A study on the correlation between ocular biometric parameters and myopia in children and adolescents: a large-scale population-based study in Chengdu, China

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Research Article

Keywords: Myopia, Ocular biometric parameters, Lens thickness, Children, Epidemiology

Posted Date: February 13th, 2024

DOI: https://doi.org/10.21203/rs.3.rs-3891426/v1

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Additional Declarations: No competing interests reported.
Abstract

PURPOSE: To investigate the characteristics and correlation of myopia and ocular biometric parameters among students in Chengdu.

DESIGN: This cross-sectional analysis of the Chengdu included students between the ages of 3 and 18 years (n = 509,530).

METHODS: Myopia, defined as spherical equivalent (SE) ≤ -0.50 D and UCVA > 0.3 logMAR for participants aged 3 years, SE ≤ -0.50 D and UCVA > 0.2 logMAR for those aged 4-5 years, SE ≤ -0.50 D and UCVA > 0 logMAR for those aged ≥6 years. All participants received non-cycloplegic autorefraction, uncorrected visual acuity (UCVA) and ocular biometric parameters. Pearson correlation analysis and multiple linear regression model were used to analyze the relationship between ocular biometric parameters and myopia.

RESULTS: The overall prevalence of myopia was 40.9% (95% CI: 40.77-41.04%). SE had strong correlations with axial length (AL), AL/CR ratio, and vitreous chamber depth, moderate correlations with lens thickness (LT) and anterior chamber depth, and weak correlations with keratometry and central corneal thickness (P < 0.001). The slopes of changes in AL and LT were highly consistent between myopic and non-myopic children aged 3-6 years. However, between 6-9 years of age, myopic children exhibited faster AL increase and greater LT thinning than non-myopic children (P < 0.001) with age. After 9 years of age, changes in both AL and LT gradually stabilized.

CONCLUSIONS: In children aged 6-9 years, a rapid increase of AL has occurred and accompanied by compensation from LT to maintain emmetropization, which gradually diminishes after age 9, suggesting that AL and LT are essential indicators for myopia control in children.

Background

Myopia, a commonly encountered refractive error, refers to the state in which parallel light rays from the external environment focus in front of the retina after passing through the ocular refractive system when the eye is in a relaxed state of accommodation. High myopia can lead to complications including retinal fissures and detachments, choroidal neovascularization, and other severe consequences resulting in permanent visual impairment. Myopia and complications of high myopia stand as major causes of visual impairment and blindness.[1]

In recent years, there has been a rapid rise in the prevalence of myopia worldwide, particularly among children and adolescents. Notably, myopia prevalence among this age group in East Asia (60%-73%) surpasses that in North America (42%), Europe (40%), South America and Africa (< 10%), and other economically disadvantaged regions (< 5%).[2, 3] Projected estimates suggest that by 2050, the global prevalence of myopia could reach 50%, affecting nearly 5 billion individuals.[4]

Refractive power is the comprehensive result of various ocular biometric parameters, including axial length (AL), corneal curvature, and lens power (LP).[5] The ocular growth during childhood and adolescence is a dynamic process, where the crystalline lens and cornea play crucial roles in compensating for the gradual elongation of AL to maintain emmetropization.[6] Researchers have shown profound interest in the interrelationships among crystalline lens thickness, lens refractive power, and various refractive status. Compensatory changes in the crystalline lens differ across different refractive conditions. A longitudinal study involving 1504 children aged 6 to 14 in the United States revealed that crystalline lens power in myopes, emmetropes, and emmetropizing hyperopes (EH), and persistent emmetropes (PE) all decreased with age. Simultaneously, crystalline lens thickness exhibited a 'U'-shaped growth pattern with age, reaching its thinnest point at the age of 10. The LP and LT changes in the persistent emmetropes group were lower compared to the other three groups.[7]

In another myopia cohort study conducted in Singapore, participants were classified into newly developed myopes (NDM), persistent myopes (PM), persistent hyperopes (PH), PE, and EH groups. The crystalline lens power (LP) in all five groups decreased with age, showing a significant decline between the ages of 6 to 10, and plateaued after the age of 10. Additionally, the PM group exhibited lower LP compared to the other four groups.[8] Previous studies have established connections between myopia and some ocular biometric parameters.[9–12] Notably, a definite correlation exists between myopia and axial length (AL), keratometry (K), Axial Length/Corneal Radius (AL/CR) Ratio, while the relationship between myopia and other ocular biometric parameters like LT, anterior chamber depth (ACD), and central corneal thickness (CCT) lacks consistent consensus, and research in this area remains relatively limited. The objectives of this study involve analyzing the relationships between myopia and ocular biometric parameters such as LT, ACD, and CCT, providing reference data to develop personalized strategies on prevention and control of myopia for children.

Methods

Setting and study population

From 2020 to 2022, a stratified random sampling method was employed at the school level to select a total of 522,083 students in Chengdu, China. After excluding individuals with incomplete information or those unable to cooperate with the required ophthalmic examinations, a final cohort of 509,530 students was included in the study. Inclusion criteria: (1) students enrolled in schools in Chengdu city (kindergarten, primary, middle, and high school levels); (2) age range of 3 to 18 years. Exclusion criteria: (1) students with amblyopia, strabismus, or severe visual functional impairments; (2) individuals with poor compliance, psychiatric disorders, or cognitive impairments. This study received approval from the Ethics Committee of Chengdu University of Traditional Chinese Medicine ineye Hospital(2019yh-007). All research methods adhered to the principles outlined in the "Declaration of Helsinki". Prior to conducting the study, the objectives and methods were presented to the principals, teachers, and parents of the participating schools to obtain informed consent, and signatures were obtained accordingly. Informed consent to participate in the study was obtained from students parents.

Data collection
With assistance of the Chengdu Education Bureau and Health Bureau, Chengdu University of Traditional Chinese Medicine Ineye Ophthalmology Hospital collected student information in advance. The information included school type, school name, grade, class, name, gender, age, and ID number. An eye health record was established through a system containing all student information along with a unique identification code, which was used to transmit examination results. Prior to the examination, the unique identification code of each student was scanned, then the results were automatically uploaded to the eye health record system.

**Ocular examinations**

All students underwent ocular examinations including uncorrected visual acuity, non-cycloplegic autorefraction, and ocular biometric parameters according to a standard study protocol by trained optometrists or ophthalmologists. Prior to data collection, equipment calibration was performed to ensure the accuracy of measurement. Distance visual acuity was examined using the light-box E-word standard logarithmic visual acuity chart (GB 11533). The results were temporarily recorded on a screening form and later entered into the eye health record system. Following visual acuity, non-cycloplegic autorefraction was examined using an Auto Refractor Keratometer (NIDEK, ARK-1, NIDEK Co., Ltd., Japan). Ocular biometric measurements for AL, K, CCT, ACD, LT, and VCD were measured using SUOER Ocular Biometric Measurement Instrument (SW-9000, Tianjin Siswe Electronic Technology Co., Ltd., China). Each eye was measured three times, and the average value of the measurements was recorded as the result.

**Assessment criteria**

The prevalence of refractive errors was determined using spherical equivalent (SE) based on non-cycloplegic autorefraction and uncorrected visual acuity (UCVA) values.[13] The following definitions and classifications were employed: (1) Myopia was defined as non-cycloplegic SE \(-0.50 \text{D} \leq \text{UCVA} > 0.3 \text{log MAR}\) (age 3), > 0.2 log MAR (ages 4–5), > 0 log MAR (age ≥ 6).\[14, 15\] (2) Myopia was categorized into low myopia (\(-3.00 \text{D} < \text{SE} \leq -0.50 \text{D}\), moderate myopia (\(-6.00 \text{D} < \text{SE} \leq -3.00 \text{D}\), and high myopia (\(\text{SE} \leq -6.00 \text{D}\)).

**Statistical analysis**

Data were analyzed using SPSS software (version 26.0, Chicago, IL, USA). Descriptive statistics were presented as means ± standard deviations for continuous variables. For comparisons between two groups, independent samples t-tests were used, and for comparisons involving multiple groups, one-way analysis of variance (ANOVA) was employed. Categorical data were expressed as n (%) and comparisons of ordinal data among multiple groups were performed using the Kruskal-Wallis H test. Pearson correlation and multiple linear regression models were used for examining correlations. The significance level was set at \(\alpha = 0.05\). Given the high correlation (\(r = 0.88\)) between right and left eyes for SE, only the data of right eyes were presented.

**Role of funding source**

The funding source had no role in study design or conduct of the study, including data collection, management, analysis, or interpretation of the results, preparation, review, or approval of the manuscript.

**Results**

**Characteristics of participants**

Among the initial pool of 522,083 eligible students, 12,553 were excluded due to incomplete data. Ultimately, completed measurements including UCVA, non-cycloplegic autorefraction, and ocular biometric parameters were obtained for a total of 509,530 students aged 3 to 18 years from 1,582 schools (108,658 children from 666 kindergartens, 231,729 from 506 primary schools, 99,300 from 274 middle schools, 69,843 from 136 high schools). Among them, 263,665 (51.7%) were male and 245,865 (48.3%) were female. The sample size in each 1-year age group ranged from 8,122 to 50,454 (Table 1).

**Prevalence by age, gender, and educational levels**

Among all students, 208,501 (40.9%) had myopia, with 114,612 (22.5%) cases of low myopia, 78,917 (15.5%) moderate myopia, and 14,972 (2.9%) high myopia (Table 1). Figure 1 showed that there were significant differences in the prevalence of myopia, low myopia, moderate myopia, and high myopia across different age groups (all \(p < 0.001\)). Specifically, the prevalence of myopia increased with age, with a relatively low and stable prevalence during 3 to 6 years, a rapid increase during 7 to 14 years, then a slow increase during 15 to 18 years. In terms of low myopia, the prevalence increased from ages 3 to 12, reaching a peak of 36.5% at age 12, and then decreased from ages 13 to 18. On the other hand, both moderate and high myopia showed an increasing trend with age.

There were also significant differences in the prevalence of myopia (low myopia and moderate myopia) and non-myopia across genders (Table 1, all \(p < 0.001\), except for high myopia (\(p > 0.05\)). Males had lower prevalence of myopia than in females (39.4% vs. 42.5%), so did low myopia and moderate myopia (21.5% vs. 23.5% and 15% vs. 16%).

As for different educational levels, there were also significant differences in the prevalence of non-myopia, myopia, low myopia, moderate myopia, and high myopia (all \(p < 0.001\)). The prevalence of myopia, moderate myopia, and high myopia all increased with higher educational levels, while the prevalence of low myopia increased from kindergarten to middle school and then slightly decreased in high school.

**Distribution of ocular biometric parameters**

Table 2 showed the significant differences in ocular biometric parameters of participants with different refractive status (all \(p < 0.001\)). Participants with higher levels of myopia had longer AL, steeper mean K, higher AL/CR ratio, thinner CCT, deeper ACD, and longer VCD, but thinner LT, than those with lower levels of myopia and non-myopia (all \(p < 0.001\)).
Among the myopic children, the average SE, AL, K, AL/CR ratio, CCT, ACD, LT and VCD were (-3.04±0.85) D, (24.75±0.91) mm, (43.27±1.61) D, (3.17±0.11), (543.68±33.27) mm, (3.21±0.31) mm, (3.48±0.29) mm, and (17.51±0.89) mm, respectively (Table 3). Among the non-myopic children, the corresponding values were (0.05±0.85) D, (22.95±0.91) mm, (43.20±1.61) D, (2.94±0.11), (540.23±33.28) mm, (2.88±0.30) mm, (3.73±0.29) mm, and (15.80±0.89) mm, respectively (Table 4). There were significant differences in SE, AL, K, AL/CR ratio, CCT, ACD, LT, and VCD among different gender, age, and educational level groups between myopic and non-myopic children (all p < 0.01).

Figure 2 showed that the slope of AL growth in myopic children was highly consistent with that in non-myopic children during ages 3-6 years (k=0.33 and 0.25) and was significantly higher than that of non-myopic children during ages 6-9 years (k=0.48 and 0.28). After 9 years of age, the AL growth gradually stabilized (k=0.07). Similarly, the slope of LT thinning in myopic was highly consistent with that in non-myopic children during ages 3-6 years (k=0.08 and -0.10) and was significantly higher than non-myopic children during ages 6-9 years (k=-0.11 and k=-0.07). After 9 years of age, the LT thinning gradually stabilized or even slightly thickened (k=0.01 and k=0.01).

**Correlation between ocular biometric parameters and SE**

Figure 3 showed that SE was negatively correlated with AL, K, AL/CR ratio, CCT, ACD and VCD (r = -0.758, -0.029, -0.795, -0.038, -0.48, -0.745, all p < 0.001). On the contrary, SE was positively correlated with LT (r = 0.373, p < 0.001). Among these ocular biometric parameters, SE had strong correlations with AL, AL/CR ratio and VCD (|r| > 0.60), moderate correlations with ACD, LT (0.40 < |r| < 0.60), and extremely weak correlations with K, CCT (|r| < 0.20).

A Multiple regression linear model was constructed to estimate the SE based on age, gender, and ocular biometric parameters, yielding an R-squared value of 0.723 (F = 189733.913, p < 0.001) (Table5). According to this model, the following factors were identified as predictors of SE: AL (β= -1.609), K (β= -0.489), CCT (β= 0.002), ACD (β=0.747), LT (β= -0.908), age (β= -0.008) and gender (β= 0.433), (all p < 0.001)

**Discussion**

To the best of our knowledge, this was the a large-scale (half a million) population-based study in children myopia with ocular biometric parameters. We found an overall prevalence of myopia of 40.9% among students aged 3–18 years in Chengdu, China. The prevalence of low, moderate, and high myopia was 22.5%, 15.5%, and 2.9%, respectively. SE had strong correlations with AL, AL/CR ratio, and VCD, moderate correlations with LT and ACD, and weak correlations with K and CCT (all p < 0.001). During ages 6–9, a rapid increase of AL occurred and accompanied by crystalline lens thickness compensation to maintain emmetropization, while after age 9, the compensatory effect of crystalline lens thickness gradually diminished.

The prevalence of myopia in Chengdu children was lower than than in Chinese children in 2020 (52.7%), and was notably lower than that in children living in coastal cities of southeastern China (63.1% – 81.35%).[16–18] However, it was still higher than that in European countries (17% – 32%).[19, 20] This study revealed that the prevalence of high myopia was 2.9% in Chengdu among students aged 3–18 years, slightly higher than that in Xinjiang (2.55%, ages 4–23 years),[21] North America (2.0%, ages 10–14 years),[4] and Western Europe (2.5%, ages 10–14 years).[4] However, it was considerably lower than that in Yiwu, Zhejiang (9.4%, ages 6–20 years),[6] Shanghai (4.2%, ages 4–14 years)[16, 22] and Xi’an, Shanxi (9.7%, ages 7–18 years).[23] These differences in the prevalence of myopia among different regions may be due to the differences in diagnostic criteria, lifestyle habits, educational levels, and racial factors.

Our study revealed that the prevalence of myopia among students aged 3–18 years exhibited an upward trend with increasing age, rising from 6.1% at age 3 years to 80.4% at age 18 years. Notably, the children aged 7 to 13 years showed a steeper increase in the prevalence of myopia, which may be linked to the age range of puberty and heightened educational pressure. Similar investigations conducted in Xi’an, Shanxi Province (ages 7–18 years), Weifang, Shandong Province (ages 5–20 years), and Spain (ages 5–7 years) also demonstrate an increasing myopia prevalence with age.[23–25] The findings of these studies indicated a correlation between the prevalence of myopia and age, which can be attributed to increased educational attainment,[26] prolonged near-distance study periods,[27] elevated usage of electronic devices,[28, 29] and reduced outdoor activity time.[30–32]

Furthermore, our study indicated that the prevalence of myopia was higher in females (42.5%) than in males (39.4%), which aligns with previous research outcomes.[16, 22, 33] Owen and colleagues[34] discovered a gender-specific disparity in the prevalence of myopia among East Asian populations, with girls surpassing boys in prevalence around the age of 9, intensifying during adolescence, and resulting in a twofold higher myopia rate among girls. Related research also suggested that the higher myopia prevalence in females was linked to hormonal levels. Xie et al.[35] measured sex hormone in 432 adolescents and found that myopic degree increased with decreased level of estrogen. Scholars also discovered that the spherical lens, vision and ocular parameters vary obviously with different levels of serum estradiol in menstrual cycle.[36] Additionally, scholars have identified genetic correlation (rs9307551) with high myopia in Chinese Han females.[37] Divergent lifestyles also emerged as principal risk factors for myopia development; females tended to engage in quiet activities like reading, leading to prolonged near-work and reduced outdoor activities[38], all of which can exacerbate myopia progression.

The present study demonstrated strong correlations between SE and AL, AL/CR ratio and VCD, moderate correlations with LT and ACD, and weak correlations with K and CCT. In emmetropia, a precise balance between corneal and crystalline lens powers and AL should result in a refractive state between +0.50 D and -0.50 D. In myopia, however, this balance was disrupted: the AL surpasses the powers of cornea and crystalline lens.[39] AL increases with age, with the growth rate being relatively fast among students aged 3 to 6 years (preschool age), consistent with other research findings.[15] In addition, the AL of myopic children was greater than that of non-myopic children across different age groups. Cohort studies on European children's AL and myopia growth risk[40] and the Northern Ireland Childhood Errors of Refraction (NICER) study[41] have both found that AL growth in myopic children was significantly faster than that in hyperopic children. They also found a close correlation between height and AL growth, which needed to be considered when interpreting growth curves.

We found that mean keratometry is negatively correlated with AL. A study on corneal biomechanics among 200 emmetropic Bangladeshi individuals aged 21 to 30 years demonstrated a negative correlation between AL and mean keratometry.[42] Recent studies suggested that cornea can compensate for the impact
of AL growth on myopia progression through changes in mean keratometry within a certain range of AL growth.[43–45] However, this corneal compensation disappeared when AL > 28 mm.[46] Moreover, Zhou et al.[47] discovered that CCT was negatively correlated with myopia progression and AL growth. Children with thinner CCT tend to have faster myopia progression and AL growth, consistent with the results of our study. Furthermore, our study revealed an inverse U-shaped pattern between LT and ACD with increasing age. Data also suggested that eyes with longer AL (more myopia) tend to have deeper ACD and thinner LT. In myopic individuals, deeper ACD may be a result of geometric scaling during AL growth.[48]

We found that the change in LT was greater in children between the ages of 3 and 9 years, followed by a smaller change aged 10 to 14 years and the change in LT became stable after 14-years old. Most previous studies have predominantly concentrated on changes in LT or Lens Power (LP) among children aged 6 years and above. A study conducted in Shanghai with 1992 students aged 6 to 18 years have identified three age groups of LP changes: before the age of 10 years, there was greater difference in LP, which became smaller between 10 and 14 years, and near plateau between 14 to 18 years.[49] Another study involving 596 students aged 6 to 16 years in Qinghai by Lu et al.[50] found that LT gradually thinned from 6- to 13-years old, with a slight thickening after 13-years old, while LT thickened among boys after the age of 13years and thickened among girls after the age of 15 years. Similarly, Shih et al.[51] conducted a survey involving 11,656 students aged 7 to 18 years in Taiwan, and discovered that LT tended to thin between ages of 7 and 11 or 12 years, and then thickened after that age range. The above results were similar to our findings, indicating the developmental process of crystalline lens at different age stages.

Multiple cohort studies have consistently found that LT tends to thin during the childhood period to around 10 years of age, after which the thinning of LT slows down significantly.[52, 53] In a cohort study conducted in Guangzhou, a three-stage pattern of LT changes was observed to decrease rapidly in children aged 3 to7, decreased slowly in children aged 7 to 11 years, and then increased in children aged 11 years and above, while LP continued to decrease in children aged 3 to 15 years.[54] Another study involving 1747 children aged 6 to 12 years showed that LP loss rate in children aged 6–12 years was relatively faster than other age groups, and LP appeared to be decreasing continuously, but slowly, after the age of 10 years. In addition, the slope of LT thinning in the newly developed myopia group was significantly greater compared to other refractive groups, which might be related to rapid changes in AL and refractive power before and after myopia onset.[8]

Our study indicated that a rapid AL increase triggered crystalline lens thickness compensation to maintain emmetropization between ages 6–9 years, which could explain the observed thinning of lens thickness. However, after the age of 9 years, this compensatory effect from crystalline lens thickness appeared to gradually diminish. A study from Singapore, involving 1775 children aged 6 to 10 years with at least 3 follow-up assessments, demonstrated that the LT growth follows a U-shaped curve pattern, with changes occurring at 9 years of age in the persistent emmetropia group, at 10 years of age in the persistent hyperopia group, while LT variation remained relatively stable with age in the persistent hyperopia group. Furthermore, the rate of LT thinning in newly myopic children was faster than that in initially emmetroptic children during the first few years, whereas the rate of LT thickening in myopic children was slower in the following years.[55] The U-shaped curve pattern of LT changes indicated that the rapid thinning of crystalline lens had depleted its capacity to compensate for axial growth before the onset of myopia.[52] Children aged 3 to 9 years experienced rapid ocular development characterized by swift growth of AL and thinning of LT. During 6 to 9 years, the rates of AL growth and LT thinning in myopic children were faster than in non-myopic children. After the age of 9 years, the AL growth slowed down, leading to reduced stretching effects, and the LT change was also relatively stable. Therefore, during age 6 to 9, the rapid AL growth could induce compensatory changes in crystalline lens to maintain emmetropization.

Relevant studies have shown that children with newly developed myopia have a higher rate of AL growth and LP loss before the onset of myopia compared to that with persistent myopia.[56] The rate of LP loss significantly increased one year before the onset of myopia, suggesting that the increased rate of AL growth might be compensated by accelerated LP loss, which continued until one year before the onset of myopia.[56] The LT thinning to a certain physiological limit can cause a sudden deceleration of LT thinning rate, while AL increased rapidly, which can contribute to the onset of myopia.[39, 49] For children and adolescents, the refractive stability was primarily determined by the dynamic equilibrium between AL and LP.[57] If the rate of AL growth surpasses the rate of LP reduction, myopia will occur.[8] The LT thinning during the process of eye growth could be mechanically stretched by the equatorial growth. The LT thinning and LP loss reached their limits due to the limitation of myopia-related scleral expansion, explaining the observed slower LP loss after age 10 years. This explained the changes in the development pattern of crystalline lens after the age of 10 years, as the onset of myopia reaches its highest.[52, 58] [7] In summary, the intricate interplay between AL growth, LT changes, and the final onset of myopia, was influenced by multiple factors.

The present study possessed a significant advantage in terms of its large sample size, covering over 500,000 students aged 3 to 18 years in Chengdu, China. This extensive coverage provided more representative and generalizable results, enhancing the credibility and reliability of the findings. Furthermore, the study comprehensively measured ocular biometric parameters in 500,000 children, including AL, K, LT, ACD, CCT and VCD. This wealth of detailed data on ocular structure and biological characteristics contributed to a comprehensive understanding of the subject matter.

However, this study also has limitations. Firstly, cycloplegic refraction was not employed due to time constraints for a large-scale population. Younger children may possess stronger accommodative abilities, which could lead to pseudo-refractive errors caused by accommodative spasm. This could potentially affect the accuracy of the study results, resulting in an overestimation or underestimation of disease prevalence. Secondly, it was a cross-sectional study, which may bias the causal relationships between observed associations, particularly regarding the relationship between LT and AL. To address these limitations, our team plans to strengthen longitudinal cohort studies in future research. This will allow for more accurate and scientific analysis of myopia, providing effective scientific foundations for the prevention and management of myopia.

**Conclusion**

Our findings demonstrated significant associations between myopia and key ocular biometric parameters such as AL and LT. Specifically, during ages 6–9 years, a rapid AL growth led to compensatory changes in crystalline lens thickness, while after the age of 9 years, the compensatory effect gradually
diminishes. Based on these insights, it was crucial to perform comprehensive assessments on critical ocular biometric parameters like AL and LT in myopia control. This approach will enable the development of personalized strategies on myopia prevention and control in children.

**Abbreviations**


**Declarations**

**Acknowledgments**

We would like to thank the Ineye Hospital of Chengdu University of TCM for their help and support in our investigations, especially the Chengdu Municipal Government and Education Bureau. We would like to thank Eye School of Chengdu University of TCM for their help for collecting the data. We thank the Beijing Tongren Hospital Affiliated to Capital Medical University, the Hong Kong Polytechnic University and State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University for its technical support.

**Contributors**

JGD, NLW and SML conceived and designed the study. JQX, JYM and JW analyzed the data. MGH and XTH contributed to the results interpretation and critically revised the manuscript. QLM, YRZ and YYN collected the data. CML, SML, TLP and HMG wrote the original draft. All the authors collected the data and reviewed, edited, and approved the final manuscript.

**Funding**

Key Research Laboratory of Visual Function Protection in TCM, State Administration of TCM (CKY20222005), National Natural Science Foundation of China, NSFC (82071000), Chengdu Education Bureau Quality Development Myopia Prevention and Control Special Project (2020-167), Beijing Natural Science Foundation (JQ20029).

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval**

This study received approval from the Ethics Committee of Chengdu University of Traditional Chinese Medicine Ineye Hospital (2019yh-007). All information acquired was kept confidential and was only accessible by the researchers.

**Data availability statement**

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

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

**References**


Tables

Table 1: Distribution of Refractive Status in Different Gender, Age, and Education Groups [n(%)]
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<th>Participant Characteristics</th>
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<th>Non-myopia n (%)</th>
<th>Myopia n (%)</th>
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<th>Moderate myopia n (%)</th>
<th>High myopia n (%)</th>
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<td>1097 5.6</td>
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<td>7460 20.4</td>
<td>1239 3.4</td>
<td>98 0.3</td>
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<td>23790 (63.6)</td>
<td>13637 36.4</td>
<td>10731 28.7</td>
<td>2742 7.3</td>
<td>164 0.4</td>
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<td>12727 36.5</td>
<td>8577 24.6</td>
<td>949 2.7</td>
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<td>13</td>
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<td>9209 (28.7)</td>
<td>23322 71.7</td>
<td>11631 35.8</td>
<td>10154 31.2</td>
<td>1537 4.7</td>
</tr>
<tr>
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<td>7225 (23.3)</td>
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<td>2213 7.1</td>
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<td>30801</td>
<td>6490 (21.1)</td>
<td>24311 78.9</td>
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<td>11897 38.6</td>
<td>2728 8.9</td>
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<td>24552</td>
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<td>19258 78.4</td>
<td>7050 28.7</td>
<td>9736 39.7</td>
<td>2472 10.1</td>
</tr>
<tr>
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<td>21037</td>
<td>4172 (19.8)</td>
<td>16865 80.2</td>
<td>5607 26.7</td>
<td>8585 40.8</td>
<td>2673 12.7</td>
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<td>6533 80.4</td>
<td>2080 25.6</td>
<td>3285 40.4</td>
<td>1168 14.4</td>
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<td><strong>Education Level</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
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<td>102030 (95.9)</td>
<td>6628 (6.1)</td>
<td>6171 5.7</td>
<td>366 0.3</td>
<td>91 0.1</td>
</tr>
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<td>231729</td>
<td>157536 (68)</td>
<td>74193 (32)</td>
<td>54467 23.5</td>
<td>18235 7.9</td>
<td>1491 0.6</td>
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<tr>
<td>Middle School</td>
<td>99300</td>
<td>26567 (26.8)</td>
<td>72733 (73.2)</td>
<td>33989 34.2</td>
<td>32790 33</td>
<td>5954 6</td>
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<tr>
<td>High School</td>
<td>69843</td>
<td>14896 (21.3)</td>
<td>54947 (78.7)</td>
<td>19985 28.6</td>
<td>27526 39.4</td>
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<tr>
<td><strong>P values</strong></td>
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</tr>
</tbody>
</table>

Note: Non-myopia: excluding myopia.

Table 2: Ocular biometric parameters of participants among different refractive status groups.
<p>| Table 3: Comparison of ocular biometric parameters among myopic children by gender, age, and education Level (x±s) |
|-----------------------------------------------|-----------------------|----------------|----------------|----------------|----------------|----------------|----------------|</p>
<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>AL(mm)</th>
<th>K(D)</th>
<th>AL/CR</th>
<th>CCT(mm)</th>
<th>ACD(mm)</th>
<th>LT(mm)</th>
<th>VCD(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>509530</td>
<td>23.67±1.36</td>
<td>43.21±1.63</td>
<td>3.03±0.17</td>
<td>541.49±33.43</td>
<td>3.01±0.34</td>
<td>3.63±0.30</td>
<td>16.49±1.31</td>
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<tr>
<td>Myopia</td>
<td>208501</td>
<td>24.75±0.91</td>
<td>43.27±1.61</td>
<td>3.17±0.11</td>
<td>543.68±33.27</td>
<td>3.21±0.31</td>
<td>3.48±0.29</td>
<td>17.51±0.89</td>
</tr>
<tr>
<td>Low myopia</td>
<td>114612</td>
<td>24.17±0.95</td>
<td>43.22±1.62</td>
<td>3.09±0.11</td>
<td>544.17±33.29</td>
<td>3.16±0.28</td>
<td>3.5±0.24</td>
<td>16.97±0.93</td>
</tr>
<tr>
<td>Moderate myopia</td>
<td>78917</td>
<td>25.27±0.89</td>
<td>43.3±1.63</td>
<td>3.24±0.11</td>
<td>543.33±33.58</td>
<td>3.27±0.25</td>
<td>3.45±0.20</td>
<td>18±0.88</td>
</tr>
<tr>
<td>High myopia</td>
<td>14972</td>
<td>26.3±1.03</td>
<td>43.47±1.62</td>
<td>3.40±0.12</td>
<td>541.93±33.33</td>
<td>3.32±0.26</td>
<td>3.47±0.20</td>
<td>19.05±1.02</td>
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<tr>
<td>Non-myopia</td>
<td>301029</td>
<td>22.95±0.91</td>
<td>43.2±1.61</td>
<td>2.93±0.11</td>
<td>540.23±33.28</td>
<td>2.88±0.31</td>
<td>3.73±0.29</td>
<td>15.8±0.89</td>
</tr>
<tr>
<td>P values</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

<p>| Table 4: Comparison of ocular biometric parameters among non-Myopic students by gender, age, and education level (x±s) |
|-----------------------------------------------|-----------------------|----------------|----------------|----------------|----------------|----------------|----------------|</p>
<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>AL(mm)</th>
<th>K(D)</th>
<th>AL/CR</th>
<th>CCT(mm)</th>
<th>ACD(mm)</th>
<th>LT(mm)</th>
<th>VCD(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten</td>
<td>6628</td>
<td>22.47±0.69</td>
<td>43.46±1.57</td>
<td>2.89±0.08</td>
<td>533.22±32.46</td>
<td>2.71±0.28</td>
<td>3.95±0.27</td>
<td>15.28±0.6</td>
</tr>
<tr>
<td>Elementary School</td>
<td>74193</td>
<td>23.33±0.79</td>
<td>43.36±1.60</td>
<td>3.12±0.09</td>
<td>543.00±32.51</td>
<td>3.19±0.28</td>
<td>3.46±0.25</td>
<td>17.13±0.7</td>
</tr>
<tr>
<td>Middle School</td>
<td>72733</td>
<td>25.00±0.88</td>
<td>43.24±1.63</td>
<td>3.20±0.10</td>
<td>545.62±33.68</td>
<td>3.26±0.28</td>
<td>3.45±0.23</td>
<td>17.75±0.8</td>
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<tr>
<td>High School</td>
<td>54947</td>
<td>25.24±0.96</td>
<td>43.15±1.90</td>
<td>3.22±0.11</td>
<td>543.29±37.95</td>
<td>3.24±0.28</td>
<td>3.49±0.24</td>
<td>17.97±0.9</td>
</tr>
<tr>
<td>P values</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Table 5: Student's t-test analysis with SE

**Participant Characteristics** | N  | SE(D) | AL(mm) | K(D) | AL/CR | CCT(mm) | ACD(mm) | LT(mm) | VCD(mm) |
--- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
All | 301029 | 0.05±0.85 | 22.95±0.91 | 43.20±1.61 | 2.94±0.11 | 540.23±33.28 | 2.88±0.30 | 3.73±0.29 | 15.80±0.8 |
Gender | Male | 141346 | 0.06±0.86 | 22.65±0.86 | 43.59±1.57 | 2.92±0.10 | 538.08±33.04 | 2.81±0.30 | 3.76±0.29 | 15.54±0.8 |
     | Female | 159683 | 0.05±0.85 | 23.21±0.86 | 42.86±1.57 | 2.95±0.11 | 542.14±33.38 | 2.94±0.30 | 3.71±0.29 | 16.02±0.8 |
P values | | | | | | | | | | <0.001 |
Age(year) | 3 | 18246 | 0.24±0.70 | 22.01±0.63 | 43.43±1.56 | 2.83±0.08 | 531.02±33.27 | 2.61±0.28 | 4.01±0.28 | 14.85±0.6 |
     | 4 | 32994 | 0.30±0.63 | 22.25±0.64 | 43.38±1.57 | 2.86±0.08 | 531.80±32.11 | 2.67±0.27 | 3.95±0.27 | 15.10±0.6 |
     | 5 | 35604 | 0.27±0.65 | 22.48±0.66 | 43.29±1.57 | 2.88±0.08 | 534.41±32.19 | 2.73±0.27 | 3.87±0.26 | 15.34±0.6 |
     | 6 | 46663 | 0.24±0.71 | 22.69±0.67 | 43.29±1.58 | 2.91±0.08 | 538.63±32.18 | 2.82±0.27 | 3.78±0.25 | 15.56±0.6 |
     | 7 | 36627 | 0.10±0.80 | 22.94±0.69 | 43.24±1.59 | 2.94±0.09 | 541.45±32.14 | 2.89±0.27 | 3.70±0.25 | 15.80±0.6 |
     | 8 | 27759 | -0.01±0.83 | 23.16±0.72 | 43.22±1.59 | 2.96±0.09 | 543.31±32.23 | 2.96±0.27 | 3.64±0.24 | 16.03±0.7 |
     | 9 | 23790 | -0.09±0.85 | 23.34±0.76 | 43.16±1.59 | 2.98±0.09 | 544.79±32.57 | 3.01±0.27 | 3.59±0.24 | 16.20±0.7 |
     | 10 | 18132 | -0.15±0.92 | 23.47±0.78 | 43.10±1.59 | 3.00±0.09 | 545.59±32.73 | 3.04±0.27 | 3.56±0.23 | 16.33±0.7 |
     | 11 | 14600 | -0.22±0.94 | 23.56±0.81 | 43.08±1.62 | 3.00±0.09 | 545.85±33.25 | 3.06±0.27 | 3.56±0.23 | 16.41±0.7 |
     | 12 | 12635 | -0.25±0.99 | 23.64±0.83 | 43.00±1.62 | 3.01±0.10 | 547.36±33.43 | 3.06±0.27 | 3.55±0.23 | 16.48±0.8 |
     | 13 | 9209 | -0.33±1.10 | 23.71±0.88 | 42.94±1.64 | 3.01±0.10 | 546.72±33.50 | 3.07±0.28 | 3.56±0.23 | 16.54±0.8 |
     | 14 | 7225 | -0.39±1.16 | 23.74±0.92 | 42.95±1.65 | 3.02±0.10 | 547.09±33.96 | 3.06±0.28 | 3.59±0.23 | 16.55±0.8 |
     | 15 | 6490 | -0.36±1.11 | 23.71±0.92 | 42.86±1.70 | 3.01±0.11 | 547.03±35.14 | 3.04±0.28 | 3.61±0.24 | 16.52±0.9 |
     | 16 | 5294 | -0.33±1.11 | 23.69±0.94 | 42.74±1.93 | 3.00±0.12 | 546.93±37.36 | 3.03±0.28 | 3.62±0.23 | 16.50±0.9 |
     | 17 | 4172 | -0.36±1.15 | 23.76±1.00 | 42.68±1.99 | 3.00±0.13 | 546.58±39.34 | 3.02±0.29 | 3.65±0.23 | 16.55±0.9 |
     | 18 | 1589 | -0.41±1.20 | 23.77±1.06 | 42.75±2.03 | 3.01±0.13 | 543.94±41.74 | 3.00±0.30 | 3.67±0.23 | 16.56±1.0 |
P values | | | | | | | | | | <0.001 |
Education Level | Kindergarten | 102030 | 0.28±0.65 | 22.34±0.69 | 43.34±1.57 | 2.87±0.08 | 533.31±32.46 | 2.70±0.28 | 3.91±0.27 | 15.20±0.6 |
     | Elementary School | 157536 | 0.00±0.85 | 23.14±0.79 | 43.20±1.60 | 2.96±0.09 | 542.97±32.51 | 2.95±0.28 | 3.65±0.25 | 16.00±0.7 |
     | Middle School | 26567 | -0.33±1.10 | 23.70±0.88 | 42.96±1.63 | 3.01±0.10 | 547.11±33.68 | 3.06±0.28 | 3.57±0.23 | 16.52±0.8 |
     | High School | 14896 | -0.34±1.10 | 23.72±0.96 | 42.74±1.90 | 3.00±0.12 | 546.42±37.96 | 3.02±0.28 | 3.63±0.24 | 16.52±0.9 |
P values | | | | | | | | | | <0.001 |
Note: Non-myopia: excluding myopia.

Table 5: Multiple linear regression analysis with SE

<table>
<thead>
<tr>
<th>Parameters</th>
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<th>P value</th>
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<td>-0.009 to -0.007</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td>0.433</td>
<td>0.427 to 0.440</td>
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</tr>
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<td>AL</td>
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<td>-1.614 to -1.605</td>
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</tr>
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<td>K</td>
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<td>-0.491 to -0.487</td>
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<td>CCT</td>
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<td>ACD</td>
<td>0.747</td>
<td>0.732 to 0.762</td>
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<td>LT</td>
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<td>-0.923 to -0.893</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Adjusted for all variables listed. R² for all subjects = 0.723. A p value of <0.05 is considered significant.
Figure 1

Trends in the prevalence of myopia and myopia grading (low, moderate, high) among different age groups
Figure 2

Correlation between AL/LT and age
* p<0.001

**Figure 3**

Plot of the correlation between SE and ocular biometric parameters