The effect of home education on myopia progression in children during the COVID-19 pandemic

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Abstract

Objectives

To evaluate the effect of the COVID-19 pandemic restrictions on myopia progression (MP) in school age children.

Methods

A total of 115 children aged 8–17 years with a diagnosis of myopia who had been followed-up for at least 3 years, were included in this study with a retrospective and single-center design. The subjects' age, the history of myopia in the family, the time spent in front of a screen, the digital devices used during home education (computer, tablet, smartphone, television), the time spent in open air (hours/day), the refractive error (RE) (spherical equivalent value) detected before the home education period and the changes in the myopia over the years, were recorded.

Results

The mean age was 12.06(± 2.29) years. Only the right eyes were included. The glasses use duration was 3.57(± 0.74) years. The annual MP amount 0.49(± 0.26), 0.41(± 0.36) and 0.54(± 0.43) diopters (D) for the 2017, 2018, and 2019 years before home education, respectively, ($p > 0,05$), and 0.71(± 0.46) D in 2020, during home education. The increase in MP amount in 2020 compared to the 2019 and 2018 years was statistically significant ($p < 0.003$). MP was statistically significantly less in children who participated in open-air activities for 2 hours a day and those who lived in detached houses ($p = 0.004$, $p = 0.006$, respectively).

Conclusion

During home confinement, education programs of school children should be designed while taking into account preventive measures for MP, in particular for allowing children to spend at least two hours of outdoor time per day.

Introduction

Myopia is an important health problem worldwide. The World Health Organization (WHO) estimates that half of the world's population will be myopic by 2050 [1]. Other estimates are that 5 billion people will be diagnosed with myopia and over 1 billion with myopia above 5 diopters (D) by 2050 [1, 2]. Some authors have described the increase in myopia in the last decade as an epidemic [3]. The insufficient time spent on outdoor activities is now being considered as an important risk factor for myopia development [4]. The duration and intensity of close distance activities is also associated with myopia [5]. High myopia (-6 D and above) is associated with problems that seriously impair vision, such as retinal detachment, glaucoma, choroidal neovascularization and posterior staphyloma [6].

It has previously been suggested that the intensive use of digital and virtual learning using a screen, resulting from the closure of schools and the intensification of home quarantine during the COVID-19 pandemic, would increase the myopia rate [7]. This kind of myopia, which is also described “Quarantine myopia”, has increased during the COVID-19 pandemic [8]. According to the United Nations Educational, Scientific and Cultural Organization, 1.1 billion children in over 140 countries have been exposed to digital devices due to pandemic restrictions and distance education during May 2020 [8, 9]. The schools were closed on March 2020 in Turkey and are still closed at the time this article was written (mid-January 2021) and home education continues.

After the WHO declared COVID-19 a pandemic in March 2020, face-to-face training was interrupted in Turkey, as in most countries, in order to restrict the spread of the virus. In addition to the negative physical and mental effects of school closures, the children were increasingly exposed to smartphones, tablets, computers and the television, during the home education process [10]. The increasing myopia within the last year has been described as “quarantine myopia”, however, the effect of the technological device used for this education on myopia progression has not yet been studied [11].

We aimed to evaluate the changes in the refractive error within the last year (during the home education period) in children diagnosed with myopia and the effect on this change of the technological devices they use to receive education, as well as the time they spent in daylight during the quarantine period.

Materials And Methods

Children aged 8–17 years with a diagnosis of myopia who had presented to the Alanya Alaaddin Keykubat University’s Eye Clinic between August 2020 and December 2020, were included in this study, with a retrospective and single center design. The spherical equivalent (SE) (the total of the spherical and cylindrical value, divided by 2) was calculated in all cases. Myopic progression in one year under 0.50 D was identified as mild, 0.50-1 D as moderate, and 1 D or more as severe [12].

The study inclusion criteria were the presence of 0.50 D or more of myopia, having been followed up at the same clinic for at least 3 years and the presence of cycloplegic refraction values in the refractive examinations. The study exclusion criteria were myopia under 0.5 D, presence of strabismus, amblyopia, retinal disease, a history of eye surgery, follow-up duration less than 3 years, the use of 0.01% atropine drops and the use of contact lenses.

Refractive data for 2016, 2017, 2018 and 2019 were extracted from medical records at the time of examination in 2020 and the SE values were noted. The age, gender, hand dominance (the hand used for writing), the subject’s mother’s educational level, the technological support device used for home education and the duration of its use, the presence and duration of outdoor activities and the type of house the patient lived in, were all queried by phone. The analysis of the data was conducted during the month of January 2021. The refractive measurements were performed with an Auto Kerato-refractometer (Nidek ARK1-S, Nidek, San Jose, CA, USA).

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. Ethics committee approval for this sectional study was obtained from the Alaaddin Keykubat University Faculty of Medicine’s Ethics Committee (Decision no: 2021/01–22).

Statistical Analysis

The paired sample t-test was used to compare the difference between the measurement values of the same individual from the different years. The Anova t-test was used in order to show any difference between the behavior of the group mean value when the normality and equal distribution assumptions were met, and the non-parametric methods of the Kruskal-Wallis H Test (group number > 2) and Mann-Whitney U Test (group number = 2) were used when they were not. As the data did not have a normal distribution, the non-parametric Spearman's Rank Correlation test was used in calculating the correlation of any two numerical variables. Statistical significance was determined as $p = 0.05$ for all cases. The IBM SPSS (Statistics Program for Social Sciences for Windows, Version 21.0, Armonk, NY, IBM Corp.) software program was used for the statistical analyses.

Results

Between August 2020 and December 2020, 135 patients met the study inclusion criteria. The family of 115 children could be reached and the study was completed with 115 participants. The mean age of the subjects was 12.06 ± 2.29 years and 75 (65.2%) were female. The glasses use duration was 3.57 ± 0.74 years.

A smartphone was the most common device used to attend the courses at 53%, the mean duration spent in front of the screen was 5.77 ± 1.34 hours/day, and the educational level of the mother was primary school in 42.6%. The characteristics of the cases are presented in Table 1.

Table 1
General characteristics of the subjects

Parameter	Group	n (%)
Mother’s Education	Primary School	49 (42.6%)
	High school	51 (44.3%)
	Illiterate	2 (1.7%)
	University	13 (11.3%)
Distance Education Type	PC	35 (30.4%)
	TV	2 (1.7%)
	Tablet	17 (14.8%)
	Phone	61 (53.0%)
Family History of Glasses	Mother or Father	42 (36.5%)
	None	51 (44.3%)
	Sibling	22 (19.1%)
Going out (2 hours/day)	2 Hours	35 (30.4%)
	30 Min	10 (8.7%)
	None	70 (60.9%)
Gender	Male	40 (34.8%)
	Female	75 (65.2%)
Hand Dominance	Right	105 (91.3%)
	Left	10 (8.7%)
Type of House	Apartment Building	85 (73.9%)
	Detached	30 (26.1%)
Break after 30 Min	Yes	6 (5.2%)
	No	109 (94.8%)

The mean SE of the refractive values was − 1.14 ± 0.66 D in 2016, -1.47 ± 0.82 D in 2017, − .45 ± 0.91 D in 2018, -1.99 ± 1.04 D in 2019 and − 2.7 ± 1.21 D in 2020. Annual progression analysis revealed a myopic progression of 0.71 ± 0.46 D in 2020 and this value was significantly higher than in 2019 and 2018 (0.54 ± 0.43, $p = 0.003$; and 0.41 ± 0.36, $p < 0.001$, respectively) (Fig. 1). The comparison of the MP values based on the years is presented in Table 2.

Table 2
Myopic progression amounts and comparison between periods

		Mean ± SD			
		Median (Min–Max)			
Param1	**Param2**	**Param1**	**Param2**	**Difference**	P-**value**
2020 – 2019 MP	2019 – 2018 MP	0.71 ± 0.46	0.54 ± 0.43	0.17 ± 0.6	**0.003**
		0.75 (-0.38–2.13)	0.5 (-0.25–1.88)	0.25 (-2.01–2.13)	
2020 – 2019 MP	2018 – 2017 MP	0.71 ± 0.46	0.41 ± 0.36	0.32 ± 0.6	**< 0.001**
		0.75 (-0.38–2.13)	0.5 (-0.5–1.5)	0.25 (-1.51–2)	
2020 – 2019 MP	2017 – 2016 MP	0.71 ± 0.46	0.49 ± 0.26	0.21 ± 0.67	0.168
		0.75 (-0.38–2.13)	0.5 (-0.25–1)	0.31 (-1.13–1.63)	
2019 – 2018 MP	2018 – 2017 MP	0.54 ± 0.43	0.41 ± 0.36	0.16 ± 0.62	0.053
		0.5 (-0.25–1.88)	0.5 (-0.5–1.5)	0.06 (-1–1.75)	
2019 – 2018 MP	2017 – 2016 MP	0.54 ± 0.43	0.49 ± 0.26	0.04 ± 0.45	0.716
		0.5 (-0.25–1.88)	0.5 (-0.25–1)	0 (-0.5–1.25)	
2018 – 2017 MP	2017 – 2016 MP	0.41 ± 0.36	0.49 ± 0.26	-0.06 ± 0.35	0.483
		0.5 (-0.5–1.5)	0.5 (-0.25–1)	0 (-0.75–0.75)	

Paired-t-Test: Parameter 1 vs. Parameter 2

Statistically significant values are shown in bold.

Spending 2 hours/day on outdoor activities and the type of housing were seen to have a statistically significant effect in the analysis of the factors influencing the MP in 2020 (Table 3). The mean myopic progression in the last year was 0.55 ± 0.42 D in children who spent time outside in the daylight for 2 hours a day, and 0.82 ± 0.45 D in children who did not (p = 0.003, Mann-Whitney U Test). The mean myopic progression in the past year was similarly 0.5 ± 0.41 D in children living in detached houses and 0.79 ± 0.45 D in those living in apartments (p = 0.006, Mann-Whitney U Test).

Table 3
The evaluation of the factors effective on myopic progression in 2020

	2020 MP amount (D) **Mean ± SD**			
	Median (Min–Max)			
Family History of Glasses	**Mother or Father (42)**	**None (51)**	**Sibling (22)**	P-**value**
	0.79 ± 0.43	0.64 ± 0.47	0.73 ± 0.47	0.22(k)
	0.75 (-0.13–1.75)	0.5 (-0.38–2.13)	0.69 (0–2)	
Mother's Education	**Primary School (49)**	**High school (51)**	**University (13)**	
	0.68 ± 0.44	0.69 ± 0.42	0.91 ± 0.63	0.621(k)
	0.62 (0–2.13)	0.75 (-0.38–1.62)	0.75 (0.25–2)	
Distance Education Type	**PC (35)**	**Tablet (17)**	**Phone (61)**	
	0.65 ± 0.48	0.79 ± 0.44	0.71 ± 0.44	0.478(k)
	0.63 (-0.38–2)	1 (0–1.63)	0.63 (-0.12–2.13)	
Gender	**Male (40)**	**Female (75)**		
	0.75 ± 0.49	0.7 ± 0.44		0.609(m)
	0.75 (-0.38–2.13)	0.62 (-0.13–2)		
Going out (2 hours/day)	**Yes (45)**	**No (70)**		
	0.55 ± 0.42	0.82 ± 0.45		**0.003(m)**
	0.62 (-0.38–1.75)	0.75 (0–2.13)		
Hand Dominance	**Right (105)**	**Left (10)**		
	0.72 ± 0.46	0.64 ± 0.48		0.48(m)
	0.75 (-0.38–2.13)	0.63 (0–1.75)		
Type of House	**Apartment Building (85)**	**Detached (30)**		
	0.79 ± 0.45	0.5 ± 0.41		**0.006(m)**
	0.75 (0–2.13)	0.5 (-0.38–1.38)		

	2020 MP amount (D) Mean ± SD		
Break after 30 Min	**Yes (6)**	**No (109)**	
	0.63 ± 0.47	0.72 ± 0.46	0.708(m)
	0.63 (0–1.25)	0.75 (-0.38–2.13)	

(k) Kruskal-Wallis Test - (m) Mann-Whitney U Test

Statistically significant values are shown in bold.

The myopia progression in 2020 was slow (0.31 ± 0.2 D) in 49 subjects (42.6%), moderate (0.82 ± 0.14 D) in 45 (39.1%) and rapid (1.42 ± 0.29 D) in 21 of them (18.3%) (Table 4). No significant correlation was found between the 2020 progression and the daily digital display device use, age and glasses use duration (r=-0.094, p = 0.32; r = 0.018, p = 0.848; r = 0.033, p = 0.727, respectively).

Table 4
The evaluation of the affecting factors based on the 2020 myopic progression rate

Difference-Group		Slow (0-0.5) N: 49 (42.6%)	Moderate (0.5-1) N :45 (39.1%)	Rapid (> 1) N: 21 (18.3%)	*P-value*
Age		12.42 ± 2.35	11.89 ± 2.34	11.57 ± 2.0	0.317(k)
Glasses use duration (year)		3.61 ± 0.81	3.51 ± 0.55	3.57 ± 0.93	0.907(k)
Time spent in front of the screen (hours/day)		5.82 ± 1.45	5.78 ± 1.28	5.67 ± 1.24	0.929(k)
Gender	Male	15 (30.6%)	19 (42.2%)	6 (28.6%)	0.4*
	Female	34 (69.4%)	26 (57.8%)	15 (71.4%)	
Family- Glasses	Mother or Father	13 (26.5%)	20 (44.4%)	9 (42.9%)	0.415**
	None	26 (53.1%)	17 (37.8%)	8 (38.1%)	
	Sibling	10 (20.4%)	8 (17.8%)	4 (19.0%)	
Mother's Education	Primary school	23 (46.9%)	20 (44.4%)	6 (28.6%)	0.455**
	High school	20 (40.8%)	21 (46.7%)	10 (47.6%)	
	University	6 (12.2%)	3 (6.7%)	4 (19.0%)	
Distance Education Type	PC	16 (32.7%)	13 (28.9%)	6 (28.6%)	0.971**
	Tablet	6 (12.2%)	8 (17.8%)	3 (14.3%)	
	Phone	26 (53.1%)	24 (53.3%)	11 (52.4%)	
Break after 30 Min.	Yes	3 (6.1%)	2 (4.4%)	1 (4.8%)	1**
	No	46 (93.9%)	43 (95.6%)	20 (95.2%)	
Going out (2 hours/day)	Yes	22 (44.9%)	19 (42.2%)	4 (19.0%)	0.11*

Difference-Group		Slow (0-0.5) N: 49 (42.6%)	Moderate (0.5-1) N :45 (39.1%)	Rapid (> 1) N: 21 (18.3%)	*P-value*
	No	27 (55.1%)	26 (57.8%)	17 (81.0%)	
Type of House	Apartment Building	32 (65.3%)	34 (75.6%)	19 (90.5%)	0.085*
	Detached	17 (34.7%)	11 (24.4%)	2 (9.5%)	
Hand Dominance	Right	45 (91.8%)	40 (88.9%)	20 (95.2%)	0.749**
	Left	4 (8.2%)	5 (11.1%)	1 (4.8%)	
p* Pearson Chi-Squared Test, p** Fisher Exact Test (k) Kruskal-Wallis Test					

The proportion of children taking breaks after screen usage or lesson every 30 minutes, was only 6 (5.2%) of all participants. Whether taking a break every 30 minutes or not did not have a statistically significant effect on the amount of myopic progression in 2020 (p = 0.708, Mann-Whitney U Test).

Discussion

The first case of COVID-19 in Turkey was announced in March 11 by the Turkish Ministry of Health, on the very same day the pandemic was declared by the WHO [13, 14]. The subjects of our study consisted of the cases that presented to our outpatient department between August and December 2020, taking into account that the schools were closed and home-education started in March 2020.

The negative effect of close work and the positive effect of daylight in keeping myopia progression under control have been demonstrated by other studies [15]. Children staying at home during the pandemic and attending online education has increased the concerns about myopia progression. The results of our study have revealed that progression in the last year, within the age range of 8–17 years, is significantly higher than in the previous years. Additionally, spending 2 hours daily in an outdoor activity and living in a detached house were both found to decrease myopic progression. However, the effect of the duration of digital device use and the type of device used (smartphone, tablet, television) on myopia progression, was not found to be statistically significant.

Wang et al. have recently reported a 1.4 to 3 times increase in the myopia prevalence in 2020 in children aged 6–8 years, compared to the previous five years, with the ‘photoscreening’ test in over one hundred thousand children [16]. We evaluated the follow-up examinations of children with a diagnosis of myopia instead of children newly diagnosed with myopia. Wang et al. did not use cycloplegia for the refraction evaluation in children [16]. The myopia results of photoscreening-based devices are known to be exaggerated and to be affected by the experience of the person performing the measuring [17, 18].

Although these devices are useful in preverbal and nonverbal children, the general ophthalmological approach in school-age children is to determine cycloplegic refraction values [19]. We only included the cases that had undergone cycloplegic evaluation in our study, in order to ensure healthy results.

The relationship of long-term exposure to digital device screens with myopia is still controversial and some studies support this relationship, while others claim the opposite [20, 21]. Interestingly, the duration of reading, watching television or playing games on the computer has been suggested to influence myopia's progression, rather than its occurrence, in the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error Study [22]. However, this may not be due to the effect of digital screens on the progression alone and could also be influenced by the "substitution effect", as in the indirect decrease of the outdoor activity related to the increased time spent in front of the screen [23]. The effect on myopia of the activities performed in front of the digital screen, may not be equivalent to the effect of reading and writing in traditional education [24, 25]. Dopamine release in the retina is stimulated by daylight and suppresses the axial expansion of the eye [26, 27]. In addition, studies have revealed that the dopaminergic system in the frontal lobe is activated by the use of a digital device [28]. The effect of display devices on the retinal dopamine levels is not known, however Spiperone, a dopamine antagonist, has been shown to inhibit the protective effect of light against the increase of the ocular axial length in experimental models [29]. It has not been possible to demonstrate the relationship between myopia progression and the duration of use of a digital display device such as a tablet, smartphone, or computer with our study.

Outdoor activities have previously been shown to decrease the occurrence and progression of myopia [30, 31]. He et al. have reported that every additional 40 minutes of outside activities decreases myopia incidence by 23% [30]. Wu et al. have suggested that myopia progression in children who spent more than 11 hours a week outdoors decreases by 53% [31]. In general, 2 hours of outdoor activities per day is assumed to decrease myopia progression in school age children [7]. We similarly observed that myopia progression was 33% less in children with 2 hours of outdoor activity daily, even though the duration spent in front of the screen was similar. Although outdoor activities had a protective effect on myopia progression in our study, we did not observe a similar protective effect on the myopia progression rate. This result indicates that myopia progression occurs as a result of multiple factors, including environmental ones.

The type of house the child lives in is one of these environmental factors and we found it to be an independent risk factor for myopia progression. Similarly, a relationship between the type of the house the subject lives in and myopia, was revealed in a study conducted in Australia [20]. Myopia was reported to be more common in children living in apartment buildings compared to those living in detached houses in the same study [20]. He et al. found a significant relationship between school location and myopia [32]. Wu et al. reported an increase in the myopia prevalence with increasing number of floors in the building [33]. We think that accepting myopia as a public health problem could be effective in the intensification of screening in pre-school and school-aged children, as well as in designing cities in the fight against myopia.

The limitations of this study include the lack of data on pre-school children, the potential bias resulting from the information about the time spent in front of the screen and outside activities being self-reported, by way of the telephone, the accuracy of which could not be verified. The lack of biometry or keratometry information and the inability to determine the cause-effect relationship, as a result of the study's cross-sectional design, are also limitations. A German study comparing refractive error information obtained from the patient statements with the information obtained from the opticians, has shown the two to be very similar [34]. Our study is, however and to the best of our knowledge, the first to evaluate the effect of home education during the COVID-19 pandemic in myopic children, using cycloplegic refraction results. It is also the first study to investigate the effect of the technological devices used for home education on myopia progression.

In conclusion, home education during the COVID-19 pandemic has increased the myopia progression rate in children, compared to the previous years. This increase has been found to be related to the duration of outdoor activities, as reported previously. A detached type of housing allows for a child to perform outside activities easily, while at home. During home confinement, education programs of school children should be designed while taking into account preventive measures for MP, in particular for allowing children to spend at least two hours of outdoor time per day.

Declarations

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Conflict of Interest

Authors declare that there is no competing financial interest in relation to the work.

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Author Contribution Statement

FA was responsible for designing the study protocol, conducting the search, obtaining data, interpreting results, drafting and revising the article. FA, NSK obtained the data, conducted the analyses, contributed to the design of the study, interpreting results and revision of the article. All authors read and approved the final paper.

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Figures

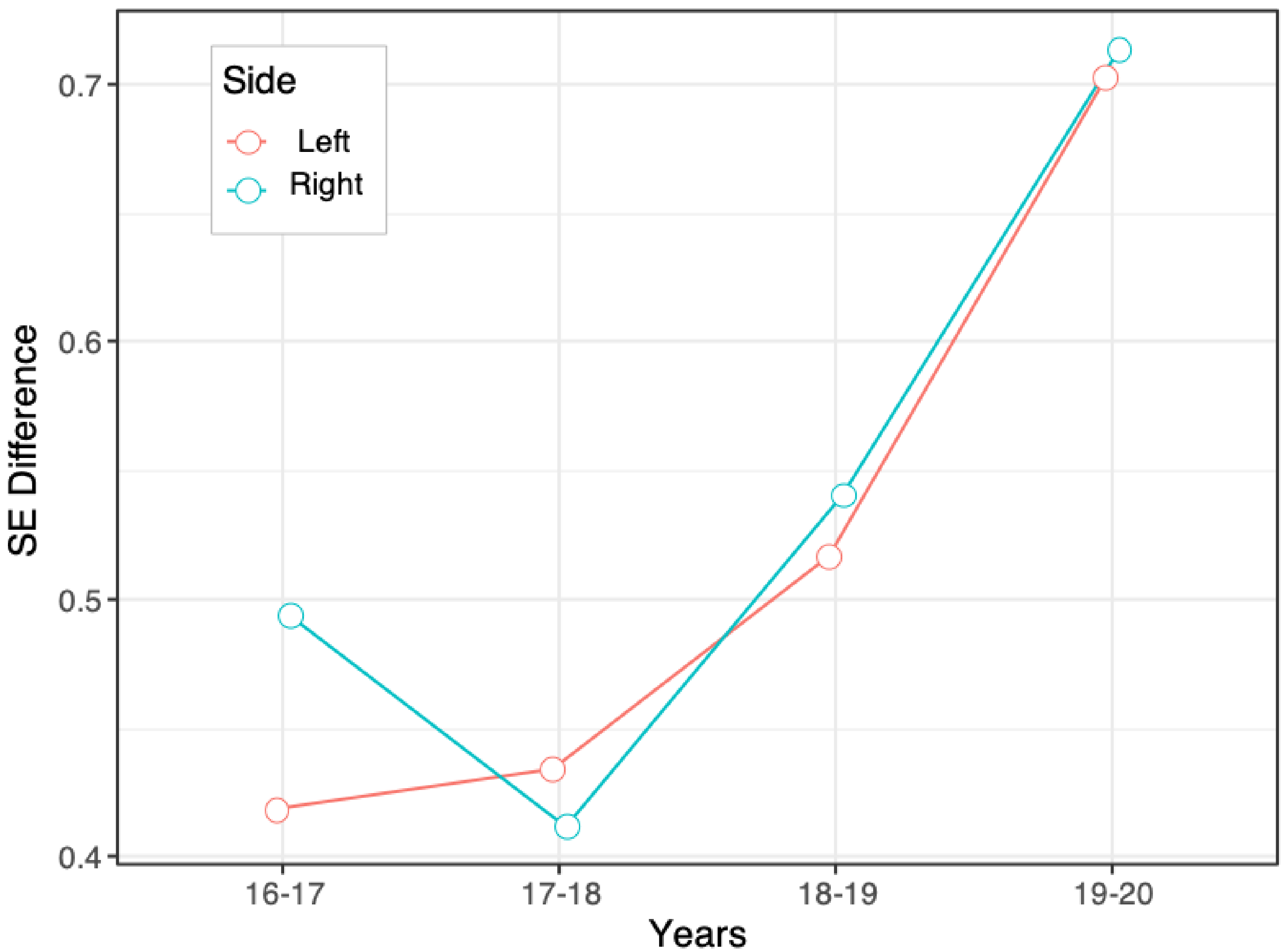

Figure 1

Evaluation of the participants' myopic progression amounts for the right and left eyes during the periods.