Original Article

Epidemiological study of refractive errors in children and adolescents of Han and Li ethnics in the Ledong and Wanning areas of Hainan Province

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Background: To determine the prevalence of refractive error and ocular biometric data (corneal curvature, axial length, and central corneal thickness) in 6 to 15 years old children of Li and Han ethnicities of China.

Methods: This study was a cross-sectional study. A cluster sampling method was used to select 2 nine-year consistent schools in the Ledong and Wanning areas of Hainan Province, with a total of 4,197 students, 3,969 valid data. Eyesight test, slit lamp, autorefraction after cycloplegia, and ocular biometric assessment were performed. The chi-square test and logistic regression analysis was taken as the comparative method.

Results: Myopia, hyperopia, and astigmatism are defined as: myopia: SE ≤–0.50 D; hyperopia: 0.50 D <SE. The absolute value of the cylinder diopter is ≥0.75 D, and the uncorrected visual acuity is lower than the lower limit of the normal age for astigmatism. The prevalence of myopia in the 6–9, 10–12, and 13–15 years old were 3.4%, 16.6%, and 36.4% for the Li, while 11.1%, 32.6 %, and 42.6% for the Han. The prevalence of myopia was significantly different between the three age groups (χ^2=26.809, 48.045, 4.907, P<0.001, P<0.001, P<0.05). The prevalences of myopia in Li boys and girls were 12.3% and 24.2%, and in the Han boys and girls were 26.1% and 36.6%. The prevalence of myopia was different between boys and girls (χ^2=60.645, 31.137, P<0.001, P<0.001). In the Wanning and Ledong areas, the prevalences of myopia for the Li were 30.5% and 16.8%, and for the Han were 30.8% and 31.1%. In regard to the prevalence of myopia, no statistical difference was seen in the two nationalities in the Wanning area (χ^2=0.012, 0.914), but not in the Ledong area (χ^2=27.305, P<0.001).

Conclusion: The overall prevalence of myopia in children and adolescents in Han is higher than that in Li The prevalence of myopia in Han and Li was significantly different in different age groups from 6 to 15 years old. The prevalence of myopia in girls was higher than that in boys, in the Wanning area than that in the Ledong area.

Keywords: Myopia; cross-sectional study; related factors; astigmatism; refractive error

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Introduction

Uncorrected refractive errors have the potential to lead to disability, which reduces productivity and affects an individual's economic income and quality of life. In many regions, economic, health care, and sociocultural differences are the most important factors limiting the correction of refractive errors (1). China has a high prevalence of myopia among children and adolescents. Epidemiological study has found that the prevalence of myopia is about 3.9% for first-grade students in primary schools and 67.3% for first-grade students in junior high schools (2). From 1990 to 2019, with the increase in the prevalence of myopia in children and adolescents, uncorrected refractive error has become an important cause of visual impairment in China. In addition, high myopia can cause many fundus complications, endanger visual health and even lead to blindness. High myopia-related retinopathy has become the first cause of irreversible blindness in adults in some areas of China Therefore, myopia not only affects the vision and quality of life of patients, but also brings a heavy burden to the public health work of the whole society. In 2018, 8 ministries including the Ministry of Education and the National Health Commission jointly issued the "Implementation Plan for Comprehensive Prevention and Control of myopia among children and adolescents", upgrading myopia prevention and control to a national strategic level (2,3).

Research shows that the prevalence of myopia and high myopia varies across regions and ethnic groups, and uncertainty remains about the rise in myopia prevalence. Regarding whether the prevalence of refractive error and myopia of ethnic minorities in China is different from that of the Han ethnic group, the research results in different regions are not the same. An analysis of 1,150 patients with refractive errors in Zhuang ethnic group has reported that myopia is more than hyperopia (4). Another survey conducted in Xinjiang also confirms the difference in the prevalence of myopia and hyperopia among ethnic minorities (5). The investigation carried out in Hainan (6) and 13 provinces in China (7) is consistent with the findings of the above study. It is believed that the prevalence of myopia and refractive errors in ethnic minorities in some areas of China is different from that of the Han ethnic group. However, some studies carried out in Guangxi, Yunnan, and Chongqing provinces in recent years believe that there is no significant difference in the prevalence of myopia between ethnic minorities and the Han ethnic group (8-10). Further analysis has identified related factors that cause the difference in the prevalence of myopia and refractive error between ethnic minorities and Han nationalities. Therefore, this study used a cross-sectional study to investigate the visual acuity and refractive factors of adolescents in the Ledong and Wanning areas of Hainan Province, so as to provide a certain basis for local myopia prevention and control. We present the following article in accordance with the STROBE reporting checklist (available at https://tp.amegroups.com/article/view/10.21037/tp-23-130/rc).

Highlight box

Key findings

- The prevalence of myopia in Han and Li nationalities was significantly different in different age groups from 6 to 15 years old.

What is known and what is new?

- The prevalence of myopia among children and adolescents in China is increasing year by year, and the age of onset is gradually changing to a younger age and a higher rate of progression.
- The prevalence of myopia in minority areas of Hainan is also on the rise, and the prevalence of myopia and the biological parameters of the eye in the Li ethnic group are significantly different from those in the Han ethnic group.

What is the implication, and what should change now?

- The focus of Hainan visual health care should be shifted to the lower grades of primary schools, focusing on testing the visual acuity of children and adolescents aged 6–9 years and giving reasonable intervention.

Methods

Areas and objects

Cluster sampling included children and adolescents in 2 nine-year consistent schools in the Wanning and Ledong areas of Hainan Province in 2019, with a total of 4,197 students, 3,969 valid data (1,245 in the Han ethnic group and 2,724 in the Li ethnic group), and a response rate of 94.56%. Grouped by age, 1,196 cases were 6–9 years old, 1,466 cases were 10–12 years old, and 1,307 cases were 13–15 years old. There were 1,986 boys and 1,983 girls, whereas 1,371 cases in the Wanning and 2,598 cases in the Ledong.

Inspection method

All participants received eyesight test, slit lamp, computer

optometry under ciliary paralysis (TOPCON, RM800), direct ophthalmoscopy, and LenstarLS900 (Haag-StreitAG, Koeniz, Switzerland) for ocular biological parameters. Those with ocular genetic diseases, history of ocular trauma and ocular surgery, corneal disease, and fundus disease were excluded. All inspectors received unified training and are skilled in inspection methods, instrument operation and inspection process. All examinations obtained the informed consent of participants' parents. This study was approved by institutional ethics board of Hainan Eye Hospital (HEH Ethical Approval 2015-003). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Eyeball biological examination

Corneal curvature radius (CR), axial length (AL), and central corneal thickness (CCT) were measured by LenstarLS900 biometric instrument. During the examination, the subject is asked to look directly at the fixation point in the inspection probe. All eyeball parameter measurements can be completed in one measurement, and the measurement is performed 5 times, and the average value is recorded.

Examination of visual acuity

All subjects were required not to wear contact lenses and spectacles, and the visual acuity was measured under normal pupils. Visual acuity was checked using the International Standard Logarithmic Visual Scale. In the 2021 expert consensus on the prevention and treatment of amblyopia in children in China, the lower limit of normal vision for children aged 3 to 5 years is 0.5, and 0.7 for children aged 6 and above (11). Poor vision is defined as poor vision in one of both eyes.

Examination of refraction

Use 1% cyclopentolate hydrochloride eye drops for cycloplegia with 2 drops 20 minutes apart and wait 1 hour to start the optometry. Computer optometry after cycloplegia was conducted to minimize the impact of eye adjustment and the refractive data on the recording panel were averaged after three measurements. Combined with the 7th edition of "Ophthalmology" diagnostic criteria, the spherical equivalent (SE = spherical lens degree + 1/2 mean of cylinder diopter) is the judgment for refractions. Emphasis: $-0.50\ D < SE \leq 0.50\ D$ and the absolute value of the cylinder diopter is less than 0.75 D; Myopia: $SE \leq -0.50\ D$; mild myopia: $-3.00\ D < SE \leq -0.50\ D$; moderate myopia: $-6.00\ D < SE \leq -3.00\ D$; high myopia: $SE \leq -6.00\ D$; hyperopia: $0.50\ D < SE$. The absolute value of the cylinder diopter is ≥0.75 D, and the uncorrected visual acuity is lower than the lower limit of the normal age for astigmatism.

Statistical methods

The optometry data were analyzed by SPSS25.0 software. Chi-square test was used for comparing enumeration data, *t*-test was for measurement data, row and column chi-square tests were for the prevalences among multiple groups, and stratified chi-square tests were for the prevalences of poor vision, myopia, and astigmatism, as well as the relative risk, and independent samples *t*-test was for eye biological parameters. $P<0.05$ was statistically significant.

Results

Analysis of myopia prevalence and influencing factors

The overall myopia prevalence in this study was 22.35%. The myopia prevalences were 27.69% for girls and 17.02% for boys; 5.43%, 21.69%, and 38.56% for 6–9, 10–12, and 13–15 years old, respectively; 30.84% for Han and 18.47% for Li; 30.71% for Wanning and 17.94% for Ledong. The ANOVA results showed that the myopia prevalences were statistically different among gender, ages, ethnics and areas. The detailed information is presented in *Table 1*.

Factors that were statistically different in the single factor comparison were analyzed by including gender, ethnicity, and region as independent variables and age group segment as dummy variables in the multi-factor logistic regression equation, and the values assigned to the factors are shown in *Table 2*.

As shown in *Table 3*, the effect of gender on myopia was statistically significant, and the risk of myopia was nearly 1.336 times higher in girls than in boys. The effect of age on myopia was statistically significant, with a 3.740 times higher risk of myopia in the 10–12 years old group compared with the 6–9 years old group, and a 10.38 times higher risk of myopia in the 13–15 years old group compared with the 6–9 years old group. The effect of ethnicity on myopia was statistically significant, and the risk of myopia was nearly 0.530 times higher in the Han group compared with the Li group. The effect of region on myopia was statistically significant, and the risk of myopia

Table 1 Differences in prevalences of myopia among the influencing factors

Variables	Myopia		Non-myopia		χ^2	P
	Number	Prevalences (%)	Number	Prevalences (%)		
Gender					65.050	<0.001
Male	338	17.02	1,648	82.98		
Female	549	27.69	1,434	72.31		
Age					395.499	<0.001
6–9 years old	65	5.43	1,131	94.57		
10–12 years old	318	21.69	1,148	78.31		
13–15 years old	504	38.56	803	61.44		
Ethnic					75.439	<0.001
Han	384	30.84	861	69.16		
Li	503	18.47	2,221	81.53		
Area					84.339	<0.001
Wanning	421	30.71	950	69.29		
Ledong	466	17.94	2,132	82.06		
Total	887	22.35	3,082	77.65		

Table 2 Assignment of values to variables in logistics regression analysis

Variables	Value
Myopia or not	
Not	0
Myopia	1
Age	
6–9 years old	1
10–12 years old	2
13–15 years old	3
Gender	
Male	1
Female	2
Ethnic	
Li	1
Han	2
Area	
Ledong	1
Wanning	2

in children and adolescents in Wanning region was nearly 0.507 times higher than that in Ledong region.

As shown in *Table 4*, there were statistical differences in the distribution of refractive status by gender, age group, ethnicity, and region, but not by laterality of eye.

Comparison of visual acuity, refractive status, and biological parameters in different age groups

The prevalences of myopia in the Li ethnic group in the 6–9 years old group, 10–12 years old group, and 13–15 years old group were 3.4%, 16.6%, 36.4%, respectively, and 11.1%, 32.6%, 42.6 %, respectively in the Han ethnic group, showing significant differences (χ^2/t=26.809, P<0.001; χ^2/t=48.045, P<0.001; χ^2/t=4.907, P<0.05). The prevalences of astigmatism in the Li ethnic group in the 6–9 years old group, the 10–12 years old group, and the 13–15 years old group were 19.1%, 15.3%, and 20.9%, respectively, and 31.1%, 33.4%, and 41.1%, respectively in the Han ethnic group, showing significant differences (χ^2/t=19.455, P<0.001; χ^2/t=63.187, P<0.001; χ^2/t=60.270, P<0.001). The prevalences of poor visual acuity in the Li ethnic group in the 6–9 years old group, 10–12 years old

Table 3 Multifactorial logistic regression analysis of factors influencing myopia

Variables	β	S.E.	Wald χ^2	P	OR (95% CI)
Age					
6–9 years old	–	–	–	–	–
10–12 years old	1.556	0.144	116.408	<0.001	4.740 (3.573–6.288)
13–15 years old	2.432	0.142	292.544	<0.001	11.381 (8.613–15.039)
Gender					
Male	–	–	–	–	–
Female	0.848	0.085	99.181	<0.001	2.336 (1.977–2.760)
Ethnic					
Li	–	–	–	–	–
Han	0.425	0.116	13.378	<0.001	1.530 (1.218–1.922)
Area					
Ledong	–	–	–	–	–
Wanning	0.410	0.115	12.799	<0.001	1.507 (1.204–1.888)

"–" represents the constant term. S.E., standard error; OR, odds ratio; CI, confidence interval.

Table 4 Differences in the distribution of refractive status among the influencing factors

Variables	Hyperopia, n (%)	Emmetropia, n (%)	Moderate myopia, n (%)	Mild myopia, n (%)	High myopia, n (%)	χ^2	P
Gender						121.234	<0.001
Male	41 (1.03)	3,349 (84.32)	422 (10.62)	138 (3.47)	22 (0.55)		
Female	57 (1.44)	2,950 (74.38)	709 (17.88)	223 (5.62)	27 (0.68)		
Age						790.964	<0.001
6–9 years old	70 (2.93)	2,217 (92.68)	92 (3.85)	10 (0.42)	3 (0.13)		
10–12 years old	20 (0.68)	2,366 (80.69)	426 (14.53)	110 (3.75)	10 (0.34)		
13–15 years old	8 (0.31)	1,716 (65.65)	613 (23.45)	241 (9.22)	36 (1.38)		
Ethnic						168.741	<0.001
Han	45 (1.81)	1,780 (71.49)	443 (17.79)	196 (7.87)	26 (1.04)		
Li	53 (0.97)	4,519 (82.95)	688 (12.63)	165 (3.03)	23 (0.42)		
Area						177.929	<0.001
Wanning	44 (1.60)	1,977 (72.10)	475 (17.32)	218 (7.95)	28 (1.02)		
Ledong	54 (1.04)	4,322 (83.18)	656 (12.63)	143 (2.75)	21 (0.40)		
Laterality						4.492	0.344
OD	50 (1.26)	3,115 (78.48)	585 (14.74)	195 (4.91)	24 (0.60)		
OS	48 (1.21)	3,184 (80.22)	546 (13.76)	166 (4.18)	25 (0.63)		
Total	98 (1.23)	6,299 (79.35)	1,131 (14.25)	361 (4.55)	49 (0.62)		

OD, oculus dexter; OS, oculus sinister.

Table 5 Comparison of the prevalence of refractive error between Han and Li in three age groups

Age	Ethnic	Myopia		Astigmatism		Poor vision	
		N (%)	95% CI	N (%)	95% CI	N (%)	95% CI
6–9 years old	Han	35 (11.1)	7.6–14.6	98 (31.1)	26.0–36.3	79 (25.1)	20.3–29.9
	Li	30 (3.4)	2.2–4.6	168 (19.1)	16.5–21.7	171 (19.4)	16.8–22.0
	χ^2	26.809		19.455		4.511	
	P	<0.001		<0.001		<0.05	
10–12 years old	Han	153 (32.6)	28.3–36.8	470 (33.4)	29.1–37.7	193 (41.1)	36.6–45.5
	Li	165 (16.6)	14.3–18.9	996 (15.3)	13.0–17.5	231 (23.2)	29.7–36.7
	χ^2	48.045		63.187		49.609	
	P	<0.001		<0.001		<0.001	
13–15 years old	Han	196 (42.6)	38.1–47.1	460 (41.1)	36.6–45.6	235 (51.1)	46.5–55.7
	Li	308 (36.4)	33.1–39.6	847 (20.9)	18.2–23.6	361 (42.6)	39.3–46.0
	χ^2	4.907		60.270		8.613	
	P	<0.05		<0.001		<0.05	

CI, confidence interval.

group, and 13–15 years old group were 19.4%, 23.2%, 42.6%, respectively, and 25.1%, 41.1%, 51.1%, respectively for the Han ethnic group, with significant differences (χ^2/t=4.511, P<0.05; χ^2/t=49.609, P<0.001; χ^2/t=8.613, P<0.05). In the 6–9, 10–12, and 13–15 years old groups, the prevalence of myopia in the Han ethnic group was 3.26 times, 1.97 times, and 1.17 times that of the Li ethnic group, respectively (OR =3.26, P<0.05; OR =1.97, P<0.05; OR =1.17, P<0.05), that of astigmatism of the Han ethnic group was 1.63 times, 2.19 times, and 1.97 times that of the Li ethnic group, respectively (OR =1.63, P<0.05; OR =2.19, P<0.05; OR =1.97, P<0.05), and that of poor vision of the Han ethnic group was 1.29 times, 1.77 times, and 1.20 times that of the Li ethnic group, respectively (OR =1.29, P<0.05; OR =1.77, P<0.05; OR =1.20, P<0.05). The eyeball biological parameters were further compared. The AL of the Han ethnic group was longer than that of the Li ethnic group among the three groups, and there was a statistically significant difference in the AL in the 10–12 years old and the 13–15 years old groups (χ^2/t=4.911, P<0.001; χ^2/t=2.472, P<0.05), in the CR values between the 6–9 and 10–12 years old groups (χ^2/t=2.597, P<0.05; χ^2/t=–2.101, P<0.05), and in the AL/CR in the 10–12 years old group (χ^2/t=4.789, P<0.001). CCT among the three groups was not different (all P>0.01). The detailed information is presented in *Tables 5*,*6* and *Figure 1*.

Comparison of visual acuity, refractive status, and biological parameters in different gender groups

In boys and girls, the prevalences of myopia in the Li ethnic group were 12.3% and 24.2%, respectively, while those of the Han ethnic group were 26.1% and 36.6%, respectively. The prevalences of astigmatism in the Li ethnic group were 15.5% and 20.8% whereas 35.3% and 36.1% in the Han ethnic group. The prevalences of poor vision in the Li ethnic group were 19.4%, 35.9%, while 32.7% and 50.4% in the Han ethnic group. The prevalences of myopia, astigmatism, and poor vision between the two ethnic group groups in boys were significantly different (χ^2/t=60.645, P<0.001; χ^2/t=101.774, P<0.001; χ^2/t=0.036, P<0.001), as well as in girls (χ^2/t=31.137, P<0.001; χ^2/t=50.065, P<0.001; χ^2/t=7.183, P<0.001). The prevalence of myopia in the Han ethnic group in boys was 2.13 times that of the Li ethnic group, and it was 1.52 times in girls (OR =2.13, P<0.05; OR =1.52, P<0.05). The prevalence of astigmatism in the Han ethnic group in boys was 2.28 times that of the Li ethnic group, and that in girls was 1.74 times (OR =2.28, P<0.05; OR =1.74, P<0.05). The prevalence of poor vision in the Han ethnic group in boys was 1.69 times that of the Li ethnic group, and 1.41 times in girls (OR =1.69, P<0.05; OR =1.41, P<0.05). As *Tables 6*,7 indicated, the difference in AL between boys and girls in the two nationalities was significant (χ^2/t=3.776, P<0.001; χ^2/t=4.911, P<0.001); Han

Table 6 Differences in eyeball biological examination between Han and Li of different ages

Age	Ethnic (number)	AL (mm)	CR (mm)	AL/CR	CCT (μm)
6–9 years old	Han (n=315)	22.963±0.735	7.502±0.390	3.070±0.177	547.691±32.142
	Li (n=881)	22.879±0.697	7.436±0.386	3.086±0.171	545.883±32.119
	t	1.819	2.597	–1.465	0.857
	P	0.069	<0.05	0.143	0.391
10–12 years old	Han (n=470)	23.633±0.963	7.436±0.400	3.187±0.206	543.447±32.031
	Li (n=996)	23.404±0.766	7.483±0.401	3.136±0.181	542.721±30.578
	t	4.911	–2.101	4.789	0.418
	P	<0.001	<0.05	<0.001	0.676
13–15 years old	Han (n=460)	23.898±1.375	7.494±0.400	3.195±0.258	540.880±31.291
	Li (n=847)	23.742±0.904	7.476±0.406	3.185±0.192	541.208±30.616
	t	2.472	0.770	0.777	–0.183
	P	<0.05	0.442	0.437	0.855

Measurements of biological examination are presented as mean ± standard deviation. AL, axial length; CR, corneal radius; CCT, central corneal thickness.

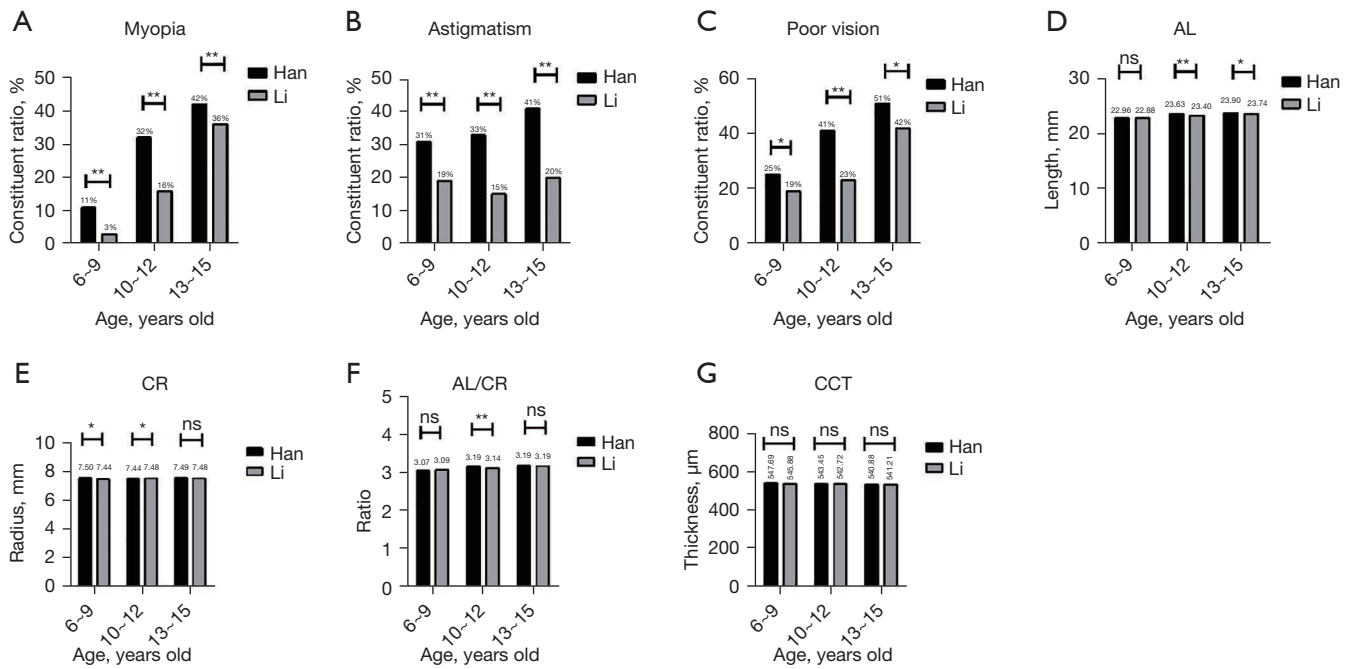

Figure 1 Age-related differences in visual acuity, refractive status, and biological parameters of eyeball. Prevalence of myopia (A), astigmatism (B), poor vision (C), AL (D), CR (E), AL/CR (F), and CCT (G) between Han and Li nationalities in each age group. Measurement data are expressed as mean standard deviation. *, P<0.05; **, P<0.001; ns, no statistical difference between the two groups. AL, axial length; CR, corneal radius; CCT, central corneal thickness.

Table 7 Comparison of the prevalence of refractive error between Han and Li in two gender groups

Gender	Ethnic	Myopia		Astigmatism		Poor vision	
		N (%)	95% CI	N (%)	95% CI	N (%)	95% CI
Male	Han	178 (26.1)	22.8–29.4	241 (35.3)	31.7–38.9	223 (32.7)	29.2–36.2
	Li	160 (12.3)	10.5–14.1	202 (15.5)	13.5–17.5	253 (19.4)	17.3–21.6
	χ^2	60.645		101.774		43.442	
	P	<0.001		<0.001		<0.001	
Female	Han	206 (36.6)	32.6–40.6	203 (36.1)	32.1–40.0	284 (50.4)	46.3–54.6
	Li	343 (24.2)	21.9–26.4	295 (20.8)	18.7–22.9	510 (35.9)	33.4–38.4
	χ^2	31.137		50.065		35.446	
	P	<0.001		<0.001		<0.001	

CI, confidence interval.

Table 8 Differences in eyeball biological examination between Han and Li of different gender

Gender	Ethnic (number)	AL (mm)	CR (mm)	AL/CR	CCT (μm)
Male	Han (n=682)	23.708±1.236	7.500±0.426	3.169±0.248	545.533±31.715
	Li (n=1,304)	23.535±0.798	7.519±0.429	3.140±0.194	544.990±31.896
	t	3.776	–0.999	2.901	0.361
	P	<0.001	0.318	<0.05	0.718
Female	Han (n=563)	23.384±1.004	7.443±0.360	3.149±0.197	541.198±31.928
	Li (n=1,420)	23.159±0.882	7.416±0.361	3.130±0.177	541.697±30.362
	t	4.911	1.522	1.995	–0.325
	P	<0.001	0.128	<0.05	0.745

Measurements of biological examination are presented as mean ± standard deviation. AL, axial length; CR, corneal radius; CCT, central corneal thickness.

AL/CR was higher than Li AL/CR (χ^2/t=2.901, P<0.05; χ^2/t=1.995, P<0.05), but CR and CCT had no difference. *Tables 7*,*8* and *Figure 2* show the myopia classification of boys and girls of two ethnic groups.

Comparison of visual acuity, refractive status, and biological parameters in different areas groups

In the Wanning and Ledong areas, the prevalences of myopia were 30.5% and 16.8% in the Li ethnic group and 30.8% and 31.1% in the Han ethnic group; those of astigmatism in the Li ethnic group were 29.9% and 16.6%, and 37.2% and 28.3% in the Han ethnic group; those of poor visual acuity in the Li ethnic group were 42.6% and 25.9% and were 42% and 34.4% in the Han ethnic group. In the Wanning area, only the prevalence of astigmatism between the two ethnic groups was significant (χ^2/t=5.923, P<0.05), while in the Ledong area, myopia, astigmatism, and poor vision were all significantly different between Li and Han nationalities (χ^2/t=27.305, P<0.001; χ^2/t=18.434, P<0.001; χ^2/t=7.183, P<0.05). In the Wanning area, the prevalence of myopia and poor vision between the two ethnic groups had no difference, but that of astigmatism in the Han ethnic group was 1.24 times that of the Li ethnic group (OR =1.24, P<0.05). In the Ledong area, the prevalences of myopia, astigmatism, and poor vision in the Han ethnic group were 1.86 times (OR =1.86, P<0.05), 1.71 times (OR =1.71, P<0.05), and 1.33 times (OR =1.33, P<0.05) those of the Li ethnic group. The eyeball biological parameters were further compared, as shown in the table below. Only

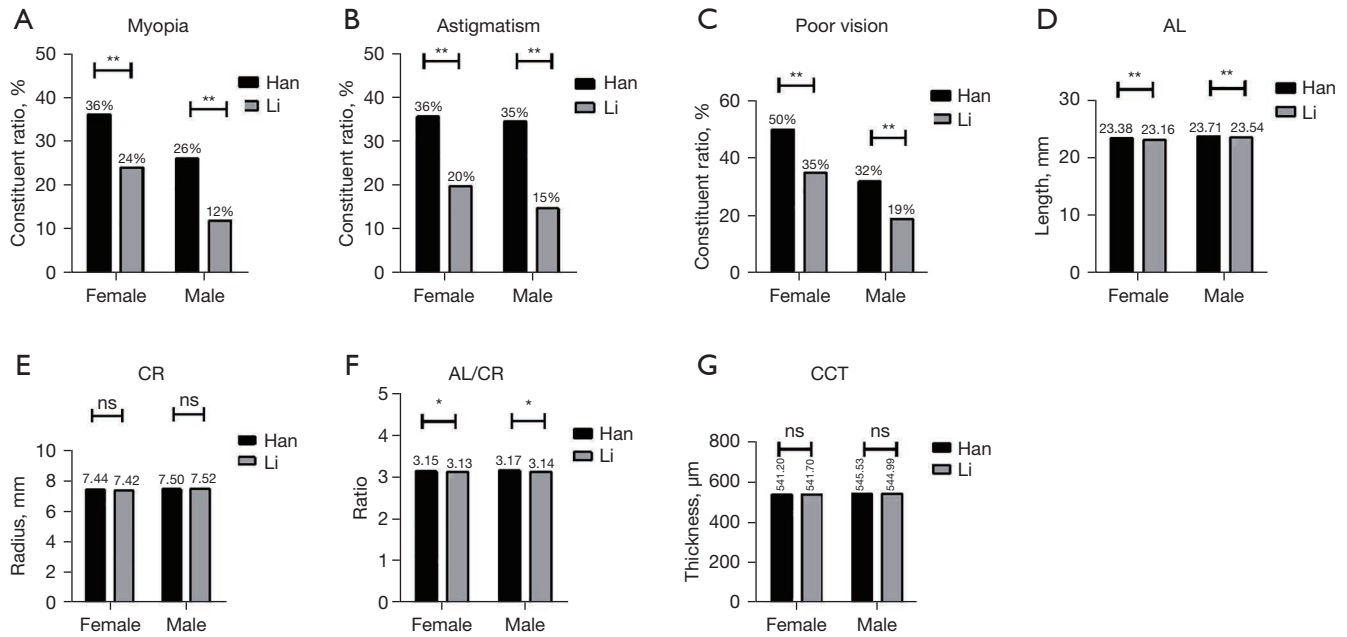

Figure 2 Gender-related differences in visual acuity, refractive status, and biological parameters of eyeball. Prevalence of myopia (A), astigmatism (B), poor vision (C), AL (D), CR (E), AL/CR (F), and CCT (G) between Han and Li nationalities in boys and girls. Measurement data are expressed as mean standard deviation. *, P<0.05; **, P<0.001; ns, no statistical difference between the two groups. AL, axial length; CR, corneal radius; CCT, central corneal thickness.

a statistically significant difference existed between the two ethnic groups in the Ledong area in terms of AL (χ^2/t=2.858, P<0.05). AL, CR, AL/CR, and CCT were not statistically different in the Wanning areas between Han and Li nationalities. In the Ledong area, the numbers of mild, moderate, and high myopia in the Li ethnic group were lower than that of the Han ethnic group. *Tables 9,10* and *Figure 3* show the myopia classification of Wanning and Ledong areas of two ethnic groups.

Some shortcomings of the study data

Due to the loss of machine measurement, the data missing rate of some eyeball biological parameters such as lens thickness and anterior chamber depth was high, and subsequent analysis could not be conducted.

Discussion

The prevalence of myopia among primary and secondary school students in China is increasing year by year, and myopia has become an urgent public health problem. In a study on community primary school students in Shanghai in 2019, the prevalence of myopia in community primary school students aged 6–10 is 45.59% (12). In a study of primary school students in Guangzhou in 2021, the overall poor vision rate was 49.04% (13). In this survey, the prevalence of myopia in the Han and Li nationalities in the two regions, genders, and age groups was lower than in developed cities in China. Compared with the research carried out in Sanya in 2014 (11.92% in the first grade and 36.46% in the sixth grade) (14), the prevalence of myopia in Han children and adolescents is increasing year by year. Compared with the study carried out in Wuzhishan (6), the prevalence of myopia in the Li ethnic group is also on the rise.

The results of the 2014 China Student Physical Fitness and Health Survey showed that the prevalence of poor vision among primary school students aged 7–12, middle school students aged 13–15, high school students aged 16–18, and college students aged 19–22 were 45.71%, 74.36%, 83.28%, and 86.36%, respectively. The prevalence of myopia among students at all study levels continued to rise, showing an increasing trend with age (15). Further research on the biological parameters of the eyeball showed that there was no significant difference in AL between the Han

Table 9 Comparison of the prevalence of refractive error between Han and Li in two areas

Area	Ethnic	Myopia		Astigmatism		Poor vision	
		N (%)	95% CI	N (%)	95% CI	N (%)	95% CI
Ledong	Han	66 (31.1)	24.8–37.4	60 (28.3)	22.2–34.4	73 (34.4)	28.0–40.9
	Li	400 (16.8)	15.3–18.3	396 (16.6)	15.1–18.1	619 (25.9)	24.2–27.7
	χ^2	27.305		18.434		7.183	
	P	<0.001		<0.001		<0.05	
Wanning	Han	318 (30.8)	28.0–33.6	384 (37.2)	34.2–40.1	434 (42.00)	39.0–45.0
	Li	103 (30.5)	25.5–35.4	101 (29.9)	25.0–34.8	144 (42.60)	37.3–47.9
	χ^2	0.012		5.923		0.036	
	P	0.914		<0.05		0.849	

CI, confidence interval.

Table 10 Differences in eyeball biological examination between Han and Li of different area

Area	Ethnic (number)	AL (mm)	CR (mm)	AL/CR	CCT (μm)
Ledong	Han (n=212)	23.476±0.904	7.477±0.402	3.148±0.203	544.700±29.096
	Li (n=2,386)	23.300±0.852	7.462±0.394	3.131±0.184	543.296±31.207
	t	2.858	0.545	1.224	0.631
	P	<0.05	0.586	0.221	0.528
Wanning	Han (n=1,033)	23.579±1.191	7.473±0.397	3.163±0.231	543.341±32.421
	Li (n=338)	23.613±0.896	7.492±0.424	3.161±0.195	543.114±30.734
	t	–0.484	–0.721	0.138	0.114
	P	0.629	0.471	0.890	0.91

Measurements of biological examination are presented as mean ± standard deviation. AL, axial length; CR, corneal radius; CCT, central corneal thickness.

and Li in the 6–9 years old group, but there was a significant difference in the 10–12 years old and 13–15 years old groups. Before puberty, the most important factors affecting refractive status are AL and corneal refractive power (16). It has also been discussed that AL/CR is more correlated with myopia compared with other ocular biological parameters, and a higher AL/CR ratio leads to a greater prevalence of myopia in children and adolescents (17). In this study, it could be seen that AL/CR only differed in the middle-aged 10–12 years old group, which was consistent with the above-mentioned axial changes. Due to genetic factors, living environment, and dietary habits, the Li ethnic group was born with a shorter axis length than the Han, and myopia increased more slowly than the Han. As they grow older and spend more time in education and using their eyes, the axis length of Han Chinese increases faster than that of Li Chinese. In the Ledong area, the axis length of Han was longer than that of the local Li, but the axis length of the two ethnic groups in the Wanning area converged, while the axis length of the Li in the Wanning area was also longer than that of the Li in the Ledong area. This may be related to the impact of population migration on the lifestyles of ethnic minorities in the two areas. The percentage of ethnic minority population in Wanning area decreased from 16.05% in the sixth census to 15.52% in the seventh census, while the percentage of ethnic minority population in Ledong area increased from 38.59% in the sixth census to 38.86% in the seventh census. As a result, the living habits of the Li in Wanning are becoming more and more "Han", while the Ledong area has been a

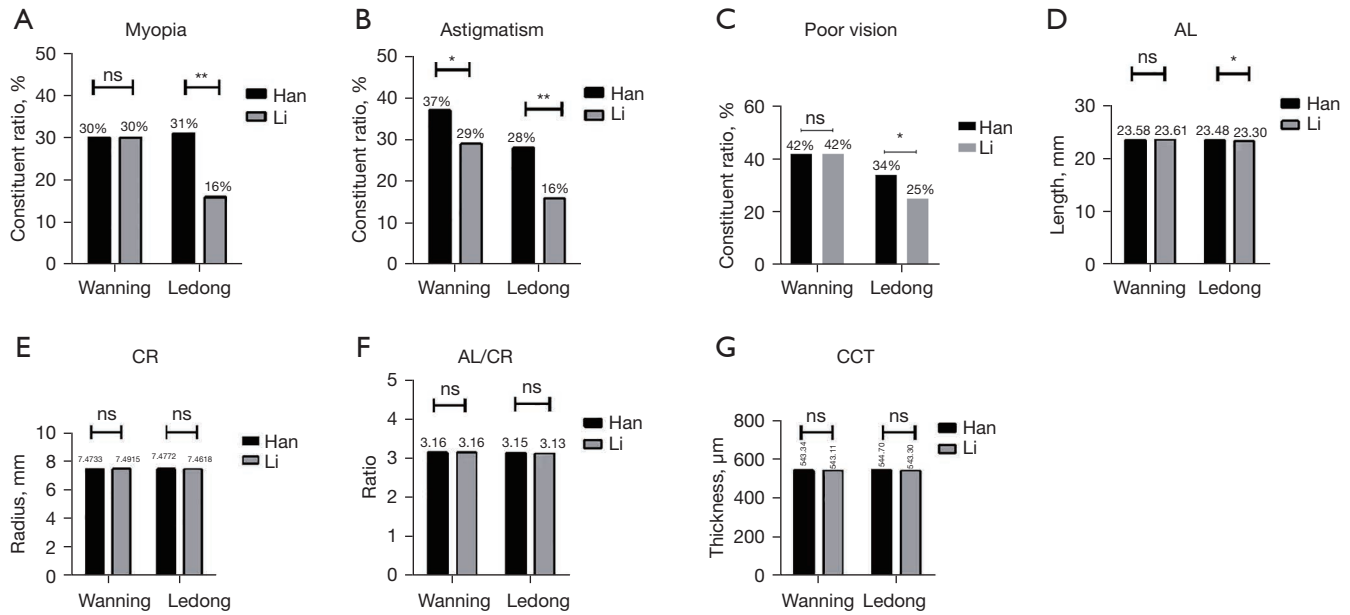

Figure 3 Location-related differences in visual acuity, refractive status, and biological parameters of eyeball. Prevalence of myopia (A), astigmatism (B), poor vision (C), AL (D), CR (E), AL/CR (F), and CCT (G) between Han and Li nationalities in the Wanning and Ledong areas. Measurement data are expressed as mean standard deviation. *, P<0.05; **, P<0.001; ns, no statistical difference between the two groups. AL, axial length; CR, corneal radius; CCT, central corneal thickness.

minority area since ancient times, with a more conservative lifestyle and a more traditional Li diet, with less protein and iron intake, and slower physical development than the Han, so the eye development of Li children and youth is also slower than that of the Han (18).

We found that the prevalences of myopia, astigmatism and poor vision of girls were higher than those of boys. This is the same as the findings of the myopia status of primary and secondary school students conducted in southern and northern China, where girls are a risk factor for myopia, which may be related to earlier development of girls than boys and the level of sex hormones in girls' bodies (19,20). At the same time, compared to boys, girls study harder, are more sedentary and less active, and participate in fewer outdoor activities, which, according to some studies, significantly increases the risk of myopia (21,22). From the perspective of biological parameters of eyeball, the AL and AL/CR of Han boys and girls are higher than those of Li boys and girls, and the AL/CR ratio of Han girls is higher than that of Li boys, which may indicate that the eyes of Han girls are longer, and the corneal refractive power is more significantly affected by the external environment. Two studies conducted in Xinjiang and Tibet had the same results, with significant ethnic disparities in ocular biological indicators, Han Chinese had longer AL and larger AL/CR values compared to local ethnic minorities (23,24).

In the comparison of the two groups, it was found that there were differences in the prevalences of myopia, astigmatism and poor vision between the two ethnic groups in the Ledong area, but the prevalences of the two ethnic groups in the Wanning area were similar. The comparison of eyeball biological parameters also found that only the eye axis data of Han and Li ethnic groups in the Ledong area were different. With the same latitude, the two areas are located in the southeast and southwest of Hainan Island, respectively, showing differences in environmental factors such as greening, light time and climate. The reason for the obvious difference between the Li ethnic group in the two areas may be related to the fact that Ledong area has been a minority-inhabited area since ancient times, eating more foods rich in vitamins. The educational and economic level of the Wanning area is better than that of the Ledong area, the time of students learning and using electronic equipment is longer than that of the Ledong, and the time of outdoor activities is less. In some studies, the prevalence of myopia in adolescents with more outdoor activities is

lower than that in those with only indoor activities, and fewer outdoor activities (22,25). Some studies have also shown that environmental risk factors, especially longer periods of near-work, have a significant impact on the prevalence of myopia (26,27). Epidemiological surveys show that the prevalence of myopia among students from economically underdeveloped areas and rural areas is lower than that of students from economically developed areas and cities (28,29).

This study showed no significant difference in the CCT among the groups, but the cornea was thicker than that of Xinjiang Uygur and African and Dutch people (30,31). Whether it is explained that the influence of environmental factors such as the same latitude, altitude, and sunshine intensity will have the same impact on the CCT of different ethnic groups remains to be further studied.

In this study, autorefraction was performed under cycloplegic, but eyesight test were taken before ciliary paralysis, and the lack of cycloplegia overestimates myopia, which may have contributed to the higher rate of poor vision than myopia in this study (32).

There are still some shortcomings in this study. First, this study adopted a convenience sampling method, and the examinees were only from two schools, which may have a selection bias and cannot fully represent the characteristics of the two regions, and the follow-up study needs to expand the locations of the selected samples to obtain more accurate data. Second, the Lenstar LS900 measuring instrument was used to measure the ocular biological parameters in this study, which requires a high degree of eye fixation and a certain amount of time to remain stationary during the examination, but some of the examinees were younger and less cooperative, resulting in some data not being measured and a certain amount of measurement error, and the follow-up study could be changed to a faster measuring instrument to reduce the discomfort of the child examinees. Thirdly, when risk factors were studied, no questionnaires were administered on the relevant factors, which did not explain well the differences in the degree and progression of myopia. A follow-up questionnaire could be used to collect information including: parents' myopia or not, students' daily time of using electronic devices, daily time of outdoor activities, and whether they rub their eyes frequently. Finally, this study, as a cross-sectional study, has limitations compared to longitudinal studies and only characterizes the study population; a cohort study is needed to determine the corresponding changes in refraction and anatomy of the eye as the biological parameters of the eye change.

Conclusions

Results of this survey demonstrated that the prevalence of refractive error among ethnic minority adolescents in the Wanning and Ledong areas of Hainan is less than that among local Han adolescents, and the degree of myopia is lighter. However, the age of onset has a tendency to gradually shift to younger age and higher progression rate. Therefore, the focus of local visual health care should be shifted to the lower grades of primary schools, focusing on testing the visual acuity of children and adolescents aged 6–9 years and giving reasonable intervention, such as reducing the burden of students' learning, widely developing, popularizing and enhancing the knowledge of myopia prevention, increasing the time for outdoor activities, etc. For ethnic minority students, especially girls, health education should also be strengthened to prevent the occurrence of myopia and delay the progress of myopia.

Due to the limited medical conditions in Ledong and Wanning, the focus of myopia prevention and control for children in these two areas should be primary prevention. The school should strengthen the propaganda and education on myopia prevention and control, and the school, parents and students should cooperate to urge students to develop good eye habits. Medical institutions involved in myopia prevention and control should also pay attention to collecting data on the biological parameters of the eyes of local children during screenings, so that they can be kept for a long time to track changes in the biological parameters of the eyes of the subjects. In case of changes in the parameters detected regularly, effective measures can be taken to intervene and avoid further development of myopia.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work, including ensuring that any questions related to the accuracy or integrity of any part of the work have been appropriately investigated and resolved. All examinations obtained the informed consent of participants' parents. This study was approved by institutional ethics board of Hainan Eye Hospital (HEH Ethical Approval 2015-003). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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