RESEARCH ARTICLE

Analysis of refraction and prevalence of myopia among school-age children in Nantong City from 2019 to 2020

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Abstract

Objective: To analyse the refractive status and prevalence of myopia among school-age children.

Method: The prospective, school-based study was conducted from September 2019 to September 2020 in Nantong, China, and comprised students from two primary and as many middle and high schools from which two classes were chosen from each grade. Ophthalmic examinations were conducted one year apart, and included measurements of refraction and vision. Data was analysed using SPSS 22.

Results: Of the 1,787 students, 959(53.7%) were boys. The overall mean age was 10.55±3.19 years. The uncorrected visual acuity of the students was lower in 2020 than in 2019, with the right eye visual acuity decreasing by 0.08±0.48. There was no significant association between gender and uncorrected visual acuity. The changes in uncorrected visual acuity, sphere and spherical equivalent refraction between the ages of 7 and 12 years were significant (p<0.05). Among those aged 6-17 years, the prevalence of myopia was higher in 2020 than in 2019 (p<0.001). At the age of 10 years, the spherical equivalent refraction decreased the most (by −0.66 D, p<0.001; Figure 2), and visual acuity decreased the most at the age of 12 years (by −0.21, p<0.001; Figure 1).

Conclusion: One year from the baseline, the students' refraction showed a myopic drift, and their uncorrected visual acuity declined. The apparent change in spherical equivalent refraction occurred two years before the decline in visual acuity.

Keywords: Myopia, Prevalence, Refraction, Vision, School-age children. (JPMA 75: 1349 2025)

DOI: https://doi.org/10.47391/JPMA.20087

Introduction

Globally, the prevalence of myopia is on the rise, with projections from the World Health Organisation (WHO) indicating an increase from 22% in 2000 to 52% by 2050. This condition is particularly common in developed, industrialised regions, and affects individuals across all age groups.[1] In a 2021 study, the prevalence of myopia and high myopia among Japanese preschool children was reported to be 2.9% and 0.2%, respectively.[2] Youngsters who develop myopia early in life are especially vulnerable to its side effects. High myopia is associated with irreversible blinding problems like retinal detachment, myopic macular degeneration and glaucoma.[3,4] Myopia progression over time may lead to high myopia. Furthermore, smaller children and those with bigger initial myopic refractive defects are more likely to develop myopia later on.[5,6]

In China, myopia is now recognised as a serious public health issue that cannot be ignored. The prevalence of myopia in the population was found to be 60%, which included 45% mild cases, 13% moderate, and 1.9% high myopia.[7] According to Dong et al.[8] the combined prevalence of myopia and high myopia in 1998 and 2016 was 3.1% and 37.7%, respectively. Myopia was more common in girls than in boys, and metropolitan areas had a higher prevalence of myopia than rural ones. Among subjects between the ages of 16 and 18 years, the pooled prevalence of myopia and high myopia rose 4.7% and 0.2%, respectively, and in those aged <7 years, the corresponding values were 56.2% and 15.1%. The myopic refractive error was associated with the academic year, female gender, and higher age. Research conducted after 2013[8] revealed that among those aged 16 to 18 years, there were 84.8% individuals with myopia and 19.3% with high myopia. In children and teenagers between the ages of 3 and 19 years, the anticipated prevalence of myopia in 2050, assuming a continued linear connection with the academic year, is approximately 84%.

The current study was planned to analyse the refractive status and prevalence of myopia among school-age children.

Subjects and Methods

The prospective, school-based study was conducted from September 2019 to September 2020 in Nantong, China. Two ophthalmic examinations were conducted one each in 2019 and 2020, and the students who completed both

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Submission complete: 22-05-2024 **1st Revision received:** 15-11-2024

Acceptance: 21-06-2025 **Last Revision received:** 20-06-2025

the examinations were included. The exclusion criteria included having a history of serious eye conditions, such as cataracts or glaucoma, and prior surgeries, the use of orthokeratology lenses, and a lack of cooperation during the examinations.

After approval from the ethics review board of the Second Affiliated Hospital of Nantong University, China, the sample size was calculated in the light of a previous research that indicated that the prevalence of myopia in Shenyang, China, was approximately 60%, with a median age of 11.9 years.[7] To achieve a statistical power of 80%, the sample size was determined using the formula:[9] $n=(z^2 pq)/d^2$, with z = 1.96 (for 95% confidence interval [CI]), *p*=0.6 (estimated prevalence), q=1-*p*=0.4, and d=0.1, and *p*=0.06 (margin of error). After adjusting for a design effect of 1.5 and a 5% non-response rate, the final sample size was worked out to be 422. To enhance the robustness of the analyses, a larger sample size was incorporated into the study protocol. Written informed consent was obtained from the parents of all the students before enrolment.

Two primary schools, two middle schools, and two high schools were chosen from both Chongchuan district and Qidong county. Using stratified cluster sampling technique, two classes were chosen from each grade of these schools. When the total number of students in two classes was <80, one more class was picked for ophthalmic examinations.

The ophthalmic examinations included measurements of refraction and vision. In addition, we recorded gender and age. During the ophthalmic examination, refraction was measured with an auto-refractor under non-cycloplegic conditions, and before the refraction test, those who wore contact lenses were told to take them out more than 30 minutes beforehand. After that, analysis was done using the mean data of the three accurate measurements. Furthermore, the type of glasses or lenses that the students wore (frame glasses, contact lenses, orthokeratology lenses, or no glasses) was also recorded. The uncorrected visual acuity (UCVA) and the best-corrected visual acuity (BCVA) were tested with a standard logarithmic visual acuity chart.

The spherical equivalent refraction (SER) was defined as half of the cylinder plus spherical power. Myopia was defined as SER-0.5 dioptre (D) or less, while +0.5D or greater was considered hypertrophy, SER ranging from -0.5D to +0.5D was considered emmetropia, and SER-6.00D or below was considered high myopia.

Data was analysed using SPSS 22. Data was expressed as frequencies and percentages, or mean±standard deviation, as appropriate. Only data from the patients' right eyes were used in analyses since the SER for their right and left eyes were significantly associated at baseline with Spearman correlation coefficient 0.898. When comparing typically continuous data, independent t-tests and paired t-test were employed. Error bars were drawn to represent the changes in VA and SER with 95% CI, which was calculated as $SD/\sqrt{n}$. P<0.05 was considered statistically significant.

Results

In 2019, the ophthalmic examination was completed by 4,826 students, while in 2020, there were 4,688 students. However, of the total 9,514 students, those who completed the examination in both the years was 1,933(20.31%). Of them, 146(7.55%) were excluded. The final sample, as such, stood at 1,787(92.44%), featuring students from grades 1 to 12. Among them, 959(53.7%) were boys. The overall mean age of the sample was 10.55±3.19 years (range: 6-17 years). Baseline UCVA showed no difference between boys and girls (*p*=0.07).

Compared to 2019,UCVA in 2020 showed a significant downward trend (*p*<0.001), decreasing by 0.08±0.48. Between boys and girls, there was no statistically significant difference (*p*=0.60). The sphere worsened from -1.40±2.00D

Table-1: Parameter changes across age groups.

Variable	year	Overall	6 year	7 year	8 year	9 year	10 year	11 year	12 year	13 year	14 year	15 year	16 year	17 year
Number of students		1787	116	242	224	217	228	94	145	188	68	32	162	70
UCVA	2019	4.70±0.48	4.95±0.17	4.93±0.20	4.91±0.26	4.82±0.32	4.74±0.63	4.69±0.38	4.54±0.38	4.51±0.57	4.51±0.37	4.47±0.46	4.30±0.57	4.35±0.45
	2020	4.62±0.57	4.96±0.45	4.88±0.27	4.83±0.50	4.69±0.52	4.64±0.53	4.53±0.69	4.33±0.60	4.46±0.64	4.37±0.77	4.45±0.45	4.31±0.55	4.32±0.45
***p*-value**		<0.001	0.80	<0.001	0.01	<0.001	<0.001	<0.001	<0.001	0.40	0.09	0.69	0.71	0.29
Sphere(D)	2019	-1.40±2.00	0.19±0.73	-0.12±1.12	-0.56±1.34	-0.81±1.39	-1.32±1.69	-1.74±2.05	-2.20±1.84	-2.20±1.95	-2.24±2.05	-2.22±2.33	-3.35±2.33	-3.20±2.16
	2020	-1.83±2.16	-0.33±1.04	-0.50±1.32	-0.96±1.68	-1.27±1.74	-1.94±1.99	-2.28±2.32	-2.62±1.89	-2.69±1.94	-2.51±2.55	-2.30±2.30	-3.55±2.48	-3.64±2.24
***p*-value**		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.21	0.79	<0.001	<0.001
SER(D)	2019	-1.71±2.11	-0.03±0.83	-0.35±1.15	-0.82±1.40	-1.11±1.43	-1.61±1.75	-2.06±2.16	-2.57±1.93	-2.54±2.02	-2.58±2.16	-2.79±2.44	-3.82±2.54	-3.62±2.33
	2020	-2.17±2.29	-0.57±1.11	-0.75±1.33	-1.23±1.81	-1.60±1.93	-2.27±2.07	-2.63±2.44	-3.03±1.98	-3.05±2.02	-2.79±2.69	-2.85±2.43	-4.06±2.67	-4.05±2.39
***p*-value**		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.37	0.85	<0.001	<0.001
The prevalence	2019	1067(59.71)	16(13.79)	66(27.16)	101(45.09)	116(53.46)	138(60.53)	67(71.28)	125(86.21)	148(78.72)	55(80.88)	26(81.25)	148(91.36)	60(86.15)
of myopia [n (%)]	2020	1,261(70.57)	42(36.21)	103(42.39)	120(53.57)	154(70.97)	173(75.88)	76(80.85)	129(88.97)	167(88.83)	56(82.35)	25(78.13)	151(93.21)	65(92.31)
Number with high	2019	60(3.36)	0(0)	0(0)	3(1.34)	1(0.46)	4(1.75)	4(4.26)	4(2.76)	4(2.13)	6(8.82)	4(12.50)	21(12.96)	9(12.85)
myopia [n (%)]	2020	87(4.87)	0(0)	0(0)	5(2.23)	5(2.30)	10(4.39)	6(6.38)	7(4.83)	7(3.72)	7(10.29)	4(12.50)	24(14.81)	11(15.71)

D: Dioptre; UCVA: Uncorrected visual acuity, SER: Spherical equivalent refraction.

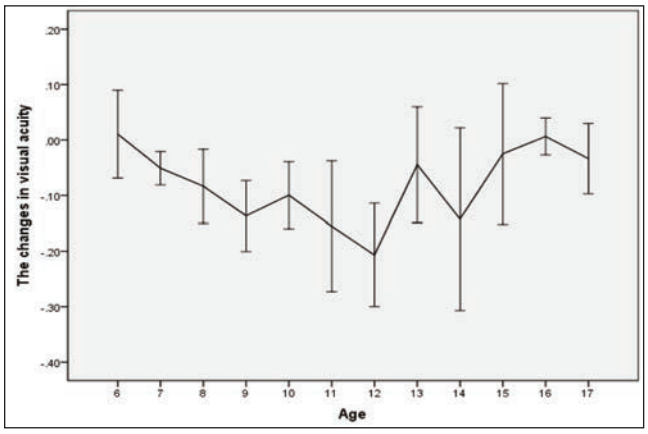

Figure-1: The changes in visual acuity in each age group.
Error bars represent 95% confidence intervals (SD/√n).

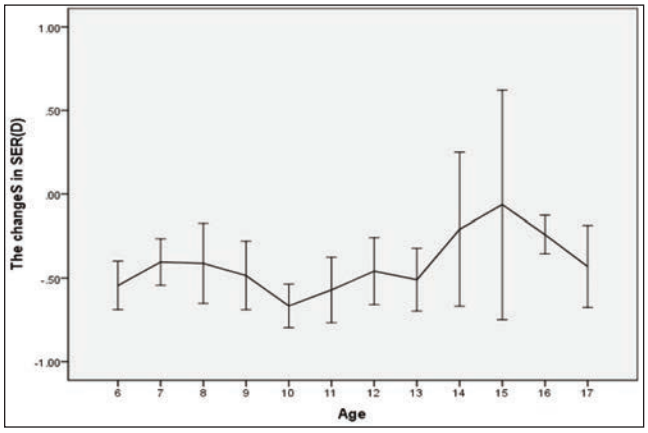

Figure-2: Changes in spherical equivalent refraction (SER) in each age group with the error bars representing 95% confidence intervals.

to -1.83±2.16D (p<0.001), and SER progressed from -1.71±2.11D to -2.17±2.29 (p<0.001). From 2019 to 2020, the number of those with myopia rose from 1067(59.71%) to 1261(70.57%). Boys and girls had a myopia prevalence of 60.06%(n=576) and 59.30%(n=491), respectively, in 2019, and the corresponding values for 2020 were 71.01%(n=681) and 70.05%(n=580). From 60(3.36%) in 2019 to 87(4.87%) students in 2020, there were more students with high myopia.

The changes in VA, sphere and SER between the ages of 7 and 12 years were statistically significant (p<0.05). After the age of 12, the changes in VA showed no statistical significance (p>0.05). Between the ages of 6 and 17 years, the prevalence of myopia was higher in 2020 than in 2019 (p<0.001) (Table 1). At the age of 10 years, the prevalence of myopia rose the most, and at the age of 12 years, VA declined the most (Figures 1, 2).

Discussion

The current study investigated the changes in refraction, UCVA and myopia prevalence children aged in 6-17 years in the Chinese city of Nantong. The study found that the average change in SER in male and female students without cycloplegia was 0.40±1.38D and 0.52±1.18D (p=0.51), respectively. Moreover, the prevalence of myopia in the two years was very similar in males and females. Previous research[10,11] showed that female subjects had a faster progression of myopia, an earlier age of onset, and a higher prevalence of myopia in the same age group. The reason for this might be that, compared to boys, the girls have greater corneal curvature, greater lens curvature, lighter anterior chambers, and shorter eye axes.[12] Some studies[13,14] believe that this difference between genders in early puberty might be related to the different ages at the onset of puberty and changes in oestrogen levels. The current results are different from those of previous research. This might be related to the educational philosophy and education model prevalent in the Nantong area, which requires a larger sample and a longer follow-up study to be supported.

UCVA decreased by 0.09 and 0.07 in male and female subjects, respectively, with the most significant decline being observed in those aged 12 years. However, the study found that the age at which SER decreased the most was 10 years, which is consistent with the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error (CLEERE) study.[15] But it was different from the age at which SER decreased the most. It can be speculated that when students were 10 years old, or about the fourth academic grade, their SER experienced a large myopic drift. The increased degree of myopia observed at that time might be pseudomyopia. Unlike pathological myopia, pseudomyopia is a biologically appropriate response to extended close work and stress.[16] Patients frequently suffer from blurred vision and asthenopia, which are more usually considered eye strain or weariness.[17] There is a close correlation between unaided distance VA and the amount of myopia, which is not maintained in the presence of pseudomyopia.[18] According to reports, the prevalence of pseudomyopia is roughly 24% in those aged 6 years and 18% in those aged 13.[19] It can be speculated that when the students developed pseudomyopia without obvious damage to their vision, parents and schools did not pay enough attention to it because they did not conduct regular inspections and monitoring, and did not take timely and effective myopia prevention and control measures. As a result, pseudomyopia gradually progressed to true myopia, and the students' VA gradually declined, with the most obvious VA loss occurring at age 12. Furthermore, the current study found that the changes in VA, sphere and SER in those aged 7-12 years were statistically significant. Vision declined year by year, and the annual decline became greater with age. The prevalence of myopia in 2019 was

59.71%, with the highest prevalence being observed in those aged 17 years, and the lowest prevalence was observed in those aged 6 years. The prevalence of myopia among those aged 6 years increased the most within a year. This reflects the significance of controlling and preventing myopia. In primary schools, starting from the first grade, parents and schools need to strengthen their prevention and control awareness, regularly monitor changes in uncorrected VA and SER, and take timely and effective prevention and control measures to effectively control the prevalence of myopia in children.

The current research was conducted during the period of the coronavirus disease-2019 (COVID-19) epidemic. According to the United Nations Educational, Scientific and Cultural Organisation (UNESCO), more than 160 countries required students to study at home in 2020 owing to the COVID-19 restrictions.[20] A meta-analysis[21] comprising 33 studies revealed that, compared to the period before COVID-19, the prevalence of myopia had risen. The outcomes of SER decreased by 0.61D, and axis length (AL) increased by 0.42mm. The average duration of screen time had risen by 6.25 hours per day, while the amount of time spent engaging in outdoor activities diminished by 1.52 hours per day. A study[22] found that home isolation measures, especially the suspension of school lessons, could lead to reduced physical activity, increased use of electronic screen time, and irregular sleep[23] and diet in children, which could have a negative impact on their physical and mental health. For example, it could lead to weight-gain[24] decreased cardiopulmonary function, and changes in mental state[25] among which reduced outdoor activities, increased use of electronic screen time, and decreased sleep quality were known hazardous factors for the occurrence and progression of myopia.[26-30]

The current study had several limitations. The sample size was large, but refractometry was not performed under cycloplegia. Although the definition of myopia was broadened to a myopic-equivalent spherical degree of ≥0.75D, the prevalence of myopia might still have been high due to the existence of false myopia.

Conclusion

The prevalence of near-sightedness increased from 59.71% to 70.57% in the population aged 6-17 years from 2019 to 2020, and the refractive state showed an obvious myopic drift. The prevalence of myopia showed no difference between males and females. As people aged, myopia became more common. At 6 years of age, the prevalence of myopia increased the most. At the age of 10 years, SER decreased most, while VA decreased most at age 12. The apparent SER change occurred two years before the VA decline.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: The Nantong Science and Technology Programme, China.

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Author Contribution:
MW: Data collection, analysis, interpretation and drafting.
YZ: Design and revision.
YJX: Data collection and analysis.
ZMS: Concept and design.