Asthenopia prevalence and vision impairment severity among students attending online classes in low-income areas of western China during the COVID-19 pandemic

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A B S T R A C T

Introduction: This study explored the impact of online learning during the coronavirus disease 2019 (COVID-19) pandemic on asthenopia and vision impairment in students, with the aim of establishing a theoretical basis for preventive approaches to vision health.

Methods: This balanced panel study enrolled students from western rural China. Participant information was collected before and during the COVID-19 pandemic via questionnaires administered at local vision care centres, along with clinical assessments of visual acuity. Paired *t* tests and fixed-effects models were used to analyse pandemic-related differences in visual status.

Results: In total, 128 students were included (mean age before pandemic, 11.82 ± 1.46 years). The mean total screen time was 3.22 ± 2.90 hours per day during the pandemic, whereas it was 1.97 ± 1.90 hours per day in the pre-pandemic period (P<0.001). Asthenopia prevalence was 55% (71/128) during the pandemic, and the mean visual acuity was 0.81 ± 0.30 logarithm of the minimum angle of resolution; these findings indicated increasing vision impairment, compared with the pre-pandemic period (both P<0.001). Notably, asthenopia prevalence increased by two- to three-fold, compared with the pre-pandemic period. An increase in screen time while learning was associated with an increase in asthenopia prevalence (P=0.034).

Conclusion: During the COVID-19 pandemic, students spent more time on online classes, leading to worse visual acuity and vision health. Students in this study reported a significant increase in screen time, which was associated with increasing asthenopia prevalence and worse vision impairment. Further research is needed regarding the link between online classes and vision problems.

Hong Kong Med J 2023;29:150–7
https://doi.org/10.12809/hkmj219864

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New knowledge added by this study

- Online learning has become increasingly popular during the coronavirus disease 2019 pandemic. Students reported a nearly twofold increase in screen time during the pandemic, compared with the pre-pandemic period.
- Students reported greater asthenopia prevalence and demonstrated worse vision impairment during the pandemic, compared with the pre-pandemic period.
- Screen time was associated with asthenopia prevalence but not with the progression of vision impairment.

Implications for clinical practice or policy

- Policymakers should carefully consider the prevalence of asthenopia and progression of vision impairment among students who are increasingly using digital devices and enrolling in online classes.
- Policies regarding vision care should be implemented in response to the increasing use of online learning approaches.

Introduction

The World Health Organization announced that the coronavirus disease 2019 (COVID-19) outbreak had become an international public health emergency on 30 January 2020; on 11 March 2020, it declared that the outbreak had become a pandemic.[1] Governments and public health authorities worldwide implemented public health policies to reduce the risk of viral

transmission, including strict physical distancing, severe travel restrictions, and the closure of many businesses and schools. On 25 January 2020, China's Central Government announced a nationwide travel ban and quarantine policy[2]; it initiated nationwide school closures as an emergency measure to prevent the spread of COVID-19.[3] Thus, >220 million school-aged children and adolescents were confined to their homes; online classes were offered and delivered via the internet.[4]

Vision problems are public health challenges; among school-aged children, these problems often involve asthenopia and vision impairment. Asthenopia is defined as a subjective sensation of visual fatigue, eye weakness, or eyestrain; it can manifest through various symptoms, including epiphora, ocular pruritis, diplopia, eye pain, and dry eye.[5] Vision impairment is defined as visual acuity (VA) of 6/12 or worse in either eye[6]; it is often caused by uncorrected refractive errors, and its estimated prevalence is 43%.[7] Although both asthenopia and vision impairment have negative effects on students, the effects of vision impairment are greater. A previous global analysis revealed that vision impairment was present in 12.8 million children aged 5 to 15 years, half of whom lived in China.[8] Moreover, students with vision impairment have lower scores on various motor and cognitive tests.[9,10]

Excessive use of digital devices contributes to increases in asthenopia prevalence and vision impairment among school-aged children.[4,11-15] The COVID-19 pandemic has led to increased use of digital device–supported online classes,[16-18] which require extended exposure to those devices.[19,20] Importantly, long durations of exposure to digital devices can contribute to many vision problems in children.[14]

Asthenopia and vision impairment related to the excessive use of digital devices during the COVID-19 pandemic have been investigated in developed countries and urban China.[4,11,12] To our knowledge, no similar studies have been conducted in western rural China. Additionally, online classes are increasingly implemented in rural areas, and the use of digital devices is becoming more prevalent[11]; thus, there is a need for research that focus on vision health in students.

The primary purpose of this study was to assess screen time, asthenopia prevalence, and vision impairment progression during the COVID-19 pandemic among students in western rural China. To achieve this goal, we first conducted a general descriptive analysis of student characteristics and screen time trends before and during the pandemic. We then investigated the prevalence of asthenopia and progression of vision impairment. Finally, we explored factors influencing the prevalence of asthenopia and progression of vision impairment before and during the pandemic.

新冠疫情期間中國西部低收入地區參加線上課程學生的視疲勞患病率和視力損傷狀況

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引言：本研究探討新冠疫情期間線上學習對學生視疲勞和視力損傷的影響，旨在為視力健康的預防方法提供理論基礎。

方法：我們使用了來自中國西部農村學生的平衡面板數據進行研究，並通過在當地視光中心進行問卷調查和視力篩查，在疫情前和疫情期間收集參與學生的資料。我們使用配對t檢驗和固定效應模型分析與疫情相關的視力狀況差異。

結果：本研究共包括128名學生（疫情前平均年齡11.82±1.46歲）。疫情期間，他們的平均總螢幕使用時間為3.22±2.90小時／天，而疫情前為1.97±1.90小時／天（P<0.001）。疫情期間的視疲勞患病率為55%（71/128），平均對數視力為0.81±0.30；這些結果表明，與疫情前相比，疫情期間的視力損傷增加（P<0.001）。值得注意的是，與疫情前相比，視疲勞患病率增加了2至3倍。學習時螢幕時間的增加與視疲勞患病率的增加相關（P=0.034）。

結論：在新冠疫情期間，由於學生線上課堂上花費的時間更多，其視力狀況更差。本研究中的學生報告了螢幕使用時間顯著增加，這與視疲勞發生率增加和視力損傷加重有關。關於線上課程和視力問題之間的聯繫還需要進一步研究。

Methods

Setting

This study focused on areas that were broadly representative of rural western China because of limited resources. Thus, the study was conducted in Shaanxi and Ningxia regions in western China. In 2019, the per capita gross domestic product in Shaanxi Province was US$10 167; this is similar to that in Ningxia Autonomous Region (US$8236).[21]

Sample selection

Vision data were acquired from local vision care centres (VCs), which had been established by the Center for Experimental Economics in Education at Shaanxi Normal University, in cooperation with county-level organisations such as the local education ministries and hospitals.

Before the pandemic, VC screenings were performed in each county, except during summer and winter vacations. Staff conducted one to two screenings per week (covering 2 to 4 schools); they completed one round of screening in one town each month. In practice, approximately 1 year is needed to complete one round of vision screening for all eligible children in a particular county. The second round and subsequent rounds of vision screening were performed using a similar workflow. After

the completion of vision screening, students who required further assessment were referred to the VC for full eye and refractive examinations. This study included students who had visited the VC 3 months before the beginning of the COVID-19 pandemic.

During the pandemic, VC staff could not attend schools to perform vision screenings. To maintain vision screening services for students, we telephoned all students who had visited the VC before the pandemic. Participants in this panel study were students who participated in data collection before and during the COVID-19 pandemic.

Data collection

We conducted two cycles of surveys in the VC. The first survey cycle was conducted from October to December 2019 (before the pandemic); the second survey cycle was conducted among a group of students who visited the VC for follow-up from July to December 2020 (during the pandemic), based on their enrolment in the study before the pandemic. The same information was collected during the two survey cycles. During the vision screening process, VC staff administered questionnaires to students for collection of the following information: sex (male=1), age, ethnicity (Han=1), residence (non-rural=1), only-child status (yes=1), parental education (parents with ≥12 years of education=1), and parental migration status (one or both out-migrated=1; defined as one or both parents worked away from home during the semester). Household assets were calculated by summing the values of 13 items owned by the family, in accordance with the China Rural Household Survey Yearbook.[22]

The survey also included the collection of information regarding screen time and asthenopia. Students completed a previously described, self-administered questionnaire concerning mean time spent throughout the day on near activities (including computer and smartphone use, television viewing, and studying/homework after school). Reports of time spent on near activities during different parts of the day were categorised as screen time while learning and screen time while playing. Information regarding asthenopia was collected via three questions focused on ocular discomfort: whether the student had experienced dry eyes (yes=1), eye pain and swelling (yes=1), and eye fatigue and watery eyes (yes=1). Asthenopia was defined as the presence of at least one of these three types of vision health problems (yes=1).[23] Furthermore, information regarding VA was collected when students visited the VC. The optometrist in the VC conducted a VA test to measure the clarity of each student's vision. All students completed VA tests without refractive correction; students with spectacles completed VA tests with their routine method of vision correction.

The questionnaire regarding asthenopia was developed and reviewed by a group of health experts from Shaanxi Normal University and Zhongshan Ophthalmic Center, a well-known ophthalmology institution in China. The included questions were constructed to ensure that they could be clearly understood by students aged 9 to 17 years with the aid of trained VC staff. These three questions can serve as good indicators of symptoms representing different degrees of asthenopia in students, and they have been used in previous research.[23]

Visual acuity assessment

Visual acuity was assessed using Early Treatment Diabetic Retinopathy Study tumbling-E charts (Precision Vision, La Salle [IL], United States). In an indoor area with sufficient light, VA was separately assessed for each eye without refraction at a distance of 4 m. Students were first examined using a 6/60 line; if they correctly identified the orientation of at least four of five optotypes, they were examined using a 6/30 line, followed by a 6/15 line and a 6/3 line. In this manner, the VA for an eye was defined as the lowest line on which four of five optotypes were correctly identified. If the participant could not read the top line at a distance of 4 m, they were tested at a distance of 1 m, and the VA result was divided by 4.

In this study, VA levels were calculated and compared using the logarithm of the minimum angle of resolution (logMAR) scale, which is a linear scale with regular increments that offers a reasonably intuitive interpretation of VA measurement.[24] In this study, vision impairment was defined as logMAR ≥0.3 (ie, VA of 6/12 or worse) in either eye.

Statistical methods

This balanced panel study compared student data between two periods (before and during the COVID-19 pandemic). Mean screen time, asthenopia prevalence, and vision impairment progression were compared among students using *t* tests, after stratification according to various demographic and behavioural factors. Fixed-effects logistic and regression models were used to explore factors influencing the prevalence of asthenopia and progression of vision impairment before and during the pandemic. Fixed-effects models were adjusted for sex, age, ethnicity, rural or non-rural residence, only-child status, parental migration status, parental education level, household assets, screen time while learning, and screen time while playing. All analyses were performed using Stata Statistical Software, version 14.1 (StataCorp, College Station [TX], United States). All tests were two-sided, and P values <0.05 were considered statistically significant.

Results

This study included 128 students from western rural

China (mean age before pandemic, 11.82 ± 1.46 years; mean age during pandemic, 12.32 ± 1.54 years; 80 girls [62.5%] and 48 boys [37.5%]). All participants had vision impairment and were attending online classes (Table 1).

During the pandemic, screen time significantly increased because of enrolment in online classes. The mean total screen time during the pandemic was 3.22 hours per day, compared with 1.97 hours during the pre-pandemic period (P<0.001). The mean screen time while learning during the pandemic was 1.70 hours per day, compared with 0.90 hours during the pre-pandemic period (P<0.001); the mean screen time while playing during the pandemic was 1.52 hours per day, compared with 1.33 hours during the pre-pandemic period (P=0.019). Additionally, rural students had significantly greater screen time while learning during the pandemic, compared with the pre-pandemic period (P<0.001); there was no such difference among non-rural students (Table 1).

The prevalence of asthenopia and progression of vision impairment significantly differed between the pandemic and pre-pandemic periods. The prevalence of asthenopia during the pandemic was 55% (71/128), whereas it was 27% (35/128) during the pre-pandemic period (P<0.001). The mean logMAR

TABLE 1. Screen time before and during the coronavirus disease 2019 pandemic, stratified according to student characteristics (n=128)*

Characteristic	Total screen time, hr		P value	Screen time while learning, hr		P value	Screen time while playing, hr		P value†
	Before pandemic	During pandemic		Before pandemic	During pandemic		Before pandemic	During pandemic	
Total	1.97 (1.90)	3.22 (2.90)	<0.001	0.90 (1.31)	1.70 (1.57)	<0.001	1.33 (1.55)	1.52 (2.24)	0.019
Male sex									
Yes	2.40 (2.56)	3.64 (4.03)	<0.001	0.92 (1.36)	1.64 (1.57)	0.003	1.75 (2.24)	2.00 (3.45)	0.134
No	1.71 (1.32)	2.97 (1.93)	<0.001	0.89 (1.29)	1.74 (1.58)	<0.001	1.07 (0.84)	1.23 (0.88)	0.007
Age, y									
9-12	1.70 (1.39)	2.87 (1.94)	<0.001	0.85 (1.28)	1.64 (1.54)	<0.001	1.09 (0.85)	1.23 (0.88)	0.006
13-17	2.72 (2.76)	4.20 (4.53)	0.001	1.05 (1.40)	1.87 (1.67)	0.009	1.97 (2.57)	2.33 (4.03)	0.139
Han ethnicity									
Yes	2.28 (2.22)	3.82 (3.33)	<0.001	1.13 (1.56)	2.04 (1.67)	<0.001	1.47 (1.81)	1.79 (2.72)	0.010
No	1.41 (0.86)	2.11 (1.32)	<0.001	0.48 (0.35)	1.08 (1.15)	<0.001	1.06 (0.84)	1.03 (0.62)	0.630
Residence									
Rural	1.92 (1.85)	3.16 (2.87)	<0.001	0.86 (1.23)	1.69 (1.56)	<0.001	1.30 (1.56)	1.47 (2.26)	0.043
Non-rural	2.68 (2.47)	3.98 (3.39)	0.055	1.41 (2.17)	1.80 (1.78)	0.321	1.67 (1.43)	2.19 (1.94)	0.026
Only child in family									
Yes	2.16 (1.64)	3.61 (2.75)	0.001	0.98 (1.53)	1.92 (1.96)	0.019	1.46 (0.96)	1.70 (1.25)	0.010
No	1.93 (1.96)	3.14 (2.94)	<0.001	0.89 (1.27)	1.65 (1.48)	<0.001	1.30 (1.65)	1.48 (2.40)	0.049
One or both parents out-migrated for work									
Yes	2.01 (2.20)	3.28 (3.41)	<0.001	0.94 (1.36)	1.67 (1.56)	<0.001	1.34 (1.84)	1.61 (2.86)	0.027
No	1.91 (1.39)	3.14 (2.00)	<0.001	0.84 (1.25)	1.74 (1.60)	<0.001	1.31 (1.01)	1.40 (0.78)	0.218
One or both parents with ≥12 years of education									
Yes	2.16 (2.00)	3.19 (2.39)	0.003	1.11 (1.86)	1.68 (1.47)	0.082	1.37 (1.11)	1.50 (1.38)	0.109
No	1.93 (1.89)	3.23 (3.02)	<0.001	0.85 (1.15)	1.70 (1.60)	<0.001	1.32 (1.64)	1.52 (2.40)	0.033
Household assets (bottom quartile)									
Yes	1.98 (2.84)	3.59 (4.80)	0.001	0.63 (0.92)	1.74 (1.80)	0.002	1.53 (2.65)	1.85 (4.33)	0.175
No	1.97 (1.54)	3.11 (2.07)	<0.001	0.98 (1.40)	1.69 (1.50)	<0.001	1.27 (1.04)	1.42 (1.06)	0.012
Household assets (top quartile)									
Yes	1.38 (0.92)	2.27 (1.34)	<0.001	0.45 (0.26)	1.20 (1.19)	<0.001	1.06 (0.94)	1.07 (0.73)	0.458
No	2.21 (2.14)	3.61 (3.26)	<0.001	1.08 (1.51)	1.90 (1.66)	<0.001	1.44 (1.73)	1.70 (2.60)	0.015

* Data are shown as mean (standard deviation), unless otherwise specified

† Characteristics were compared between two groups using paired *t* tests

VA was worse during the pandemic compared with the pre-pandemic period (0.81 vs 0.65; P<0.001). The prevalence of asthenopia was higher during the pandemic than during the pre-pandemic period, regardless of the characteristics used to stratify participants. The mean logMAR VA was worse during the pandemic than during the pre-pandemic period, although the difference being insignificant among participants with non-Han ethnicity and participants in the top quartile of household assets (Table 2).

Fixed-effects logistic models for asthenopia revealed that screen time while learning was associated with asthenopia prevalence, and the probability of asthenopia increased by 24.6% for each 1-hour increase in screen time while learning (95% confidence interval [CI]=1.02-1.53; P=0.034). Additionally, older age (odds ratio [OR]=2.073, 95% CI=1.13-3.81, P=0.019), Han ethnicity (OR=2.405, 95% CI=1.22-4.74; P=0.011), and only-child status (OR=0.488, 95% CI=0.21-1.13; P=0.095) were factors associated with asthenopia; screen time while playing was not (Table 3).

Fixed-effects regression models showed that

TABLE 2. Asthenopia prevalence and visual acuity (in logarithm of the minimum angle of resolution [logMAR]) before and during the coronavirus disease 2019 pandemic, stratified according to student characteristics (n=128)*

Characteristic	Asthenopia		P value	logMAR visual acuity†		P value‡
	Before pandemic	During pandemic		Before pandemic	During pandemic	
Total	35 (27.3%)	71 (55.5%)	<0.001	0.65 (0.25)	0.81 (0.30)	<0.001
Male sex						
Yes	12 (9.4%)	26 (20.3%)	<0.001	0.64 (0.24)	0.79 (0.37)	0.002
No	23 (18.0%)	45 (35.2%)	<0.001	0.66 (0.26)	0.83 (0.25)	<0.001
Age, y						
9-12	22 (17.2%)	48 (37.5%)	<0.001	0.64 (0.26)	0.79 (0.32)	<0.001
13-17	13 (10.2%)	23 (18.0%)	<0.001	0.69 (0.24)	0.87 (0.23)	0.001
Han ethnicity						
Yes	27 (21.1%)	56 (43.8%)	<0.001	0.62 (0.24)	0.84 (0.30)	<0.001
No	8 (6.3%)	15 (11.7%)	0.003	0.72 (0.28)	0.76 (0.31)	0.200
Residence						
Rural	32 (25.0%)	66 (51.6%)	<0.001	0.65 (0.25)	0.80 (0.31)	<0.001
Non-rural	3 (2.3%)	5 (3.9%)	0.085	0.73 (0.26)	0.97 (0.19)	0.031
Only child in family						
Yes	4 (3.1%)	13 (10.2%)	<0.001	0.61 (0.25)	0.75 (0.32)	0.046
No	31 (24.2%)	58 (45.3%)	<0.001	0.66 (0.25)	0.83 (0.30)	<0.001
One or both parents out-migrated for work						
Yes	15 (11.7%)	32 (25.0%)	<0.001	0.64 (0.25)	0.80 (0.31)	<0.001
No	20 (15.6%)	39 (30.5%)	<0.001	0.67 (0.25)	0.84 (0.29)	<0.001
One or both parents with ≥12 years of education						
Yes	8 (6.3%)	15 (11.7%)	0.003	0.60 (0.27)	0.86 (0.25)	<0.001
No	27 (21.1%)	56 (43.8%)	<0.001	0.66 (0.25)	0.80 (0.31)	<0.001
Household assets (bottom quartile)						
Yes	7 (5.5%)	13 (10.2%)	0.006	0.69 (0.22)	0.77 (0.22)	0.034
No	28 (21.9%)	58 (45.3%)	<0.001	0.64 (0.26)	0.83 (0.32)	<0.001
Household assets (top quartile)						
Yes	6 (4.7%)	16 (12.5%)	<0.001	0.68 (0.27)	0.70 (0.31)	0.403
No	29 (22.7%)	55 (43.0%)	<0.001	0.64 (0.25)	0.86 (0.29)	<0.001

* Data are shown as mean (standard deviation), unless otherwise specified

† Change of 0.1 in logMAR value indicates a one-line change in the visual acuity examination. Larger logMAR values indicate worse vision

‡ Characteristics were compared between two groups using paired *t* tests

residence in a non-rural area (OR=-0.200, 95% CI=-0.355 to -0.046; P=0.011) and only-child status (OR=-0.099, 95% CI=-0.197 to 0.000; P=0.049) were factors associated with logMAR VA. The probability of worse logMAR VA increased by 0.200 in non-rural areas, compared with rural areas. However, screen time while learning and screen time while playing were not associated with vision impairment (Table 4).

Discussion

The global spread of the COVID-19 pandemic has affected the education of >1.5 billion children and adolescents worldwide.[25] The participants in our study were representative of this important population. They demonstrated declines in VA and vision health during the pandemic, in relation to the excessive use of digital devices; these findings were consistent with the results of previous studies.[19,26]

All students in our study were attending online classes during the pandemic. We observed an increase in the mean daily time spent on digital devices between the pre-pandemic and pandemic periods; these results are consistent with international findings that screen time was greater during the pandemic than before the pandemic.[19] Notably, we found that total screen time and screen time while learning significantly changed among rural students

TABLE 3. Fixed-effects logistic analysis of factors associated with asthenopia before and during the coronavirus disease 2019 pandemic (n=128)

Dependent variable	Asthenopia*			
	Odds ratio	Standard error	95% Confidence interval	P value
Screen time while learning (per 1-hour increase)	1.246	0.130	1.02-1.53	0.034
Screen time while playing (per 1-hour increase)	1.114	0.111	0.92-1.35	0.280
Male sex (1=yes; 0=no)	0.751	0.231	0.41-1.37	0.352
Age (1=13-17 years; 0=9-12 years)	2.073	0.643	1.13-3.81	0.019
Han ethnicity (1=yes; 0=no)	2.405	0.833	1.22-4.74	0.011
Residence (1=rural; 0=non-rural)	0.863	0.555	0.24-3.05	0.819
Only child in family (1=yes; 0=no)	0.488	0.210	0.21-1.13	0.095
One or both parents out-migrated for work (1=yes; 0=no)	1.332	0.405	0.73-2.42	0.346
One or both parents with ≥12 years of education (1=yes; 0=no)	1.195	0.486	0.54-2.65	0.661
Household assets (Ref=middle quartile)				
Bottom quartile	0.610	0.240	0.28-1.32	0.208
Top quartile	0.700	0.259	0.34-1.44	0.334

* Asthenopia is a categorical variable (yes=1, no=0)

TABLE 4. Fixed-effects regression analysis of factors associated with visual acuity (in logarithm of the minimum angle of resolution [logMAR]) before and during the coronavirus disease 2019 pandemic (n=128)

Dependent variable	logMAR visual acuity			
	Odds ratio	Standard error	95% Confidence interval	P value
Screen time while learning (per 1-hour increase)	0.001	0.013	-0.024 to 0.026	0.940
Screen time while playing (per 1-hour increase)	0.003	0.010	-0.016 to 0.022	0.732
Male sex (1=yes; 0=no)	-0.032	0.037	-0.105 to 0.041	0.392
Age (1=13-17 years; 0=9-12 years)	0.037	0.039	-0.040 to 0.113	0.349
Han ethnicity (1=yes; 0=no)	-0.016	0.041	-0.097 to 0.064	0.689
Residence (1=rural; 0=non-rural)	-0.200	0.078	-0.355 to -0.046	0.011
Only child in family (1=yes; 0=no)	-0.099	0.050	-0.197 to 0.000	0.049
One or both parents out-migrated for work (1=yes; 0=no)	0.001	0.036	-0.071 to 0.072	0.986
One or both parents with ≥12 years of education (1=yes; 0=no)	-0.057	0.051	-0.157 to 0.043	0.259
Household assets (Ref=middle quartile)				
Bottom quartile	-0.054	0.047	-0.147 to 0.039	0.250
Top quartile	-0.070	0.044	-0.158 to 0.018	0.116

but not among non-rural students; these results are also consistent with previous findings.[19] This difference presumably occurred because, compared with rural students, non-rural students were more likely to use digital devices and online classes before the pandemic.

We observed a significant difference in asthenopia prevalence among students in low-income areas of western China before and during the pandemic; this finding supports the results of previous studies.[26,27] Although the risk of asthenopia reportedly increases with screen time,[28] there is no published literature concerning changes in asthenopia among students in relation to the COVID-19 pandemic. Similar to previous studies,[14] we found that the prevalence of asthenopia was approximately twofold greater among students aged 13 to 17 years than among those aged 9 to 12 years. Furthermore, Moon et al[26] reported that symptoms of dry eye diseases were more common among older children than among younger children. Older children spend more time using digital devices, leading to a higher prevalence of asthenopia.[29]

This study showed significant progression of vision impairment in relation to the pandemic; similarly, a study in eastern China revealed that students had worse vision during the pandemic, compared with their vision at pre-pandemic examinations.[4] However, screen time has not been associated with vision impairment among students. Furthermore, evidence regarding the impact of digital devices use on vision impairment has been inconsistent,[30,31] with computer screen time made students' vision worse while television viewing had no effect. We speculate that the association will become clearer as school-aged children spend increasing amounts of time using these devices.

This study had three important limitations. First, the screen time data were retrospectively collected through a self-reporting mechanism, which may have led to recall bias. However, considering the resource and measurement limitations that researchers encountered during the pandemic, self-reported recall was regarded as the optimal method for collection of screen time data in the present study. Second, the selection of students with poor vision may lead to underestimation of screen time effects on the general population, and the results should be generalised with caution. Third, the study was not designed to accurately distinguish between vision impairment caused by intrinsic factors and vision impairment caused by pandemic-related eye strain.

Our findings provide new evidence regarding the effects of increased screen time on asthenopia and vision impairment among students in western rural China during the pandemic; they can also serve as a basis for future research. Although pandemic-related school closures are temporary, the increasing popularity of online classes may accelerate the overall acceptance of digital devices. The use of online learning approaches is associated with multiple vision problems, which merit attention in future studies.

Conclusion

The present study demonstrated that asthenopia and vision impairment among students in western rural China were also affected by the pandemic; these findings provide critical insights regarding the effects of the pandemic on vision health in rural students. Moreover, the findings highlight important issues related to childhood vision health during the pandemic; parents, teachers, and eye care providers should consider evidence-based measures to avoid asthenopia and vision impairment in children. The current pace of economic and technological development is leading to increased use of digital devices and online learning approaches, but vision problems in rural China have not received sufficient consideration. Thus, there is a critical need for greater efforts to monitor VA and vision health among students in this region.

Author contributions

Concept or design: All authors.
Acquisition of data: Y Ding, H Guan, K Du.
Analysis or interpretation of data: Y Ding, H Guan, K Du, Y Shi.
Drafting of the manuscript: Y Ding, Y Zhang, Z Wang.
Critical revision of the manuscript for important intellectual content: H Guan, Y Shi.

All authors contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

As an International Editorial Advisory Board member of the journal, Y Shi was not involved in the peer review process. Other authors have disclosed no conflicts of interest.

Acknowledgement

We thank Dr Wenting Liu, Dr Jiaqi Zhu, and staff from the Center for Experimental Economics in Education of Shaanxi Normal University, China for their valuable contributions.

Funding/support

H Guan received funding for this study from the National Natural Science Foundation of China (Grant No.: 7180310) and Soft Science Project of Shaanxi Province (Grant No.: 2023-CX-RKX-127). Y Ding received funding for this study from the Fundamental Research Funds for the Central Universities (Grant No.: 2020CSWY018). This study was supported by the 111 Project (Grant No.: B16031). The funders had no role in designing the study, collecting, analysing or interpreting the data, or in drafting this manuscript.

Ethics approval

This study protocol was approved by Sun Yat-sen University, China (Registration No.: 2013MEKY018) and all procedures followed the principles of the Declaration of Helsinki. Permission was obtained from the local boards of education in the study area, as well as the principals of all participating schools. All participating children provided oral assent before baseline data collection, and legal guardians provided written informed consent for their children to be enrolled in the study.

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