Age- and gender-specific Prevalence of Reduced Visual Acuity in Children from a Representative Urban District in China from 2002 to 2018

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Abstract

Background To investigate age- and gender-specific trends in the prevalence of reduced visual acuity (VA), a proxy measure for myopia, in a representative urban district in China. And to identify the susceptible age for the emerging of reduced VA epidemic. **Methods** Data were extracted from the dataset of 2002 and 2018 Annual Survey on Students' Constitution and Health from Yuhua District, Changsha City, China. Children aged 6 to 15 years were included. The visual acuity was measured by a LogMAR tumbling E chart. The prevalence of reduced VA was calculated by age and gender. Cochran–Armitage test was used for detecting trends. **Results** The final VA analysis included 26217 children in 2002 and 45510 children in 2018. The overall prevalence of reduced VA increased from 28.3% in 2002 to 46.5% in 2018 ($P < 0.001$). The prevalence of reduced VA started to increase markedly from the age of 14 years in 2002, and in 2018 it started to increase at the age of 9 years. The prevalence of severely reduced VA increased in all age groups from 2002 to 2018 and increased with age (all $P < 0.001$). Between age 6 to 15 years, the proportion of normal VA decreased from 61.4% to 31.9% in 2018. **Conclusions** Both the prevalence of reduced VA and severely reduced VA in children aged 6-15 years old increased significantly from 2002 to 2018 in Yuhua District. The remarkable epidemic of reduced VA started 5 years earlier in 2018 than in 2002. Evidence from the present study suggests interventions should be launched before the age of 9 years.

Background

Myopia is the most common eye disease affecting the eyesight of children and adolescents [1]. It not only damages physical and mental health, learning and working ability, but also increases the risk of eye complications, including retinopathy, glaucoma, retinal detachment, and blindness [2, 3]. Many epidemiological studies have confirmed that a high educational level of children and parents, female, less outdoor activity, and near work are associated with myopia [4-6].

In the east and southeast Asia, where 80-90% of the adolescents are affected by myopia, the myopia epidemic has become a public health threat [7,8]. Therefore, it is one of the main priorities of the five vision 2020 initiatives launched by WHO[9]. China, with its rapid economic development and transitions in behavior and lifestyle, is one of the countries with the highest rates of childhood myopia in the world [10]. According to surveys, the prevalence of myopia among adolescents is about 95.5% in Shanghai and 74.2% in Beijing [11, 12]. The Chinese government pays more attention than ever before to the eyesight health of children and adolescents.

Identifying at what age the prevalence of myopia starts to increase is important for the development of interventions. Also, comparing the age-specific prevalence of myopia overtime can help pinpoint the ages in childhood when the eyesight is most sensitive to change. Using visual examination data from the dataset of 2002 and 2018 Annual Survey on Students' Constitution and Health from Yuhua District, Changsha City, China, the purpose of this study was to investigate age- and gender-specific trends in the prevalence of reduced visual acuity (VA), a proxy measure for myopia, in a representative urban district in

China. And therefore provide references for the development of interventions to stop the increasing trend of myopia in China and in other countries that encountered similar challenges.

Methods

Study subjects

Changsha, the capital of the Hunan province of central China, has more than 3.5 million residents living in six urban districts. It has well developed elementary and secondary education system, all school-age children will join the nine-year compulsory education in elementary school (6 years) and secondary school (3 years). We performed the analysis using data extracted from the dataset of 2002 and 2018 Annual Survey on Students' Constitution and Health from Yuhua District, Changsha City, China. The random cluster sampling method was used to select elementary and secondary schools from Yuhua District. All students from the selected schools underwent visual examinations according to the manual of the National Student Constitution and Health Survey (Chinese version). Children aged less than 6 years or older than 15 years from the dataset were excluded from the analysis. We collected general information including name, sex, age, and the name of their school of all participants.

VA determinations

The visual acuity was measured by a retro-illuminated LogMAR chart with tumbling-E optotypes (Precision Vision, La Salle, IL, USA). The specific measurement method was as follows: (1) The fourth line from the bottom (6/6) should be equal to the visual altitude of the test eye. (2) Both eyes were examined separately, first the right eye, then the left eye. (3) Measurements started at a distance of 5 m, starting from the fourth line from the bottom (6/6), using a staircase protocol, four of the five optotypes identified considered as correct. (4) The VA equals the lowest line reading successfully. (5) If the top line was not read, the child would move forward until he could read. The protocol of VA examinations was the same in both surveys. Presenting and best-corrected VA were not measured.

Normal VA was defined as equal to or greater than 6/6. Mildly reduced VA was defined as greater than 6/9 and less than 6/6. Moderately reduced VA was defined as greater than 6/18, equal to or less than 6/9, and severely reduced VA was defined as equal to or less than 6/18.

Statistical analysis

Prevalence of reduced VA and severely reduced VA were calculated by age and gender. Chi-square test was used to compare the differences between groups. The Cochran–Armitage test was used to examine the age trends for the prevalence of severely reduced VA. All statistical analyses were performed using SPSS version 22.0 (IBM, New York, USA). The figures were plotted using Microsoft Excel 2007. All of the statistical tests were two-sided. All *P* values were 2-sided and *P* < 0.05 was considered significant for all tests.

Results

A total of 26644 children in 2002 and 45696 in 2018 were measured. 427 children in 2002 and 186 children in 2018 were excluded from the analysis because of incomplete information. The final analysis included 26217 children in 2002, and 45510 children in 2018. There were no significant differences in age and sex between the two surveys ($P>0.05$).

Table 1 shows that the overall prevalence of reduced VA increased from 28.3% (95% CI, 27.8%-28.9%) in 2002 to 46.5% (95% CI, 46.0%-46.9%) in 2018 ($P<0.001$).

Table 2 shows the prevalence of reduced VA stratified by age and sex.

Reduced VA was more prevalent across age groups in 2018 than in 2002, except for 6~ to 8~ year age group ($P<0.001$). The prevalence of reduced VA in boys increased from 24.8% in 2002 to 43.2% in 2018, and from 32.3% to 50.2% for girls ($P<0.001$).

Fig1 shows reduced VA prevalence of girls was higher than boys in all age groups. In 2018, the prevalence of reduced VA started to increase markedly from the age of 9 years, while in 2002, the prevalence started to increase markedly from the age of 14 years.

Table 3 shows the prevalence of severely reduced VA increased in all age groups from 2002 to 2018 (all $P<0.001$). Between age 6 to 15 years, the prevalence of severely reduced VA ranged from 0.8% to 14.9% in 2002, while in 2018, the prevalence increased from 1.5% to 38.6% (all $P<0.001$).

In 2002, normal VA accounted for the majority of all age groups. In 2018, the proportion of normal VA decreased from 61.4% to 31.9% respectively (Fig 2 and Fig 3).

Discussion

In this population-based study on school children aged 6-15 years old in Changsha, we found that there has been a significant increase in the overall prevalence of reduced unaided VA from 2002 to 2018. In 2002, 71.7% of children had normal VA, while only 53.5% had normal VA in 2018. Similar trends are seen in other studies conducted among school children in China [13-16]. Among Chinese children in Guangzhou, by the end of schooling, less than 15% of children had normal VA in 2007 compared with around 30% in 1988[13]. Sun reported the overall prevalence of reduced VA of Chinese Students increased from 28.6% to 56.8% from 1985 to 2010 in mainland China [14].

Unaided VA was a justified measure of myopia because of its satisfactory sensitivity and specificity in myopia screening in previous studies[13, 14]. Therefore, although cycloplegic refraction (the gold standard for myopia assessment) was not measured due to the large sample size, the observed trend of the increase was largely due to the increased prevalence of myopia. In China, visual impairment is usually caused by refractive error, and myopia is the most common form of refractive error in school-age children[17].

Compared to 2002, our results indicated that both the prevalence of reduced VA and severely reduced VA increased significantly across almost all age and gender groups of children in Changsha in 2018. The results showed that the age-specific prevalence of reduced VA had an obvious trend that it increases with age. We also observed that girls had a higher prevalence of reduced VA than boys, which is consistent with findings from other studies [18-21]. The previous study showed that women are 3.9 times more likely than men to suffer from refractive errors [19]. In traditional Chinese culture, girls are expected to be quiet. They spend more time indoors doing near work while boys spend more time outdoors which may prevent the development of myopia [22].

Our results also showed that the proportion of severely reduced VA in 2018 increased more rapidly as children aged, which was consistent with previous research results[23,24]. In China, the intensity of studying increases with age. Therefore, they have to spend more time doing homework every day and less time playing outdoors. Studies have shown that the intensity of studying is the main environmental and behavioral factor of myopia[21].

To our knowledge, this is the first study focusing on the vision of elementary and secondary school students in central China. However, there were some limitations. First, because of the large sample size, we did not perform refractive examination. We used unaided VA as an alternative measure of myopia because of its satisfactory sensitivity and specificity in myopia screening[13,14]. Second, rather than using a national representative sample, we used a sample from a representative urban district from China, therefore our result may not be able to reflect the trends of reduced VA in rural China. Also, the prevalence rate in Yuhua District could be different from the national prevalence rate in China, because there are regional differences. However, the main purpose of our study was to identify the changes in age-specific trends, and our findings should be able to reflect the trends in urban China. It could also be used as a reference for other Asia countries that facing an epidemic of myopia.

Conclusion

Both the prevalence of reduced VA and severely reduced VA in children aged 6-15 years old increased significantly from 2002 to 2018 in Yuhua District. The remarkable epidemic of reduced VA started 5 years earlier in 2018 than in 2002. Evidence from the present study suggests interventions should be launched before the age of 9 years.

Abbreviations

VA :Reduced visual acuity

WHO: World health organization

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Hunan Children's Hospital. Informed written consent was obtained from a legal guardian of each child involved in our study.

Consent to publish

All authors approved the final manuscript for submission and gave consent for publication.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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No funding was given to the study.

Authors' contributions

STX and SZ contributed equally to designing this article, performing the statistical analyses, and drafting the manuscript. XL provided critical revision of the manuscript. YZ and LPL participated in the design of the study. LHX and RTK helped completed the acquisition of data. All authors read and gave final approval of the version to be published.

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Tables

Table 1 General characteristics of the study participants in 2002 and 2018

Category	2002		2018		<i>P</i>
	<i>n</i>	%(95%CI)	<i>n</i>	%(95%CI)	
Age(y)					
6~11	17583	66.0(65.4,66.6)	29968	65.6(65.1,66.0)	0.261
12~15	9061	34.0(33.4,34.6)	15728	34.4(34.0,34.9)	
Sex					
Boys	14127	53.0(52.4,53.6)	24409	53.4(53.0,53.9)	0.305
Girls	12517	47.0(46.4,47.6)	21287	46.6(46.1,47.0)	
Visual acuity					
Normal	18786	71.7(71.1,72.2)	24357	53.5(53.1,54.0)	<0.001
Reduced ^a	7431	28.3(27.8,28.9)	21153	46.5(46.0,46.9)	
Reduced Visual acuity					
Mildly reduced ^b	3557	47.9(46.7,49.0)	5704	27.0(26.4,27.6)	<0.001
Moderately reduced ^c	2762	37.2(36.1,38.3)	7978	37.7(37.1,38.4)	
Severely reduced ^d	1112	15.0(14.2,15.8)	7471	35.3(34.7,36.0)	

a. Reduced visual acuity was defined as worse than 6/6.

b. Mildly reduced VA was defined as greater than 6/9 and less than 6/6.

c. Moderately reduced VA was defined as greater than 6/18, equal to or less than 6/9

d. severely reduced VA was defined as equal to or less than 6/18

Table 2 Prevalence of reduced visual acuity stratified by sex and age among students aged 6~15 years

Category	2002			2018			<i>P</i>
	<i>n</i>	Total	%(95%CI)	<i>n</i>	Total	%(95%CI)	
Age(y)							
6	2014	914	45.4(43.2,47.6)	4845	1872	38.6(37.3,40.0)	<0.001
7	2919	1038	35.6(33.8,37.3)	5714	1849	32.4(31.1,33.6)	0.003
8	3091	880	28.5(26.9,30.1)	5379	1648	30.6(29.4,31.9)	0.036
9	3133	734	23.4(21.9,24.9)	4773	1728	36.2(34.8,37.6)	<0.001
10	2957	688	23.3(21.7,24.8)	4648	1904	41.0(39.5,42.4)	<0.001
11	3185	694	21.8(20.4,23.2)	4470	2155	48.2(46.7,49.7)	<0.001
12	3197	716	22.4(21.0,23.8)	5096	2887	56.7(55.3,58.0)	<0.001
13	2378	559	23.5(21.8,25.2)	5113	3312	64.8(63.5,66.1)	<0.001
14	1862	609	32.7(30.6,34.8)	4680	3259	69.6(68.3,71.0)	<0.001
15	1481	599	40.4(37.9,42.9)	792	539	68.1(64.8,71.3)	<0.001
Sex							
Boys	13878	3447	24.8(24.1,25.6)	24293	10496	43.2(42.6,43.8)	<0.001
Girls	12339	3984	32.3(31.5,33.2)	21217	10657	50.2(49.6,50.9)	<0.001

Table 3 Prevalence of severely reduced visual acuity stratified by sex and age among students aged 6~15 years

Category	2002			2018			<i>P</i>
	<i>n</i>	Total	%(95%CI)	<i>n</i>	Total	%(95%CI)	
Age(y)							
6	2014	17	0.8(0.4,1.2)	4845	74	1.5(1.2,1.9)	<0.001
7	2919	32	1.1(0.7,1.5)	5714	129	2.3(1.9,2.6)	<0.001
8	3091	40	1.3(0.9,1.7)	5379	208	3.9(3.4,4.4)	<0.001
9	3133	71	2.3(1.7,2.8)	4773	378	7.9(7.2,8.7)	<0.001
10	2957	95	3.2(2.6,3.8)	4648	522	11.2(10.3,12.1)	<0.001
11	3185	122	3.8(3.2,4.5)	4470	833	18.6(17.5,19.8)	<0.001
12	3197	176	5.5(4.7,6.3)	5096	1365	26.8(25.6,28.0)	<0.001
13	2378	162	6.8(5.8,7.8)	5113	1773	34.7(33.4,36.0)	<0.001
14	1862	176	9.5(8.1,10.8)	4680	1883	40.2(38.8,41.6)	<0.001
15	1481	221	14.9(13.1,16.7)	792	306	38.6(35.2,42.0)	<0.001
Sex							
Boys	13878	470	3.4(3.1,3.7)	24293	3505	14.4(14.0,14.9)	<0.001
Girls	12339	642	5.2(4.8,5.6)	21217	3966	18.7(18.2,19.2)	<0.001

Figures

Figure 1

Prevalence of Reduced Visual Acuity in China by Sex Group in 2002 and 2018

Figure 2

Percentages of Students With Normal, Mildly, Moderately, and Severely Reduced Visual Acuity in 2002

Figure 3

Percentages of Students With Normal, Mildly, Moderately, and Severely Reduced Visual Acuity in 2018