated changes in the ocular parameters including AL elongation and lifestyle factors continuously from the prepandemic to the postpandemic period. We showed that the school closure and decreasing time spent outdoors might have caused greater AL elongation among schoolchildren in Tokyo; however, it is possible that, although the time spent in near work still increased, the return to the time spent outdoors to the prepandemic levels may have affected the slowing of AL elongation after lockdown. In other words, the results indicated that despite the increased time spent using smartphones and tablets due to the pandemic, spending more time outdoors may have reduced the AL elongation.

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Footnotes and Disclosures

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Abbreviations and acronyms:
AL = axial length; **AL/CR** = axial length–corneal radius curvature ratio; **SE** = spherical equivalent.

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