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A Study of the Present Prevalence of Myopia in Children of School Age in Two Regions of Eastern Inner Mongolia

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ABSTRACT

Background: The study was conducted to assess the prevalence of myopia among school-aged children in Xing'an Meng and Hulunbuir from Inner Mongolia, as well as to identify the factors of myopia.

Methods: A total of 25795 students from the Xing'an Meng and Hulunbeier were selected as the research subjects from October to November 2021 using stratified random whole-group sampling. The students underwent visual acuity examination, followed by a survey of myopia-related factors via questionnaire.

Results: The rate of myopia detection was 65.2% in Xing'an Meng and Hulunbeier. The rate of myopia detection was higher in females (70.3%) than that in males (60.2%). The risk of myopia among female students was 1.543 times that of male. The risk of myopia in Mongolian was 0.78 times than that of than Han Chinese students. Middle school, high school, and vocational high school students had a myopia risk that was 2.43 times, 4.168 times, and 1.16 times that of elementary school students, respectively. female, high study level, reading and writing with eyes less than one foot (33 cm) from the book, using mobile electronic devices for more than an average of 0.5 hours per day, reading or looking at electronic displays in sunlight, reading or looking at electronic displays while lying on one's back or lying down, and having myopic parents were risk factors for myopia. Living in a suburban county, being of Mongolian descent, and spending recess outside were protective factors against myopia.

Conclusion: Gender, ethnicity, and lifestyle habits were related to myopia in children of school age. Maintaining good reading habits and engaging in outdoor activities were effective approaches to prevent myopia.

INTRODUCTION

Myopia is the most prevalent form of refractive error. Myopia is currently a significant issue all over the world and seriously damages the eye health of teenagers Baird et al. (2020). An international study of the prevalence of myopia in school-aged children (6-19 years) revealed that the prevalence was highest in eastern Asia (73%) and North America (42%). Less than 10% of adolescents in South America and Africa were myopia Grzybowski et al. (2020). The prevalence of myopia among school-aged children (5-16 years) in southern India was 17.5% Gopalakrishnan et al. (2022). Myopia prevalence among high school students (14-21 years old) in western Iran was 29.3% and substantially increased with age Hashemi et al. (2014) Clearly, the prevalence of myopia among pupils in East Asia was high. Myopia was significantly more prevalent in high-income country of Asia-Pacific nations than in another region Holden et al. (2016).

In recent years, the prevalence of myopia among school-aged children in China has been high. According to the statistics, the prevalence of myopia among Suzhou secondary school pupils was 78.23% in 2018 Hu et al. (2021). In 2019, 46.3% of Leshan's pupils in elementary and secondary school had myopia Qin et al. (2021). In 2021, the prevalence of myopia among Hubei's elementary and secondary school pupils was 65.1% Shi et al. (2021). The prevention and control of myopia is a critical issue in China, especially for school-age children. Multiple factors, including environmental factors, genetic factors, and eye patterns, affect the incidence of myopia. But the true pathogenesis of myopia has not been thoroughly studied. There is an urgent need for a large quantity of epidemiological survey data and scientific experimental data to clarify the pathogenesis of myopia. It may prevent and treat myopia more effectively, reduce its incidence, and enhance the quality of life.

Both Xing'an Meng and Hulunbeier are located in the eastern portion of Inner Mongolia and share a similar geographical environment, way of life, and ethnic distribution. In the two regions, Mongolians make up a

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large percentage of the population and have a unique way of life. The survey was conducted to assess the current prevalence of myopia among school-aged children in Xing'an Meng and Hulunbuir City, as well as to identify the factors that may contribute to the occurrence of myopia among students. In 2021, we surveyed the myopia of school-aged children in the two regions, and analyzed the potential influencing factors. It may provide a basis for the prevention and control of myopia.

MATERIALS AND METHODS

Research Subjects

The students from Xing'an Meng and Hulunbeier City participated in this survey for the surveillance project of prevalent diseases and health-influencing factors. Two monitoring stations were established in each location, one located in the city and one in the suburbs. The urban monitoring sited in Xing'an Meng and Hulunbeier City were Wulanhaote City and Hailar District, respectively. The suburban counties comprised every banner and county. In urban areas, seven schools were monitored, including two elementary schools, two middle schools, two high schools, and one vocational school. In each suburban county, five schools were monitored, including two elementary schools, two middle schools, and one high school. The survey population consisted of the pupils enrolled in each school. In elementary schools, the students only in grades 4, 5, and 6 were included. All grades in middle schools, high schools, and vocational high schools were investigated. The Inner Mongolia Medical University Medical Ethics Committee reviewed and approved the study.

Inclusion criteria: (1) elementary school students in grades four and above; (2) those with strong reading and comprehension skills; and (3) those whose school, parents, and themselves have given their informed assent.

Exclusion criteria: (1) Have eye diseases that affect vision, such as amblyopia, hyperopia, corneal disease, or congenital cataracts; (2) Students who have had myopia correction surgery and are now myopic again, are receiving low-level atropine treatment, or have worn keratoprosthesis lenses; (4) Those whose questionnaire responses were incomplete.

Sampling technique

The stratified random whole-group sampling was adopted in the study. The schools in Xing'an League and Hulunbuir City that were monitored from October 9 to November 12, 2021 were stratified by grade into elementary school (grades 4 to 6), middle school, high school, and vocational high school. A random sample was taken from classes with fewer than 80 students per grade, or fewer than 240 students per school. Inadequacies were compensated for by adjacent schools of the same type.

Questionnaire

The questionnaire was administered using the "Special Questionnaire on Students' Poor Vision and Influencing Factors (for Primary and Secondary Schools)". The questionnaire included questions about gender, ethnicity, place of residence, level of education, outdoor activities, sleep, and whether or not your parents are nearsighted. The additional information about questionnaire was displayed in supplementary materials. The questionnaire was reliable and legitimate, with a Cronbach's alpha coefficient of 0.74 and a KMO value of 0.82. The questionnaire was disseminated uniformly and collected on time.

The investigators distributed questionnaires in the classroom and informed the students of the standardized method of filling them out. The process required the students to independently complete the questionnaires distributed on site and retrieve them on the spot. The data were entered through EpiData 3.1 software (using double-entry) and the data were matched and integrated according to the student number and name. Incomplete, incorrect, and other data that did not meet the requirements needed to be filtered or modified.

Visual Acuity Examination

The examination includes testing for distance vision and refractive error. The examination team consists of at least one ophthalmologist with a national medical license and a number of optometry-trained technicians or nurse practitioners. The distance vision examination is consistently administered using a 5-meter standard logarithmic visual acuity scale (GB 11533 Standard Logarithmic Visual Acuity Scale). Refractive examinations were performed in the absence of ciliary muscle dysfunction using a desktop automatic computerized optometry instrument that complies with the requirements of the standard. (ISO 10342 Ophthalmic Instruments-Optometry). The instruments and apparatus used for screening must be authorized and tested by the appropriate authorities and subjected to regular metrological verification and calibration.

Related indicators and definitions

One of the following two conditions must be met to be diagnosed as myopic: (1) confirmed use of keratoplasty lenses; or (2) unaided eye visual acuity 5.0 in either eye and computerized spherical equivalent (SE) -0.50 D under non-ciliary muscle paralysis. The rate of rate of myopia detection = (number of myopic students / number of pupils surveyed) *100.0%.

Criteria for quantifying frequency: reading and writing posture, close eye use, and other factors "never" refers to the previous week where the event was not performed; "occasionally" refers to the previous week where exposure to the event was less than 1 hour per day.

"often" refers to the previous week's exposure of 1-2 hours per day; "always" refers to the previous week's exposure of an average of 2 hours per day or more.

Quality Controls

All survey participants were required to complete training on survey techniques, be knowledgeable about myopia, and be familiar with the methodologies and instruments. The study utilized a standardized workbook and questionnaire. The testing procedure was standardized, survey questionnaires were reviewed prior to distribution and collection, and those that did not satisfy the criteria were gathered.

The class component collects the student's name, grade, and school identification number. During the daily testing procedure, 5% of subjects were chosen at random for visual acuity evaluation to excluding testing errors.

Statistical Methods

The data were analyzed using spss25.0. Normal distribution data were expressed as mean and standard deviation (SD). The chi-square test was used for univariate analysis. Binary logistic regression was used to analyze the factors associated with myopia. $\alpha=0.05$ was used as the significance level, and a two-sided $P<0.05$ was deemed statistically significant.

RESULTS

Baseline characteristic of the students

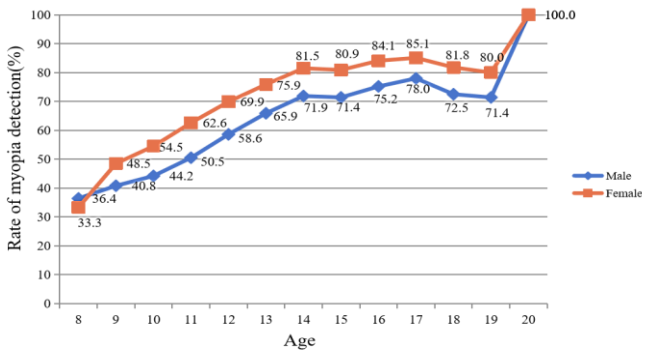
A total of 25795 students were surveyed, including 13002 males (50.4%) and 12793 females (49.6%). The age of students ranged from 8 to 20 years old, with an average of (12.64±2.405) years. There were 14198 Han Chinese students (55.0%), 8742 Mongolian students (33.9%), and 2855 other ethnic minority students (11.1%). There were 10,309 students enrolled in elementary school (40.0%), 10,085 students enrolled in junior high school (39.1%), 4,906 students enrolled in high school (19.0%), and 495 students enrolled in vocational high school (1.9%). There were 3,636 students (14.1%) in urban areas and 22,159 students (84.9%) in suburban counties.

In urban areas, there were 2241 Han Chinese students (61.6%), 1040 Mongolian students (28.6%), and 355 students of other nationalities (9.8%). In suburban counties, there were 11,957 Han Chinese students (54.0%), 7,702 Mongolian students (34.8%), and 2,500 students of other nationalities (11.3%). Table 1 showed the ethnic distribution of students.

The myopia information of students

In this survey, 16,815 students were diagnosed with myopia, and the rate of myopia detection was 65.2%. The rate of myopia detection was higher in females (70.3%) than that in males (60.2%). The number of myopic students in urban areas was 2,613 (71.9%), and that were 14,202 (64.1%) in suburban counties. The rate of myopia detection was higher in urban students than among suburban students ($P<0.001$, Table 2). In addition, the rate of myopia detection in high school (82.0%) was highest among all learning Stage (Table 2). The rate of myopia detection gradually increases with age. Meanwhile, the rate of myopia detection was higher in female than male at the same age (Figure 1).

Figure 1: Variation in the rate of myopia detection by age and gender among surveyed students.



The influencing factors of myopia in students

We analyzed the influencing factors of myopia. The significant differences ($P<0.05$) were found between the prevalence of myopia and 21 influential factors, including eye use in and out of school, reading and writing posture, electronic screen use time, near eye use, outdoor activities and sleep, and whether your parents had myopia ($P<0.05$, Supplementary Table 1).

The myopia status was used as the dependent variable (0=non-myopia; 1=myopia). Twenty-five factors (all $P<0.05$) were used as independent variables, including gender, place of residence, ethnicity, stage of study, eye use in and out of school, and reading and writing posture. The independent variables were screened using the forward method and the binary logistic regression were performed. The variables in this study were allocated the reference value "0". The values of the variables are shown in Supplementary Table 2.

According to the results of binary logistic regression, the risk of myopia in female (1.543%) was higher than that of male. The risk of myopia in Mongolian was 0.78 times than that of than Han Chinese students. The risk of myopia was 0.809 times greater in suburban counties than that in urban. Middle school, high school, and vocational high school students had a myopia risk that was 2.43 times, 4.168 times, and 1.16 times that of elementary school students, respectively. During recess, the risk of myopia in outdoor was 0.90 times greater than inside the classroom. When reading and writing, the risk of myopia was 1.363, 1.408, and 1.202 times greater for students whose eyes were never, occasionally, and frequently more than one foot (33 centimetres) away from a book than for those whose eyes were always more than one foot away.

Table 1: Ethnic distribution of students in different places of residence.

Variables	Urban area (n=3636) Number of respondents (n)	Percentage (%)	Suburban counties (n=22159) Number of respondents (n)	Percentage (%)
Ethnicity				
Han Chinese	2241	61.6	11957	54
Mongolian	1040	28.6	7702	34.8
Other nationalities	355	9.8	2500	11.3

Table 2: The myopia information of students.

Variables	Number of respondents (n)	Number of myopia (n, %)	$\chi 2$	P
Gender			290.162	<0.001
Male	13002	7824 (60.2)		
Female	12793	8991 (70.3)		
Place of residence			83.167	<0.001
urban area	3636	2613 (71.9)		
Suburban County	22159	14202 (64.1)		
Ethnicity			184.287	<0.001
Han Chinese	14198	9743 (68.6)		
Mongolian	8742	5232 (59.8)		
Other ethnic groups	2855	1840 (64.4)		
Learning Stage			1689.918	<0.001
Elementary School	10309	5268 (51.1)		
Middle School	10085	7210 (71.5)		
High School	4906	4023 (82.0)		
Vocational High School	495	314 (63.4)		

In the past week, students who used mobile electronic devices for an average of 0.5-1 hour and 1-2 hours per day had a 1.148- and 1.111-fold increased risk of myopia than those who used them for less than 30 minutes per day, respectively. The risk of myopia was 1.136 times greater in students who occasionally read books or electronic displays in direct sunlight than those who did not. The risk of myopia was 1.146, 1.183, and 1.145 times greater in students who occasionally, frequently, and constantly read books or electronic screens reclining down or on their stomachs than those who did not do so. Compared with students with neither myopic parent, the risk of myopia was 3,217, 2,148, and 2,334 times greater for students with both myopic parents, only myopic father, and only myopic mother, respectively ($P<0.05$, Supplementary Table 3). The results suggested that female, high study level, reading and writing with eyes less than one foot (33 cm) from the book, using mobile electronic devices for more than an average of 0.5 hours per day, reading or looking at electronic displays while lying on one's back or lying down, and having myopic parents were risk factors for myopia. Living in a suburban county, being of Mongolian descent, and spending recess outside were protective factors against myopia.

DISCUSSION

Myopia seriously affects the visual health of school-age children. In our study, the rate of myopia detection was 65.2% in the school-age children of Xingan Meng and Hulunbeier City. Compared to other regions in China, the rate of myopia detection in eastern Inner Mongolia was lower than that of Baotou City (73.1%) Jin et al. (2022), comparable to that of Hubei Province (65.1%) Shi et al. (2021), but higher than those of Chifeng City (52.2%) Yin et al. (2021) and Beijing Yanqing District (57.1%) Wang et al. (2021). In addition, the rate of myopia detection in eastern Inner Mongolia was lower than that of east Asia (73.0%) Grzybowski et al. (2020), and higher than that in North America (42.0%) Grzybowski et al. (2020) and southern India (17.5%) Gopalakrishnan et al. (2022).

It was suggested that the myopia prevention and control were more severe in the school-age children eastern Inner Mongolia.

We found that the rate of myopia detection in females was 1.543%, which higher than that in mela. During recess, the percentage of females who engage in physical activity (45.6%) was lower than that of males (54.4%, $P<0.001$). This may associate with the higher rate of myopia in female. Studies demonstrated that girls prefer solitude and reading, and prefer to stay in the shade to avoid sunburn in the summer Du et al. (2021). It also suggested that the higher prevalence of myopia in girls may be related to the earlier maturation. However, the mechanism about the gender differences in myopia rates is still unknown and requires further investigation Liu et al. (2022). Xu et al. found that 7% of the risk of myopia in females was associated with their first menstrual period, whereas the association between myopia and ejaculation in boys was small and insignificant Xu et al. (2022). The pubertal status of Chinese adolescents may be an independent risk factor for myopia in girls, suggesting that early and middle adolescence may be an optimal time to prevent myopia in girls.

Our study found that ethnicity was a protective factor against the development of myopia, which consistent with the findings of previous study conducted in Baotou Bian et al. (2021). The prevalence of myopia in the Inner Mongolian population was comparable to that of the Mongolian population Wang et al. (2019). The prevalence of myopia in Mongolians is lower than in other East Asian populations, according to researchers Wickremasinghe et al. (2004). Most Mongolian students live in suburban counties and pastoral areas and prefer to play in pastoral pastures. It increases the amount of time spent outdoors and decreases the amount of time spent indoors playing with cell phones, watching television, and reading, thereby reducing visual fatigue and the incidence of myopia. It may be also be associated with the genetic.

The study revealed that students living in suburban counties had an increased risk of myopia by 0.809% compared to students living in urban areas. It may be associated with the multiple factors, including the lower usage of electronic products, and fewer after-school tutorials and homework assignments, as well as the sparsely built houses in rural areas, where students have a wide field of vision during activities Zhang et al. (2021). According to a study by Dragomirova et al. (2022), the prevalence of myopia among pupils in urban populations was 31.4% (capital city), 19.9% (medium city), and 8.4% (rural). Morris et al. (2020) discovered a correlation between myopia and population density. Compared to children living in areas with a lesser population density, those living in areas with a higher population density had a higher incidence of myopia Morris et al. (2020). It was discovered that the prevalence of myopia in students increased with their educational level. Thorn et al. (2020) discovered that the development of myopia increased with grade level, and that the rate of myopia development was substantially faster in third grade students in a competitive and focused school. It suggested that it may be associated with increased academic stress. It was discovered that the prevalence of myopia in the upper grades was higher than in the lower grades in Oman, and the prevalence of myopia among fourth, seventh and tenth grader were 2.44%, 4.41%, and 7.36%, respectively Khandekar et al. (2018). Zhang et al. (2019) suggested that the elevated learning stage, increased learning pressure, increased daily eye time, and large amounts of after-school homework make tired eyes inadequately rested, which, along with less time spent engaging in outdoor activities, contribute to the development of myopia.

The present study revealed that outdoor activities during recess were a protective factor against myopia in students. Several studies have demonstrated that "being outside during recess" is a factor that protects against myopia Shang et al. (2021), Qian et al. (2018), Wu et al. (2018). A meta-analysis revealed that outdoor activity decreases the incidence of myopia but has little influence on its progression Xiong et al. (2017).

We found that Incorrect reading and writing posture and close eye use were the risk factors for myopia, including reading and writing with eyes less than one foot (33 cm) from a book, reading a book or electronic screen in direct sunlight, and reading a book or electronic screen while lying on one's stomach or back. Previous study discovered that reading and writing with eyes more than one foot away from books delays the advent of visual impairment Shi et al. (2022). The improper reading and writing posture increase the likelihood of protracted close eye use, which in turn causes eye fatigue and a reduction in eye axis regulation. Sherwin et al. (2012) demonstrated that children working closer than 30 cm were 2.5 times more prone to develop myopia than children working further away. The prolonged close work increases the risk of myopia, with significant changes in eye axis length and choroidal thickness with increasing time spent working at close distances Ghosh et al. (2014). These changes may be the result of a combination of biomechanical factors, such as extraocular muscle force and ciliary muscle contraction.

Current study showed that using mobile electronic devices for more than 0.5 hours per day on average was a risk factor for myopia. It was reported that the use of mobile devices by infants and adolescents (2 h/d) was a risk factor for myopia Li et al. (2022). Using cell phone for more than two hours per day was associated with myopia development Singh et al. (2019). Unquestionably, the lifestyles of today's children and adolescents have changed, and although the prevalence of myopia has been on the rise for decades, the increased level of near visual stimulation from smartphones may constitute an independent risk factor for myopia McCrann et al. (2021). This study found that myopia in the father alone, in the mother alone, and in both parents were 2,148, 2,334, and 3,217 times more prevalent than myopia in neither parent.

Lifestyle can be determined by genetics and vice versa Enthoven et al. (2019).

parental myopia has become a well-established myopia risk factor. Mutti et al. (2002) controlled for the influence of environmental factors and found that the risk ratio for myopia in pupils with no myopia, one or two myopic parents were 1, 3.22, and 6.40, respectively. It indicated that children with two myopic parents were more likely to develop myopia.

It was discovered that myopic parents were more educated and academically demanding of their children Tu et al. (2022). This resulted in early education, protracted close-up work, and a lack of outdoor activities.

This study's population was limited to pupils in the fourth grade and above, and did not include elementary school students in grades kindergarten through third. Considering that the age factor has a significant impact on myopia, the next similar study can include students in lower elementary school and use a more appropriate questionnaire so that students in lower elementary school can better comprehend and answer the questions.

CONCLUSION

This study investigated the influences of myopia in children of school age in Xing'an Meng and Hulunbeier from eastern Inner Mongolia. Female, high study level, reading and writing with eyes less than one foot (33 cm) from the book, using mobile electronic devices for more than an average of 0.5 hours per day, reading or looking at electronic displays in sunlight, reading or looking at electronic displays while lying on one's back or lying down, and having myopic parents were risk factors for myopia.

Living in a suburban county, being of Mongolian descent, and spending recess outside were protective factors against myopia.

DECLARATIONS

Ethical approval and consent to participate

The investigation was approved by the Inner Mongolia Medical University's Ethics Committee and was conducted in accordance with the Declaration of Helsinki. The authors provided evidence that participants were aware of the study's goals, dangers, and advantages. Informed consent was obtained from subjects, their legal guardians, and the school.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available upon reasonable request from the corresponding authors.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SMY and BTE conceived and directed the research, analysis, and drafting design for this paper. SMY performed the data extraction and data analysis. The first draft of the paper was written by ZKR and ZJ. YYH and WHQ collected the data. SMY, YYH, WHQ, ZKR, ZJ and BTE contributed to the discussion of the results, revision, and approval of the manuscript.

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