Clinical and Epidemiologic Research

Association of Attention-Deficit Hyperactivity Disorder With Myopia Among School Children

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Purpose. To determine the relationship of attention-deficit hyperactivity disorder (ADHD) with myopia among school children.

Methods. Children aged six to eight years in Hong Kong were recruited through a stratified, clustered randomized sampling frame and subsequently invited to undergo cycloplegic autorefraction and axial length measurements between 2016 and 2021. ADHD diagnoses were made by qualified physicians according to ICD-10 criteria. ADHD symptoms were assessed using the Strengths and Weaknesses of ADHD-symptoms and Normal-behaviors Questionnaire.

Results. Totally 474 children with ADHD and 9950 control children were included. The age- and sex-adjusted myopia prevalence was lower in ADHD group (21%) versus controls (26%; $P = 0.02$). Multivariable regression analysis showed less myopia (odds ratio [OR] = 0.75; $P = 0.03$), higher spherical equivalent refraction (SER) ($\beta = 0.13$; $P = 0.04$), and shorter axial length (AL) ($\beta = -0.07$; $P = 0.03$) in children with ADHD. Specifically, ADHD with oral methylphenidate (MPH) treatment had less myopia (OR = 0.61, $P = 0.04$), higher SER ($\beta = 0.36$; $P < 0.001$) and shorter AL ($\beta = -0.25$; $P < 0.001$) compared to controls. Each additional month of MPH treatment was associated with a higher SER ($\beta = 0.02$; $P = 0.01$) and shorter AL ($\beta = -0.01$; $P = 0.01$). For each one-point increase in attention-deficit scores, children were found to be less myopic (OR = 0.88, $P = 0.01$), having higher SER ($\beta = 0.07$; $P = 0.003$) and shorter AL ($\beta = -0.04$; $P = 0.001$). The prevalence of myopia among ADHD increased to 32% during COVID-19 pandemic compared with 23% before COVID-19 pandemic ($P = 0.04$).

Conclusions. This cross-sectional study found that ADHD is associated with reduced myopia prevalence, more hyperopic SER, and shorter AL. Of note, the observed effect sizes of these associations were small; therefore the interpretation of the clinical meaning needs to be cautious.

Keywords: attention-deficit hyperactivity disorder, myopia, COVID-19 pandemic

Attention-deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder that occurs usually during childhood and often persists into adulthood. It is characterized by symptoms of inattention, hyperactivity-impulsivity, and high levels of comorbidity with other neurodevelopmental disorders.[1] The worldwide prevalence of ADHD is approximately 5% among children and 2.5% among adults, with males more affected than females.[2,3]

ADHD can increase the risk of other psychiatric disorders and negative life outcomes such as educational and occupational failures, accidents, criminality, and addictions.[3] ADHD casts a substantial health and financial burden for the individuals, their family, and the community.

ADHD patients have been reported to have increased risks of ocular disturbances, including astigmatism, strabismus, reduced near point of convergence, color discrimination, and contrast sensitivity.[4–7] Globally, myopia is the most common ocular disease and has become a heavy public health burden in many parts of the world.[8] There are several reported studies on refractive errors in ADHD patients; most found no difference in the prevalence of myopia between ADHD patients and healthy controls.[4,9,10] These studies have been limited by the small sample size or unstandardized methods for ADHD assessment and refraction measurement. Notably, oral methylphenidate (MPH) treatment remains the first-line pharmacotherapy for ADHD. MPH functions by inhibiting the reuptake of dopamine and norepinephrine, thereby enhancing catecholaminergic activity in the brain regions involved in ADHD pathogenesis, which leads to symptom improvement.[11–13] Concurrently, the dopamine system plays a significant role in mediating myopic eye growth and is broadly associated with other myopic mechanisms.[14,15] Thus it is intriguing to explore whether MPH affects myopia by influencing dopamine levels. Additionally, it is well established that near-work and outdoor activity influence myopia prevalence. Given that children with ADHD may exhibit different patterns of near-work and outdoor activity compared to their peers, the impact of ADHD symptoms on myopia remains unclear.

During the COVID-19 pandemic, quarantine measures in many cities in the world have resulted in significant changes in children's lifestyles and behavior, including reduced time spent outdoors and increased use of electronic devices for remote learning. These changes were found to be associated with an increase in the prevalence of myopia. Our recent study revealed that the COVID-19 pandemic was a significant risk factor for the development of myopia among Chinese children in Hong Kong.[16] However, no study to date has investigated whether the COVID-19 pandemic influences the prevalence of myopia in children with ADHD. Therefore this study aimed to determine the association of ADHD with myopia and the change of myopia prevalence in ADHD children as affected by the COVID-19 pandemic.

Methods

Study Population

Participants for this cross-sectional study were recruited from the ongoing Hong Kong Children Eye Study (HKCES), a population-based study on ocular conditions among children aged six to eight years attending primary school,[17–21] using data collected between 2016 and 2021. The flowchart is shown in Figure. Once participants' consent form were obtained, they were invited to the Chinese University of Hong Kong Eye Centre for comprehensive ocular examinations and completion of standardized questionnaires according to a unified protocol.[17] Ocular examinations included cycloplegic refraction, axial length measurement, visual acuity, intraocular pressure measurement, color vision test, and fundal examination.[17] Simultaneously, parents completed a questionnaire containing structured scales, socioeconomic and environmental factors of the family, and children's lifestyle information including outdoor time and near-work time.[17] The study protocol was approved by the ethics committee board of the Chinese University of Hong Kong, and all study procedures adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from all children and their parents prior to their participation in the study, including agreement for direct access to the child's original medical records for verification of clinical trial procedures and/or data. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline.

Ocular Examinations

Visual acuity was assessed using the logMAR (logarithm of the minimum angle of resolution) chart (Nidek, Tokyo,

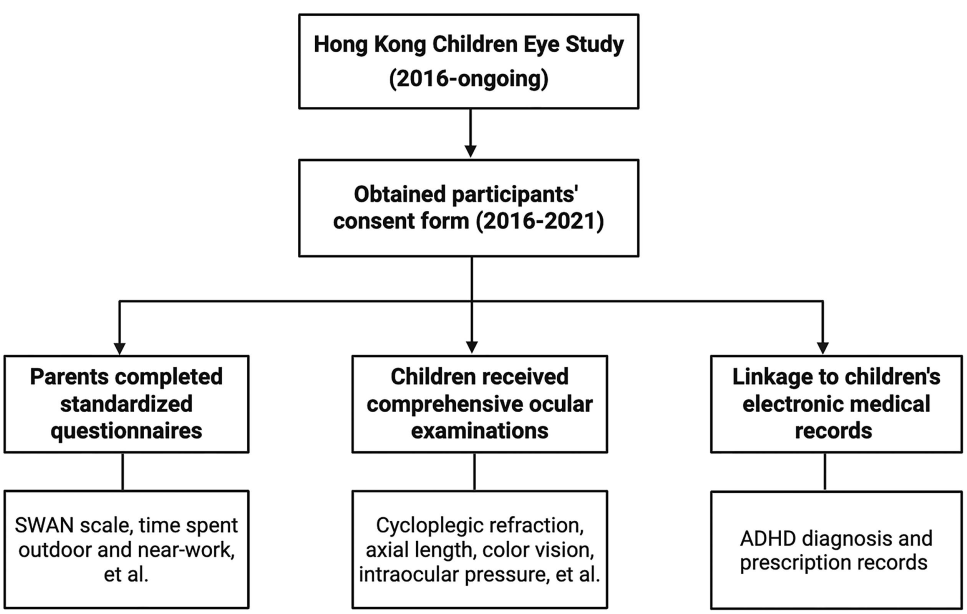

Figure. Flow chart of this study.

Japan). Cycloplegic autorefraction was performed using an autorefractor (ARK-510A; Nidek) after a cycloplegic regimen consisting of at least two cycles of eye drops. In the first cycle, two separate eye drops, cyclopentolate 1% (Cyclogyl; Alcon-Couvreur, Bornem, Belgium) and tropicamide 1% (Santen, Osaka, Japan), were administered to both eyes at a five-minute interval. The second cycle of the same cycloplegic eye drops was administered 10 minutes after the first. A third cycle of the same cycloplegic eye drops was given 30 minutes after the second cycle if the pupillary light reflex was still present or if the pupil size was <6.0 mm. Further cycles of cycloplegic eye drops would be administered if necessary to ensure that the pupils were well dilated. However, pupil size does not determine whether accommodation is fully relaxed. Five readings, all of which had to be <0.25 D apart, were obtained and averaged, at 30 min after the last drop of cycloplegic agent. If cycloplegia failed to reach these criteria, the children were excluded from the analysis.[17] Ocular axial length (AL) was measured using partial coherence laser interferometry (IOLMaster 700; Carl Zeiss Meditec, Jena, Germany). Color vision testing was performed using the HRR Standard Pseudoisochromatic Test (4th Edition).

Identification of Children With ADHD and Access of ADHD Symptoms

For children who underwent ocular examinations and whose parents provided informed consent, we extracted their ADHD diagnosis and prescription information from the Hospital Authority (HA) electronic medical records system, ensuring that all records were dated prior to the date of the ocular examination. The Hong Kong HA, a statutory entity, administers all hospitals and the majority of outpatient clinics within the public sector, delivering approximately 90% of healthcare services in Hong Kong.[22] In 2000, the HA implemented a comprehensive electronic medical records system across the territory to systematically collect clinical data for all individuals attending public hospitals and clinics. The diagnosis, made by a psychiatrist based on ICD-10 criteria and confirmed through a semi-structured interview, was followed by treatment prescribed by the diagnosing doctor. ADHD that was treated with MPH for at least one month prior to ocular examination was categorized in the MPH treatment group, while other ADHD cases were categorized in the non-MPH treatment group.

Additionally, we used parental versions of the Chinese Strengths and Weaknesses of ADHD-symptoms and Normal-behaviors Questionnaire (SWAN) to assess children's ADHD symptoms. The SWAN has been validated and shown to possess good psychometric properties in Hong Kong,[23,24] with higher scores indicating more severe symptoms. It consists of 18 items rated on a seven-point scale, with the average score providing the ADHD-combined score. The first nine items assess inattentive symptoms, and the last nine assess hyperactive/impulsive symptoms, with each subset's average yielding the respective subscale score.[25]

Definition and Outcomes

Participants from 2016 to 2021 were divided into two distinct periods: before COVID-19 pandemic, from 2016 to December 2019, and during COVID-19 pandemic, from January 2020 to 2021. Spherical equivalent refraction (SER) was calculated as the sum of the spherical diopters and half of the cylindrical diopters. Myopia was defined as a SER of −0.50 diopters (D) or less in at least one eye. This study obtained children's lifestyle information from questionnaire, then calculated the outdoor time, near-work time, screen time, and diopter-hour based on this information. The detailed method for calculation was derived from our previous study.[17] Parental myopia was defined as one or both parents having myopia. Because color-deficient individuals are less susceptible to the onset and development of myopia[26]; therefore children with color vision deficiency were excluded from this study. The outcomes of the study were (1) associations between ADHD and myopia prevalence, SER, and AL; and (2) changes in myopia prevalence, SER, and AL before and during the COVID-19 pandemic in children with ADHD.

Statistical Analysis

The demographic characteristics of participants in this study were summarized using descriptive statistics. Continuous variables were reported as means and standard deviations (SDs), whereas categorical variables were reported as counts and percentages. Analyses of SER and AL were based on binocular data, using generalized estimating equations to adjust for intereye correlation within the same participant. To analyze associations between ADHD and myopia/SER/AL, we performed five multivariable regression models (logistic regression for myopia prevalence, linear regression for SER/AL), adjusting for potential confounders (age, sex, parental myopia, family income, outdoor time, and near-work time). Model 1 examined ADHD-myopia/SER/AL associations. Model 2 stratified ADHD cases by MPH treatment status. Model 3 focused specifically on inattention and hyperactivity symptoms. Model 4 simultaneously incorporated both MPH treatment and symptom severity. Finally, Model 5 accounted for potential COVID-19 influences on ADHD-myopia relationships.

Propensity score matching was used to reduce confounding effects in this observational study.[27] The analysis used 1:1 nearest-neighbor matching without replacement, with propensity scores estimated using a generalized linear model that included age, sex, parental myopia, family income, outdoor time and near-work time. Balance diagnostics demonstrated effective covariate adjustment, with all post-matching standardized mean differences below 0.1 and variance ratios between 0.8–1.25, indicating adequate balance (Supplementary Table S1). The matched dataset was subsequently used for comparison between ADHD and controls. All statistical analyses were performed using R version 4.3.0, with a two-sided P value <0.05 considered statistically significant.

Results

Population Demographics

As shown in Table 1, a total of 10,424 children were included in the analysis, encompassing all participants from 2016 to 2021 after excluding 193 cases with color vision deficiency (16 from the ADHD group and 177 from controls). Of these, 474 (5%) children had ADHD and 9950 served as controls. The mean age of children with ADHD was 7.51 ± 0.87 years, whereas that of the control group was 7.33 ± 0.90 years ($P < 0.001$). The proportion of males

Table 1. Demographic and Ocular Characteristics Among all Participants From 2016 to 2021

	ADHD Group (n = 474)	Control Group (n = 9950)	P Value*
Age (y), mean (SD)	7.51 (0.87)	7.33 (0.90)	<0.001
Male	364 (77%)	5003 (50%)	<0.001
Parental myopia (n = 1)	200 (42%)	3896 (39%)	0.19
Parental myopia (n = 2)	160 (34%)	3437 (35%)	0.64
Family income < HK$ 25,000/mo	237 (50%)	3726 (37%)	<0.001
Outdoor time (hours/day), mean (SD)	1.30 (0.57)	1.36 (0.64)	0.03
Near-work time (hours/day), mean (SD)	3.65 (1.33)	3.52 (1.32)	0.05
Ocular examination during COVID-19 pandemic	96 (20%)	2062 (21%)	0.85
Visual acuity (Log Mar), mean (SD)†	0.11 (0.15)	0.11 (0.19)	0.97

* Two-sample T test for continuous data and chi-square test for categorical data, and didn't adjust for confounding factors.
† Mean and SD were calculated using data from right eye.

Table 2. Association Between ADHD and Myopia Among all Participants From 2016 to 2021

	Model 1		Model 2		Model 3		Model 4		Model 5	
	OR	P Value*	OR	P Value*	OR	P Value*	OR	P Value*	OR	P Value*
ADHD (controls as reference)	0.75	0.03							0.75	0.04
ADHD with MPH treatment (controls as reference)			0.61	0.04			0.72	0.19		
ADHD without MPH treatment (controls as reference)			0.82	0.18			0.97	0.87		
Inattention symptoms					0.88	0.01	0.89	0.02		
Hyperactivity symptoms					1.01	0.84	1.01	0.77		
Age	1.78	<0.001	1.78	<0.001	1.78	<0.001	1.78	<0.001	1.78	<0.001
Sex, male as reference	0.88	0.02	0.88	0.02	0.88	0.01	0.87	0.01	0.88	0.03
Parental myopia	1.54	<0.001	1.54	<0.001	1.54	<0.001	1.54	<0.001	1.55	<0.001
Family income <25,000 HKD	1.05	0.42	1.05	0.41	1.06	0.29	1.07	0.28	1.07	0.27
Outdoor time	0.88	0.002	0.88	0.002	0.87	0.001	0.87	0.001	0.92	0.05
Near-work time	1.09	<0.001	1.09	<0.001	1.09	<0.001	1.09	<0.001	1.03	0.23
During COVID-19†									1.30	0.002

* P values were generated by logistic regression.
† No significant interaction between ADHD and COVID-19 was found.

was 77% in the ADHD group and 50% in the controls (P < 0.001). There were more low-income families of the ADHD group (50%) than the control group (37%, P < 0.001). Among participants, 96 (20%) with ADHD and 2062 (21%) controls completed ocular examinations during the COVID-19 pandemic, whereas the remaining participants completed examinations before the COVID-19. Among the 474 children with ADHD, 116 (24%) received MPH treatment (duration range 1–35 months; mean = 12.5 ± 8.7 months), whereas the remaining 358 were in the non-MPH group (Supplementary Table S2).

Association of ADHD With Myopia

Among all 10,424 children from 2016 to 2021, the prevalence of myopia was 25% in the ADHD group and 27% in the control group. The age- and sex-adjusted myopia prevalence was lower in ADHD group (21%) versus controls (26%; P = 0.02). The ADHD group showed higher SER (0.26 D vs. 0.16 D; P = 0.09) and shorter AL (22.95 mm vs. 23.05 mm; P < 0.001) after age and sex adjustment. These differences were more pronounced in the ADHD with MPH treatment group, which demonstrated lower myopia prevalence (19% vs. 26%; P = 0.08), higher SER (0.43 D vs. 0.16 D; P = 0.01), and shorter AL (22.77 mm vs. 23.05 mm; P < 0.001) compared to controls. ADHD with MPH treatment exhibited significantly shorter AL (22.77 mm vs. 23.00 mm; P = 0.04), but nonsignificantly lower myopia prevalence (19% vs. 22%; P = 0.70) and higher SER (0.43 D vs. 0.20 D; P = 0.62) than non-MPH treatment ADHD. The results above were consistent with the propensity score matching–adjusted results (Supplementary Tables S3, S4).

Multivariable regression analysis showed that children with ADHD were associated with less myopia (OR = 0.75; P = 0.03), higher SER (β = 0.13; P = 0.04), and shorter AL (β = −0.07; P = 0.03) after adjusting for confounding factors (Model 1 in Tables 2–4). Specifically, ADHD with MPH treatment were associated with less myopia (odds ratio [OR] = 0.61; P = 0.04), higher SER (β = 0.36; P < 0.001) and shorter AL (β = −0.25; P < 0.001) compared to controls (Model 2 in Tables 2–4). ADHD with MPH were associated with higher SER (β = 0.17, P = 0.18) and shorter AL (β = −0.18, P = 0.01) than ADHD non-MPH group. Each additional month of MPH treatment was associated with a higher SER (β = 0.02; P = 0.01) and shorter AL (β = −0.01; P = 0.01). For each one-point increase in attention-deficit scores, children were found to be less myopic (OR = 0.88, P = 0.01), had higher SER (β = 0.07; P = 0.003), and shorter AL (β = −0.04; P = 0.001) (Model 3 in Tables 2–4). There was no significant association between hyperactivity/impulsivity scores and myopia prevalence, SER or AL (Model 3 in Tables 2–4).

Change of Myopia Prevalence and Lifestyle Before and During COVID-19 Pandemic

The prevalence of myopia among ADHD children increased to 32% during COVID-19 pandemic compared with 23%

Table 3. Association Between ADHD and SER Among all Participants From 2016 to 2021

	Model 1		Model 2		Model 3		Model 4		Model 5	
	β	*P* Value*	β	*P* Value*	β	*P* Value*	β	*P* Value*	β	*P* Value*
ADHD (controls as reference)	0.13	0.04							0.14	0.04
ADHD with MPH treatment (controls as reference)			0.36	<0.001			0.27	0.01		
ADHD without MPH treatment (controls as reference)			0.05	0.51			−0.04	0.58		
Inattention symptoms					0.07	0.003	0.06	0.004		
Hyperactivity symptoms					−0.006	0.75	−0.01	0.67		
Age	−0.40	<0.001	−0.39	<0.001	−0.39	<0.001	−0.39	<0.001	−0.39	<0.001
Sex, male as reference	0.13	<0.001	0.13	<0.001	0.13	<0.001	0.13	<0.001	0.12	<0.001
Parental myopia	−0.36	<0.001	−0.35	<0.001	−0.35	<0.001	−0.35	<0.001	−0.36	<0.001
Family income <25,000 HKD	−0.12	<0.001	−0.11	<0.001	−0.12	<0.001	−0.12	<0.001	−0.13	<0.001
Outdoor time	0.05	0.01	0.05	0.01	0.05	0.005	0.05	0.005	0.02	0.37
Near-work time	−0.03	<0.001	−0.03	<0.001	−0.03	<0.001	−0.03	<0.001	0.004	0.75
During COVID-19†									−0.18	<0.001

* Binocular data was used, *P* values were generated by linear regression based on generalized estimating equation.
† No significant interaction between ADHD and COVID-19 was found.

Table 4. Association Between ADHD and AL Among all Participants From 2016 to 2021

	Model 1		Model 2		Model 3		Model 4		Model 5	
	β	*P* Value*	β	*P* Value*	β	*P* Value*	β	*P* Value*	β	*P* Value*
ADHD (controls as reference)	−0.07	0.03							−0.08	0.02
ADHD with MPH treatment (controls as reference)			−0.25	<0.001			−0.22	<0.001		
ADHD without MPH treatment (controls as reference)			−0.01	0.71			0.02	0.61		
Inattention symptoms					−0.04	0.001	−0.04	0.004		
Hyperactivity symptoms					0.01	0.23	0.01	0.16		
Age	0.33	<0.001	0.33	<0.001	0.33	<0.001	0.33	<0.001	0.33	<0.001
Sex, male as reference	−0.57	<0.001	−0.57	<0.001	−0.57	<0.001	−0.57	<0.001	−0.57	<0.001
Parental myopia	0.13	<0.001	0.13	<0.001	0.13	<0.001	0.13	<0.001	0.13	<0.001
Family income <25,000 HKD	0.03	0.03	0.03	0.03	0.03	0.01	0.04	0.01	0.03	0.02
Outdoor time	−0.01	0.28	−0.01	0.28	−0.01	0.18	−0.01	0.18	−0.005	0.65
Near-work time	0.02	<0.001	0.02	0.002	0.02	0.001	0.02	0.001	0.008	0.20
During COVID-19†									0.06	0.08

* Binocular data was used, *P* values were generated by linear regression based on generalized estimating equation.
† No significant interaction between ADHD and COVID-19 was found.

Table 5. SER and AL Before and During COVID-19 Pandemic in ADHD and Control Group

	All Participants (2016–2021)	Before COVID-19 Pandemic (2016–2019)	During COVID-19 Pandemic (2020–2021)	*P* Value*,†,‡
SER (D), mean (SD)§				
ADHD	0.26 (1.48)	0.35 (1.45)	−0.10 (1.53)	MD = −0.37; *P* = 0.006
Control	0.16 (1.48)	0.23 (1.45)	−0.09 (1.53)	MD = −0.21; *P* < 0.001
	MD = 0.13; *P*†,‖ = 0.04	MD = 0.14; *P*†,‖ = 0.04	MD = 0.02; *P*†,‖ = 0.88	
AL (mm), mean (SD)§				
ADHD	22.95 (0.83)	22.92 (0.83)	23.06 (0.85)	MD = 0.17; *P* = 0.04
Control	23.05 (0.83)	23.01 (0.83)	23.20 (0.85)	MD = 0.07; *P* < 0.001
	MD = −0.07; *P*†,‖ = 0.03	MD = −0.09; *P*†,‖ = 0.006	MD = −0.02; *P*†,‖ = 0.74	

* *P* values were adjusted for age and sex, parental myopia, and family income.
† Binocular data was used, *P* values were generated by linear regression based on generalized estimating equation.
‡ MD was the mean difference between before COVID-19 pandemic versus during COVID-19 pandemic (during COVID-19 as reference).
§ Mean values were adjusted by age and sex.
‖ *P* values were adjusted for age and sex, parental myopia, family income, outdoor time and near-work time. MD was the mean difference between ADHD and controls (controls as reference).

before COVID-19 pandemic ($P = 0.04$). A similar trend in myopia prevalence was observed before (25%) and during COVID-19 pandemic (36%, $P = 0.007$) among controls. The mean of SER decreased from 0.35 before COVID-19 pandemic to −0.10 after COVID-19 pandemic ($P = 0.006$) in ADHD, similar to controls (Table 5). Corresponding trends were observed for changes in AL in both groups (Table 5). In the multivariable regression, COVID-19 exposure was a risk factor for myopia (OR = 1.30, $P = 0.002$), while children with ADHD were still associated with less myopia

(OR = 0.75; P = 0.04) in the same model (Model 5, Table 2).

For lifestyle, the time spent outdoors in children with ADHD was 1.36 hours per day before COVID-19 pandemic, which then decreased to 1.03 hours per day during COVID-19 pandemic ($P < 0.001$). However, the near-work time, screen time, and diopter-hours increased during COVID-19 pandemic in ADHD. Similar trends were observed in the control group (Supplementary Table S5).

Discussion

This study revealed that among Hong Kong children aged six to eight years, those with ADHD were less myopic, having higher SER and shorter AL. Furthermore, ADHD with oral MPH treatment had less myopia, and children with more inattention symptoms had less myopia. However, the effect sizes of the differences in SER and AL between ADHD and control groups were 0.1 D and −0.1 mm, respectively—small when compared to the annual changes of −0.27 D and 0.27 mm in age-matched Chinese children.[28] Therefore the interpretation of the clinical meaning needs to be cautious. Children with ADHD had an increased risk of myopia during the COVID-19 pandemic, similar to controls. Significant lifestyle changes were observed for both groups during the COVID-19 pandemic, including decreased time spent outdoors and increased time spent on near-work and screen time.

In this study, the ADHD group demonstrated significantly older age, a higher male predominance, and a greater proportion of low family income compared to the control group. Consistent with prior literature, the prevalence of ADHD is reported to be two to nine times higher in boys than in girls within clinical samples and two to three times higher in population-based studies,[29] with low family income recognized as a prominent socioeconomic determinant of ADHD.[30] Importantly, older age, male sex, and low family income are also well-established risk factors for myopia.[16,17] Consequently, associations between ADHD and myopia attained statistical significance after adjustment for the aforementioned confounding variables in the regression model. However, these findings should be interpreted with caution because of the uneven case distribution between groups, particularly the relatively small sample size in the MPH-treated subgroup and the inherent limitations of cross-sectional designs in establishing causal relationships.

This study showed that ADHD with MPH treatment was potentially associated with less myopia. MPH acts by inhibiting dopamine and norepinephrine reuptake, thereby increasing dopamine levels in the brain.[11] Meanwhile, retinal dopamine serves as a stop signal for myopic eye growth.[15] Because the retina is considered an extension of the brain, MPH may increase the concentration of dopamine in both brain and retinal regions. However, this hypothesis is based solely on findings from a cross-sectional study and requires further validation. More robust evidence—such as longitudinal studies or laboratory experiments—is needed to confirm this potential mechanism. Studies have reported ocular side effects under MPH treatment, including blurred vision,[31] lens opacities,[32] glaucoma,[33] and decreased accommodation capacity.[34] However, no significant difference was found in reported blurred vision and intraocular pressure between ADHD children with and without MPH in this study (Supplementary Tables S6, S7).

Our results showed that children with ADHD had slightly longer screen time than children without, which could be attributable to the weak yet significant influence of screen time on the onset of inattention symptoms.[35] Sims et al.[36] measured the relations between inattention and hyperactivity/impulsivity and literacy skills in preschool children and found that inattention was a unique correlate of literacy skill, whereas hyperactivity/impulsivity was not. Children with inattentive symptoms have more continuing reading problems and cannot focus on near-work for extended periods.[37] Continuous near-work time has been identified as a risk factor for the development and progression of myopia. In elementary school children, rapid myopia progression was associated with continuous reading without break every 30 minutes.[38] Another study found that discontinuing near-work every 30 minutes could decrease the prevalence of myopia and reduce its progression.[39] Continuous near-work may induce accommodative dysfunction, such as a higher accommodative convergence/accommodation ratio[40,41] or the lag of accommodation,[42] both of which have been proposed to be associated with the onset of myopia.

The COVID-19 pandemic increased myopia prevalence in both ADHD and control children. The decreased outdoor time and increased near-work time and screen time were similar lifestyle changes that affected myopia development. It is well reported that the prevalence of myopia has increased dramatically during the COVID-19 pandemic as a result of lifestyle changes caused by quarantine policies.[16,43–45] Children with ADHD are less likely to have their myopia recognized and corrected in a timely manner compared to other children. The resulting impaired vision may exacerbate symptoms of inattention and hyperactivity, leading to further adverse academic and life outcomes. Therefore the shift in myopia in children with ADHD during the COVID-19 pandemic warrants serious attention.

Our findings indicated that ADHD children exhibited marginally higher SER and shorter AL compared to controls; however, only the data collected before the COVID-19 pandemic reached statistical significance, whereas those during COVID-19 did not. First, the reduced sample size during COVID-19 likely limited our statistical power to detect subtle associations. Second, quarantine policies and travel restrictions affected routine ophthalmic care, potentially creating selection bias in our clinic-based cohort. Therefore regression model 5 was constructed to evaluate the ADHD-myopia association while adjusting for COVID-19 pandemic exposure. The results demonstrated that although the pandemic was associated with higher myopia prevalence, ADHD remained significantly associated with reduced myopia risk in the same model.

This study represents the largest investigation to date exploring the association between ADHD and myopia. However, several limitations must be acknowledged. In this cross-sectional study, changes in myopia before and after a period of MPH prescription in the same patient were not assessed, and the impact of MPH dosage and discontinuation on myopia remains to be explored. Future longitudinal studies are warranted to investigate these topics. Additionally, this study primarily focuses on Chinese children in Hong Kong, and the effects of MPH on myopia may be specific to this population. Therefore these findings may not be generalizable to other ethnicities, necessitating further research in diverse populations.

This cross-sectional study found that ADHD is associated with reduced myopia prevalence, more hyperopic SER, and shorter AL. Of note, the observed effect sizes of these associations were small, therefore the interpretation of the clinical meaning needs to be cautious.

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