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Discriminant Analysis of Nomogram Prediction Model for Myopia in Primary and Secondary School Students

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Abstract: The aim is to create a model of myopia risk forecasting for primary and secondary school pupils in Xi'an City, and to supply a scientific foundation for the prevention and regulation of myopia in primary and secondary school students. In 2023, 12 schools in Xi'an City were chosen to be the focus of monitoring common student diseases, and stratified whole group sampling was conducted for each grade of primary school (4~6), junior high, and senior high. The current state of myopia screening was outlined, and multifactorial logistic regression was used to analyse the correlates of myopia, as well as to construct a nomogram prediction model. Resultly, a total of 3531 students aged 9~18 years were selected, with 2776 myopes and a myopia rate of 78.6%. The multifactorial logistic regression model showed that females (OR=1.34, 95% CI: 1.13~1.59), school level (junior high school: OR=2.13, 95% CI: 1.72~2.66; senior high school: OR=3.91, 95% CI: 3.00~5.11), and number of eye exercises performed per day (2: OR=0.68, 95% CI: 0.49~0.94; 3: OR=0.61, 95% CI: 0.42~0.91), eyes one foot away from books (always: OR=0.53, 95% CI: 0.31 to 0.91), and parental myopia (b2222oth myopic: OR=3.61, 95% CI: 2.66-4.98; father's myopia only: OR=1.96, 95% CI: 1.51 -2.56; mother's myopia only: OR=1.81, 95% CI: 1.44-2.30), and the number of vision examinations in the previous year (≥2: OR=1.41, 95% CI: 1.17-1.70) were statistically significant (all P values <0.05). The column chart prediction model showed that the risk factors for myopia among primary and secondary school students in Xi'an were gender, school year, frequency of eye exercises/day, eye distance from books, parental myopia, and the number of previous year's visual acuity examinations, respectively. In conclusion, a graphical prediction model of column-line design can accurately detect risk elements for myopia and offer scientific backing for the prevention and regulation of myopia in primary and secondary school students.

1. Introduction

Myopia has become a major eye disease worldwide [1], with a rapidly increasing prevalence that is evolving into a global health challenge [2]. Myopia can significantly increase the risk of pathologic ocular changes such as foramen ovale retinal detachment, myopic macular degeneration, and myopic

glaucomatous optic neuropathy [3]. As a result, myopia has become one of the leading causes of irreversible blindness and visual impairment. It is predicted that by 2050 [4], the global myopic population will account for 49.8% of the total population, of which 9.8% will be highly myopic. The prevalence of myopia among children and adolescents in China is among the highest in the world, far exceeding the international average [5]. According to the National Health and Health Commission, the myopia rate of children and adolescents in China has reached 52.7% in 2020. In China, myopia in children and adolescents shows a trend of low age, high prevalence and severe myopia, and is growing rapidly. Therefore, it has become imperative to study the risk factors of myopia in children and adolescents and focus on preventive and control measures.

Columnar predictive modeling is widely used in ophthalmology research to construct a columnar model by analyzing the influence of different factors on the outcome variables, and assessing the predictive ability of the model to predict the risk of an event occurring. Many scholars have used column chart prediction models in different directions such as, diabetes and retinopathy anterior end of the eye disease [6], myopia prevention and treatment [7], retinal detachment and ocular tumors [8] .In this study, we analyzed the myopia situation of primary and secondary school students, constructed a column-line diagram prediction model, provided individualized prediction, conducted monitoring and evaluation, improved the awareness of prevention, and provided a scientific basis for myopia prevention and control strategies for primary and secondary school students.

2. Objects and Methods

2.1. Research target

Elementary and middle school students in grade 4 and above from schools monitoring common diseases among students in Xi'an City in 2023 were selected as the study subjects, and stratified whole-cluster sampling was used to randomly select two elementary schools, two junior high schools, two high schools, and one vocational high school in Xincheng District, and two elementary schools, two junior high schools, and one high school in Lantian County. Categorized by grade, and randomized whole cluster sampling by class, the most included 3, 531 students between the ages of 9 and 18 years old, and all subjects gave informed consent.

2.2. Content of research

Myopia is determined according to the screening myopia judgment criteria through the Questionnaire on Students' Health Status and Influencing Factors and the Special Questionnaire on Students' Poor Vision and Influencing Factors. Students in grades 4 to 6 in elementary schools, junior high schools and senior high schools in the monitoring point schools were surveyed, and the survey included basic information (area of residence, gender, grade, etc.), place of recess activities, frequency of desk and chair adjustments, frequency of eye exercises at school, whether or not the chest was one fist away from the desk, eyes one foot away from books, fingers one inch away from pens, myopia status of parents, and vision checkups in the previous year.

2.3. Criteria for determining screening myopia

Screening myopia, including right and left eye visual acuity, was examined using the Key Common Disease Surveillance Chart for Students. When the naked eye visual acuity <5.0 and non-ciliary muscle paralysis, computerized optometry equivalent spherical lens power ≤-0.50D, SE = spherical lens power + 1/2 column lens power, if a single eye was determined to be screening myopia, or keratoconus wearers were counted in the number of screening myopia [9].

2.4. Statistical methods

Data were statistically analyzed using SPSS 26.0 software. Frequencies or percentages were used to describe categorical data, and the χ2test was used when comparing different groups. Factors associated with myopia were explored through the use of multifactorial logistic regression models, and the Rms package in the R studio 4.3.1 statistical software was used to construct column-line graphical prediction models. The discrimination and accuracy of the model were evaluated by ROC curves and internal correction curves. Statistical tests were all two-sided tests with test level a = 0.05.

3. Event

3.1. Basics

The overall detection rate of myopia among primary and secondary school students in this survey was 78.60% (2, 776), of which 75.10% (1, 655) were boys and 81.71% (1, 876) were girls, and the detection rate of myopia in elementary school (grades 4-6) was 65.50% (1, 119), that of junior high school 80.15% (1, 189), and that of senior high school 89.12% (1, 223), with statistically significant differences. 89.12% (1, 223), the differences were statistically significant, (all p-values <0.05). See Table 1.

Table 1: A contrast of the rate of myopia detection among pupils by features

Variables	Options	numbers	myopia (%)	χ2	P
Area	urban area	2042	1689(82.71%)	48.307	<0.01
	county town	1489	1087(73.00%)		
Sex	male	1655	1243(75.10%)	22.859	<0.01
	female	1876	1533(81.71%)		
Segments	secondary school	1119	733(65.50%)	196.447	<0.01
	middle school	1189	953(80.15%)		
	high school	1223	1090(89.12%)		
Intercurricular activities	Inside the school building	2264	1833(80.96%)	20.639	<0.01
	indoor	1267	943(74.42%)		
Frequency of desk and chair adjustments	never	2694	2152(79.88%)	11.717	<0.01
	Once a school year	243	181(74.48%)		
	Once a semester	310	236(76.13%)		
	Once every two to three months	284	207(72.88%)		
Frequency of eye exercises/day	0	523	452(86.42%)	60.644	<0.01
	1	981	821(83.69%)		
	2	1698	1270(74.79%)		
	≥3	329	233(70.82%)		
One punch to the chest from the table.	never	349	283(81.08%)	16.467	<0.01
	sometimes	1495	1209(80.86%)		
	regular	1047	814(77.74%)		
	always	640	470(73.43%)		
Eyes a foot from the book.	never	309	256(82.84%)	31.279	<0.01
	sometimes	1480	1215(82.09%)		
	regular	1083	826(76.26%)		

	always	659	479(72.68%)		
Fingers one inch from the tip of the pen	never	340	278(81.76%)	10.154	<0.05
	sometimes	1236	999(80.82%)		
	regular	1101	848(77.02%)		
	always	854	651(76.22%)		
Frequency of continuous close eye use	≤1h	2534	1984(78.29%)	15.641	<0.01
	1-2h	604	502(83.11%)		
	2-3h	156	120(76.92%)		
	≥3h	237	200(84.38%)		
Parental myopia	neither	1789	1308(73.11%)	75.702	<0.01
	all	521	463(88.86%)		
	Father only	549	459(83.60%)		
	Mothers only	672	546(81.25%)		
Number of vision examinations /year	<2	1112	845(75.98%)	6.673	<0.01
	≥2	2419	1913(79.08%)		

3.2. Multifactorial analysis of myopia in children and adolescents between different characteristics

The myopia status of children and adolescents (No=0, Yes=1) was analyzed as the dependent variable in a one-way analysis of variance, and the statistically significant factors in the one-way analysis of variance were included as independent variables in the final multifactorial logistic regression analysis. The results showed that the gender of primary and secondary school students, their school year, the frequency of eye exercises, the distance of their eyes from the books, the myopia status of their parents and the number of vision check-ups in the last year were the associated with the occurrence of myopia in primary and secondary school students (p-value <0.05). See Table 2.

Table 2: A logistic analysis of multiple elements that affect myopia in primary and secondary school pupils. (n=3531)

Variables	Options	β	P	OR(95％ＣＩ)
Area	urban area			1
	county town	-0.11	0.27	0.89(0.74~1.09)
Sex	male			1
	female	0.29	<0.01	1.34(1.13~1.59)
Segments	secondary school			1
	middle school	0.76	<0.01	2.13(1.72~2.66)
	high school	1.36	<0.01	3.91(3.00~5.11)
Intercurricular activities	Inside the school building			1
	indoor	-0.17	0.06	0.84(0.71~1.01)
Frequency of desk and chair adjustments	never			1
	Once a school year	-0.03	0.88	0.97(0.71~1.34)
	Once a semester	0.13	0.38	1.14(0.85~1.54)
	Once every two to three months	0.07	0.66	1.07(0.79~1.46)
Frequency of eye exercises/day	0			1
	1	-0.17	0.32	0.85(0.60~1.18)
	2	-0.39	0.02	0.68(0.49~0.94)

	3	-0.48	0.02	0.61(0.42~0.91)
One punch to the chest from the table.	never			1
	sometimes	0.02	0.89	1.02(0.69~1.50)
	regular	0.18	0.39	1.20(0.78~1.82)
	always	0.21	0.38	1.23(0.77~0.97)
Eyes a foot from the book.	never			1
	sometimes	-0.10	0.66	0.90(0.57~1.41)
	regular	-0.39	0.11	0.67(0.41~1.08)
	always	-0.62	0.02	0.53(0.31~0.91)
Fingers one inch from the tip of the pen	never			1
	sometimes	0.11	0.59	1.11(0.75~1.64)
	regular	0.09	0.66	1.09(0.72~1.64)
	always	0.26	0.25	1.29(0.83~2.01)
Frequency of continuous close eye use	≤1h			1
	1-2h	0.24	0.06	1.27(0.99~1.63)
	2-3h	-0.29	0.16	0.75(0.50~1.14)
	≥3h	0.14	0.48	1.15(0.79~1.72)
Parental myopia	neither			1
	all	1.28	<0.01	3.61(2.66~4.98)
	Father only	0.67	<0.01	1.96(1.51~2.56)
	Mothers only	0.59	<0.01	1.81(1.44~2.30)
Number of vision examinations per year	<2			1
	≥2	0.35	<0.01	1.41(1.17~1.70)

3.3. Constructing Column Line Chart Prediction Models

Nomogram predictive modeling was performed according to the screening results of the logistic regression analysis. Each variable had its own unique score, and the higher the score, the higher the risk of developing myopia. Six main factors influence the occurrence of myopia among children and adolescents in Xi'an, including gender, school year, frequency of eye exercises/day, eye distance from books by one foot, parental myopia, and number of vision checkups in the previous year. (See Figure 1)

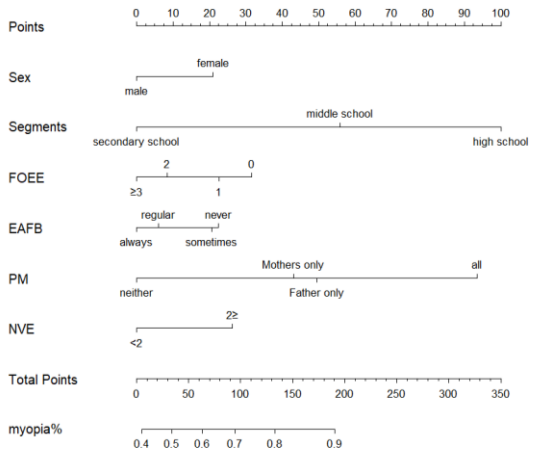

Figure 1: A line graph prediction model for risk of myopia in primary and secondary school students

3.4. ROC curve analysis for predictive modeling

Analysis of the ROC curves revealed that the model predicted an area under center (AUC) of 0.712 (95% CI = 0.692 to 0.732) for the occurrence of myopia, which suggests that the predictive model performs well in terms of differentiation and has high predictive validity.

3.5. Internal validity analysis

The model was tested using the Bootstrap validation method and 1, 000 replicate samples were taken, and after calibration, the AUC value reached 0.692, and the calibration curve of this line graph model predicting the onset of myopia was more similar to the actual curve, indicating a good fit. (see Figure 2)

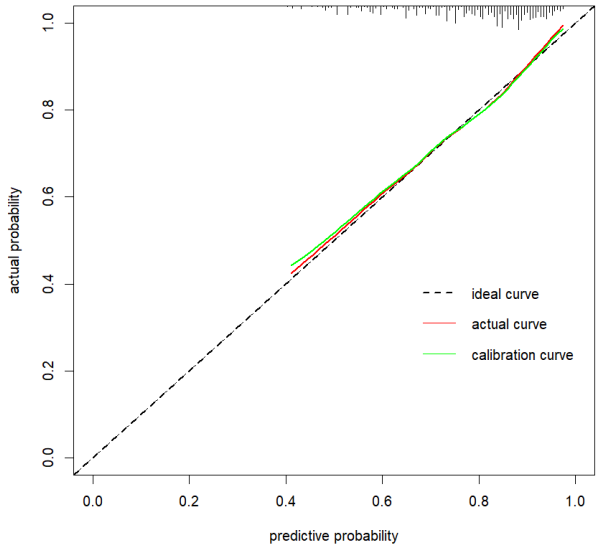

Figure 2: Calibration curves for line graph models

4. Deliberations

Myopia is an important health problem affecting elementary and middle school students. The overall myopia detection rate of 3, 531 elementary and middle school students in the region in 2023 was 78.6%, with myopia detection rates in elementary (grades 4-6), middle school, and high school being 65.50%, 80.15%, and 89.12%, respectively. Myopia detection rate in middle school and high school. Primary and secondary school students are the primary focus of myopia prevention and control because they are in a critical period of physical and visual development, have a heavy academic load, use their eyes frequently and have not yet fully developed good habits.

In the present study, gender, school level, frequency of eye exercises, eye distance from books, parental myopia and number of vision examinations in the previous year were found to be risk factors for myopia in students. The association between frequency of eye exercises at school and myopia in primary and secondary school students has been confirmed in many previous studies. A coming research study has shown that yoga eye exercises reduce eyestrain symptom scores by increasing the efficiency of the extraocular muscles [10]. Therefore, it can be considered a therapeutic and non-pharmacological intervention for reducing eyestrain and related visual fatigue symptoms, increasing the frequency of eye exercises, and having a protective effect on the eyes. A research study from Ningbo City showed that a reading distance of >33 cm was found to be a protective factor against

myopia in female students (OR = 0.31, 95% CI = 0.15-0.64), in elementary school (OR = 0.55, 95% CI = 0.30-0.99) and in secondary schools (OR = 0.37, 95% CI = 0.15-0.90) [11]. In a study of myopia from northern China, it was found that it was the mother's vision status that had a greater influence on the vision of high school middle school students, and that all traits were highly heritable [12]. Similar evidence for genetic factors was found in a study of myopia in college students [13]. These are important risk factors for myopia in children and adolescents, and many previous studies have reached similar conclusions [14]. The idea that there is a genetic link between myopia and heredity, and that those children who have parents with myopia are more likely to develop myopia, is also consistent with our findings. In this study, the risk of developing myopia was 1.41 times higher for ≥2 previous year vision examinations than for <2 vision examinations. The possible reason for this is that parents got a timely reflection of whether their child was myopic early detection and examination, reflecting the importance that parents attach to their child's myopia and timely review, leading to a higher risk of developing myopia with more examinations.

5. Summary

In summary, this survey shows that the myopia rate among primary and secondary school students remains high, and the situation is serious and cannot be ignored. By establishing a risk prediction model for myopia in primary and secondary school students, individualized prediction and monitoring can be performed for each student, and their myopia risk can be assessed at an early stage. Through this model, it can raise the preventive awareness of students, parents, schools and the society, and provide solid data support and theoretical basis for scientific and accurate myopia prevention and control. Based on the specific prediction results, different players (e.g., schools, parents, and medical institutions) can develop targeted interventions to promote the effective implementation of myopia prevention and control.

On the school side [15], focus on cultivating students' eye habits. Conduct eye exercises regularly to relieve eye fatigue. Teachers pay attention to students' postures and guide them to develop correct habits. Remind students to maintain proper distance between books and eyes. At family level [16], parental support is crucial. Families with myopic parents should pay more attention. Parents help children develop good eye habits. They should control device use, ensure good environment and posture. Also, take children for regular vision check-ups. Students should cooperate with prevention measures and develop good eye habits. Only with joint efforts of schools, families and students can myopia be slowed down to protect students' visual health and improve quality of life.

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