• Investigation •

Ocular biometric parameter characteristics and influence on refractive power in Chinese children

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Received: 2024-12-21 Accepted: 2025-02-19

Abstract

● **AIM:** To analyze ocular parameters and refractive status in children aged 3-12y and to explore differences in these parameters across age groups with identical refractive status for studying refractive progression.

● **METHODS:** Demographic characteristics, cycloplegic refraction data, and ocular parameters of the participants were collected. Changes in ocular parameters were described according to different age groups. After adjusting for refractive factors, the relationship between age and ocular parameters was explored. Standard regression coefficients (β) obtained from multiple linear regressions were used to compare the magnitude of the effect of age on the parameters and ocular components on refractive power.

● **RESULTS:** Data were collected from the right eyes of 1504 participants. Lens thickness (LT) decreased with age, whereas the axial length (AL) and anterior chamber depth (ACD) increased. In the high-hyperopia group, changes in age were only associated with AL and LT. In the low-myopia group, the increase in age was also associated with corneal astigmatism. In the overall model, the β value for LT was the highest at 0.41, whereas β for ACD and AL was significant in all groups except for the high-hyperopia group. The β value of the LT on refractive power in children was slightly greater in the low age group than in the high age group.

● **CONCLUSION:** Among children with the same refractive status, the older the age, the longer the axis length and the thinner the lens. The lens affected refractive power in children in the younger age group more than in the older age group. The ocular parameter most affected by age was LT.

● **KEYWORDS:** pediatric eye conditions; refractive error; ocular parameters; lens thickness; axis length

DOI:10.18240/ijo.2025.12.20

Citation: Ye CY, Liu YJ, Xing WQ, Shang JM, Xu YF, Qu XM. Ocular biometric parameter characteristics and influence on refractive power in Chinese children. *Int J Ophthalmol* 2025;18(12):2372-2379

INTRODUCTION

Refractive error is the leading cause of visual impairment globally, and uncorrected high refractive error and anisometropia can induce amblyopia[1-2], which can affect vision and cause delays in cognitive and motor development[3], ultimately affecting psychosocial functioning[4].

Recently, the prevalence of myopia has increased globally, with early-onset and high incidence rates observed in China[5]. In addition to the reduced quality of life from the use of corrective glasses, progressive myopia can significantly increase the risk of blinding eye diseases such as macular degeneration, retinal detachment, glaucoma, and cataracts[6]. Managing refractive errors or treating related complications requires substantial medical resources and increases the burden on the national economy[7], making this a serious public health concern in China.

Growth and development of the human eye is a dynamic process that continuously progresses toward emmetropization[8]. Clear vision throughout the entire process can only be achieved when the refractive power of the cornea and lens match the axial length (AL) of the eye, and the lens has a normal accommodative function. Imbalance among these factors causes refractive abnormalities such as myopia, resulting in parallel light rays focusing in front of the retina[9]. Modern optical biometry techniques based on Fourier domain interferometry minimize the measurement time, allowing for rapid and accurate measurement of parameters such as AL, corneal curvature, anterior chamber depth (ACD), and lens thickness (LT), thereby improving the reliability of eye examinations in children[10].

A previous study found regularities in the changes in refractive power in children of different ages and refractive statuses[11]. Ocular parameters, such as AL and corneal curvature, are also widely recommended for regular monitoring and recording of refractive development and have become routine examination criteria for refractive development monitoring. Therefore, the measurement of ocular parameters allows determination of the exact refractive error and its type, which in turn facilitates correction to achieve better vision.

However, the differences in ocular parameters among adolescents with the same refractive state and the influence of age on these parameters have not been studied. This cross-sectional study aimed to investigate the refractive power and ocular biometric parameters in children and adolescents aged 3-12y, characterize them across different age groups and refractive status, and compare the differences of these parameters among age groups with same refractive status, aiming to hypothesize potential patterns of change in ocular parameters and to establish a foundation for studying the role of these changes in myopia onset.

PARTICIPANTS AND METHODS

Ethical Approval This study complied with the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of Eye and ENT Hospital of Fudan University (approval No.2022015). All participants and their guardians signed informed consent forms after fully understanding the research contents, risks, and benefits.

Participants Data from the right eyes of children and adolescents who visited the Ophthalmology Outpatient Department of Eye and ENT Hospital of Fudan University (Shanghai, China) and met the inclusion criteria were analyzed. The inclusion criteria were as follows: children and adolescents aged 3-12y; astigmatism measured after cycloplegia not exceeding -2.00 D; clear bilateral refractive media and a best-corrected visual acuity better than logMAR 0.3; compliant with medication instructions and cooperative during examinations. Those with active eye diseases, a history of organic eye diseases (excluding intermittent exotropia, cataracts, Marfan syndrome, aphakia, keratoconus, glaucoma, and retinopathy of prematurity), or a history of intraocular surgery; previous or current user of atropine or tropicamide eye drops, orthokeratology lenses, or other treatment measures that may affect the assessment of myopia progression; with concomitant systemic diseases that may affect refractive power (such as endocrine diseases, neurological diseases, and cardiovascular diseases); and those a history of allergy to atropine, tropicamide, cyclopentolate, or similar drugs or contraindications to their use were excluded.

Measurements One drop of 0.5% tropicamide (Phillips Fritz Pharma Co., Ltd, China) was administered to each eye every 5min. After five doses, cycloplegic refraction data were obtained using an automatic computerized refractometer (ARK 510A; NIDEK, Japan), whereas subjective refraction after cycloplegia was obtained using a comprehensive refractometer (RT-5100 visual acuity tester and CP-770 visual acuity chart projector, NIDEK, Japan). Ocular biometric parameters under non-cycloplegic conditions were obtained using IOLMaster 700 (Carl Zeiss Meditec, Inc., Dublin, CA, USA). These parameters included central corneal thickness (CCT), ACD, aqueous depth (AQD), LT, AL, and flat (K1) and steep (K2) meridians. In this study, spherical equivalent (SE) power was calculated based on the examination results as spherical degrees plus 1/2 cylinder degrees. A standardized database was established after conducting data quality checks.

The sample size was calculated using the formula $n=(U_\alpha \sigma/\delta)^2$, where σ=3.72, obtained from preliminary experiments as the standard deviation of the SE power after cycloplegia in children and adolescents aged 3-12y, with a permissible error set at δ=0.50, and α=0.05. The sample size was calculated as 213. Based on the results of the preliminary experiments, the core variables of this study were initially determined to include at least seven variables, such as SE power, age, and major ocular biometric parameters (AL, corneal curvature, ACD, LT, and CCT); therefore, the sample size should be increased by seven times, totaling 1491 cases. Considering possible data loss, the final sample size was set at 1500.

Definition of the Groups The participants were grouped based on their age and SE measured under cycloplegic conditions. Participants aged 3-6y were categorized into the low age group, those aged 7-9y into the medium age group, and those aged 10-12y into the high age group. Participants with SE<-6.00 D were classified into the high-myopia group, those with SE from -6.00 to <-3.00 D into the moderate-myopia group, those with SE from -3.00 to ≤0 D into the low-myopia group, those with SE from 0 to ≤3.00 D into the low-hyperopia group, those with SE from 3.00 to ≤6.00 D into the moderate-hyperopia group, and those with SE>6.00 D into the high-hyperopia group.

Statistical Analysis Categorical variables were presented as numbers (percentages). Chi-square or Fisher's exact test was used to compare the rates across multiple groups based on the expected frequency. Continuous variables were expressed as mean±standard deviation, and the Kolmogorov-Smirnov test was used to assess normality. For normally distributed quantitative data, a one-way *t*-test or one-way analysis of variance was used, followed by the least significant difference test for multiple comparisons if the homogeneity of variance test was met. For skewed distributed quantitative

Table 1 Demographic characteristics and refractive parameters of children in different age groups mean±SD

Characteristics	Total (*n*=1504)	Low age (*n*=507, 33.71%)	Medium age (*n*=630, 41.89%)	High age (*n*=367, 24.4%)	*P*
Sex, *n* (%)					0.486[a]
Female	757 (50.33)	266 (52.47)	312 (49.52)	179 (48.77)	
Male	747 (49.67)	241 (47.53)	318 (50.48)	188 (51.23)	
Age (y)	7.64±2.37	4.94±1.00	8.01±0.80	10.74±0.77	<0.001
SE (D)	0.43±3.92	1.45±4.16	0.19±3.63	-0.56±3.74	<0.001
AL (mm)	23.22±1.66	22.44±1.48	23.41±1.52	23.97±1.68	<0.001[b]
J0 (D)	-0.01±0.41	-0.03±0.40	0.00±0.38	0.00±0.47	0.458
J45 (D)	0.01±0.45	0.02±0.46	0.00±0.43	0.02±0.46	0.777
K (D)	43.10±1.57	43.13±1.57	43.16±1.55	42.97±1.60	0.160[b]
K1 (D)	42.36±1.53	42.39±1.54	42.44±1.52	42.18±1.51	0.031
K2 (D)	43.88±1.69	43.89±1.68	43.91±1.65	43.80±1.77	0.608[b]
δK (D)	-1.52±0.73	-1.51±0.76	-1.47±0.69	-1.63±0.74	0.010
ACD (mm)	3.55±0.29	3.39±0.26	3.60±0.27	3.66±0.29	<0.001
AQD (mm)	3.00±0.29	2.85±0.27	3.05±0.27	3.11±0.29	<0.001
LT (mm)	3.48±0.22	3.61±0.21	3.44±0.18	3.38±0.20	<0.001
CCT (μm)	549.38±32.28	542.06±31.19	551.65±31.26	555.60±33.65	<0.001[b]

[a]Chi-squared test; [b]One-way analysis of variance; the remaining parameters were compared using the Kruskal-Wallis nonparametric test. SD: Standard deviation; SE: Spherical equivalent; AL: Axial length; J0/J45: Jackson cross-cylinders (J0/J45); K: Mean meridian; K1: Flat meridian; K2: Steep meridian; δK: Difference between K1 and K2 (*i.e.*, corneal astigmatism); ACD: Anterior chamber depth; AQD: Aqueous depth; LT: Lens thickness; CCT: Central corneal thickness.

data, the Mann-Whitney *U* test or Kruskal-Wallis rank-sum test was performed, and Bonferroni correction was used for multiple comparisons to calculate the significance of pairwise comparisons between the groups. Partial correlation and multiple linear regression analysis were conducted to examine the relationship between the biometric parameters and age. Common factors affecting refractive status in different age groups were identified using stepwise regression, and multiple linear regression was used to assess the effects of these parameters on the refractive status. Statistical analysis and graphical presentations were performed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Data organization and chart drawing were performed using GraphPad Prism version 9.5.0 (GraphPad, La Jolla, CA, USA). The significance level was set at α=0.05 to control for type I error.

RESULTS

Participant Characteristics A total of 1504 children aged 3-12y were enrolled in this study: 507 (33.71%) aged 3-6y, 630 (41.89%) aged 7-9y, and 367 (24.40%) aged 10-12y. Age-stratified analysis revealed that as age increased, SE and LT decreased, whereas AL, ACD, and AQD increased. The CCT in the low age group was significantly lower than those in the other two groups (Table 1).

Refractive-group disparities were also observed for these parameters, with the exception of J0 and J45. The moderate-myopia group had the oldest overall age, which was significantly higher than that of the other five groups. Corneal refractive power was significantly higher in children with high myopia than in children with hyperopia, and corneal astigmatism deepened as myopia worsened; astigmatism was also significantly lower in children with low myopia than in those with moderate to high myopia. The ACD and AQD of the myopic group were significantly deeper than those of the hyperopic group; the LT was higher in those with hyperopic high myopia, whereas it was thinner in children with low and moderate myopia, and the cornea was thinner in children with moderate to high myopia (Table 2).

Distribution and Comparison of Ocular Refractive and Biometric Parameters Among Different Age Groups with the Same Refractive Status Across all refractive statuses, a gradual increase in AL and decrease in LT were observed with age (Figure 1). In participants with myopia, progressive increases in ACD and AQD occurred concurrently. Notably, children aged 3-6y in the low-myopia group exhibited significantly less myopia and thinner corneas than those aged 7-12y. Conversely, those aged 10-12y demonstrated flatter refraction but higher corneal astigmatism (δK) than those aged 7-9y. In the high-myopia group, children aged 10-12y had a flatter K1 than those aged 3-6y.

Among the children and adolescents with hyperopia, those with low and moderate hyperopia showed a decrease in the degree of hyperopia with age, accompanied by an increase in ACD, AQD, and corneal thickness. However, in the high-hyperopia group, the changes were limited to the AL and LT.

Table 2 Demographic characteristics and biometric parameters of children in different refractive statuses mean±SD

Characteristics	High-myopia	Moderate-myopia	Low-myopia	Low-hyperopia	Moderate-hyperopia	High-hyperopia	*P*
Total, *n* (%)	73 (4.85)	181 (12.03)	584 (38.83)	390 (25.93)	222 (14.76)	54 (3.59)	
Sex, *n* (%)							0.156[a]
Female	31 (42.47)	88 (48.62)	281 (48.12)	218 (55.90)	112 (50.45)	27 (50.00)	
Male	42 (57.53)	93 (51.38)	303 (51.88)	172 (44.10)	110 (49.55)	27 (50.00)	
Age (y)	7.19±2.76	8.96±2.21	7.89±2.09	7.16±2.48	7.17±2.31	6.67±2.47	<0.001
SE (D)	-8.35±3.16	-4.02±1.08	-0.89±1.16	2.28±1.35	5.27±1.15	8.39±1.77	<0.001
AL (mm)	25.95±1.47	25.03±1.03	23.77±0.94	22.45±0.89	21.48±0.83	20.18±1.23	<0.001
J0 (D)	-0.21±0.74	0.02±0.53	-0.02±0.29	0.01±0.37	0.03±0.48	-0.05±0.41	0.012
J45 (D)	0.03±0.83	0.01±0.54	0.03±0.38	-0.01±0.40	0.03±0.44	-0.09±0.41	0.271
K (D)	43.79±1.65	43.39±1.49	43.20±1.52	43.02±1.51	42.57±1.47	42.84±2.28	<0.001
K1 (D)	42.80±1.55	42.62±1.46	42.56±1.46	42.26±1.45	41.72±1.49	41.96±2.23	<0.001
K2 (D)	44.83±1.86	44.23±1.62	43.86±1.65	43.81±1.64	43.48±1.53	43.76±2.37	<0.001[b]
δK (D)	-2.03±0.83	-1.61±0.79	-1.29±0.64	-1.56±0.71	-1.76±0.72	-1.80±0.55	<0.001
ACD (mm)	3.64±0.29	3.76±0.25	3.65±0.24	3.43±0.27	3.35±0.26	3.29±0.25	<0.001
AQD (mm)	3.10±0.29	3.21±0.25	3.10±0.24	2.88±0.26	2.80±0.27	2.74±0.24	<0.001
LT (mm)	3.51±0.21	3.36±0.19	3.43±0.18	3.55±0.22	3.57±0.24	3.58±0.23	<0.001
CCT (μm)	539.96±33.45	543.23±33.51	550.13±32.45	548.77±31.08	556.64±31.18	549.31±31.63	<0.001

[a]Chi-squared test; [b]One-way analysis of variance; the remaining parameters were compared using the Kruskal-Wallis nonparametric test. SD: Standard deviation; SE: Spherical equivalent; AL: Axial length; J0/J45: Jackson cross-cylinders (J0/J45); K: Mean meridian; K1: Flat meridian; K2: Steep meridian; δK: Difference between K1 and K2 (*i.e.*, corneal astigmatism); ACD: Anterior chamber depth; AQD: Aqueous depth; LT: Lens thickness; CCT: Central corneal thickness.

Partial Correlation Analysis of Biometric Parameters and Age in Each Refractive Group After controlling for SE in the partial correlation analysis, we found that age was correlated with AL, ACD, and LT in all groups, except for the high-hyperopia group. With increasing age, both AL and ACD gradually increased, whereas LT gradually decreased. Corneal thickness increased with age in the low-myopia, high-myopia, low-hyperopia, and moderate-hyperopia groups. Furthermore, in children with low myopia, increasing age negatively correlated with corneal refractive power (Figure 2).

Regression Model Construction of Biometric Parameters Age, sex, and SE were included in the regression models for ocular parameters (Figure 3). The regression coefficient (β) of age on AL ranged from 0.27 to 0.38, except in the high-myopia group. For LT, the regression coefficient of age ranged from -0.29 to -0.47, with a β value of 0.41 in the overall model. LT was the ocular parameter most affected by age in all groups. The effect of age on ACD was also significant in all groups, except in the high-hyperopia group, with β values ranging from 0.15 to 0.46. The ACD was most affected by age in the high-myopia group (β=0.46) and least affected in the moderate-hyperopia group (β=0.15). Age was also negatively correlated with corneal curvature in the low-myopia group but not in the other groups.

Models of the Effects of Ocular Parameters on Refractive Error in Age Groups Stepwise regression equations were used to screen the ocular parameters that had an effect on refractive error in each age group; the common parameters were sex, AL, LT, and ACD. Incorporating the above factors to construct the model revealed that girls had smaller refractive errors than boys and were more myopic in different age groups; refractive error was affected by crystal thickness in the lower age group than in the middle and older age groups; in this model, the high age group's refractive error in adolescents was not affected by LT (Table 3).

DISCUSSION

In this study, we described the age-related changes in ocular refractive characteristics. We also used refractive status as a stratification factor to describe ocular parameter variations in adolescents of different ages and assessed the influence of age on these parameters.

Under normal circumstances, a strong correlation exists between biometric parameters of the eye (such as corneal curvature and AL) at birth and the proportional development of all ocular components. After birth, especially during early development, the refractive status influences axial elongation of the eye, leading to asymmetrical changes in various ocular structures[12]. Despite the unclear compensatory and maintenance mechanisms of the intraocular refraction balance, as the eye axis grows, the corneal curvature flattens, the lens thins, and its anterior and posterior surfaces flatten, resulting in a decrease in the refractive power of the cornea and lens[13-14].

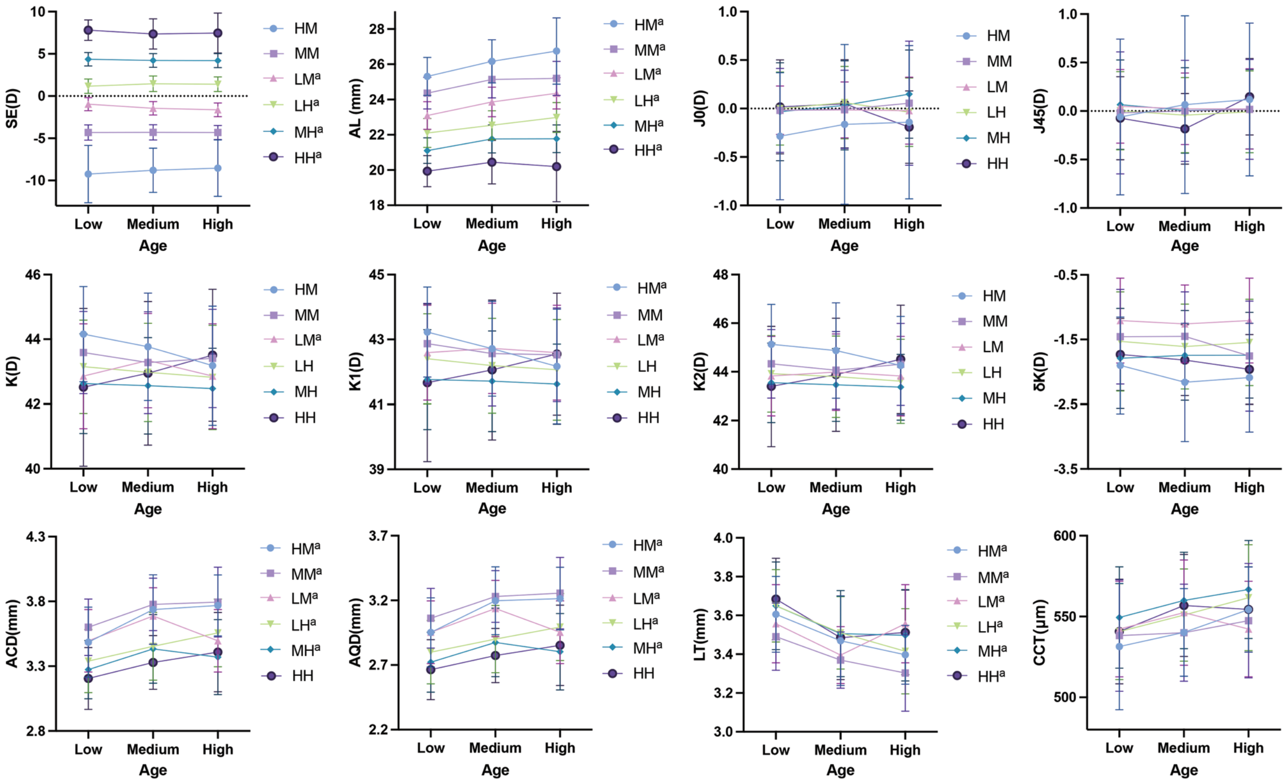

Figure 1 Stratified by refractive statuses, comparison of biometric parameters between children of different age groups Refractive status included HM, MM, LM, LH, MH, and HH. HM: High myopia; MM: Moderate myopia; LM: Low myopia; LH: Low hyperopia; MH: Moderate hyperopia; HH: High hyperopia; SE: Spherical equivalent; AL: Axial length; J0/J45: Jackson cross-cylinders (J0/J45); K: Mean meridian; K1: Flat meridian; K2: Steep meridian; δK: Difference between K1 and K2 (*i.e.*, corneal astigmatism); ACD: Anterior chamber depth; AQD: Aqueous depth; LT: Lens thickness; CCT: Central corneal thickness. [a]P<0.05, indicating that the difference of this parameter between groups in the corresponding refractive status is significant.

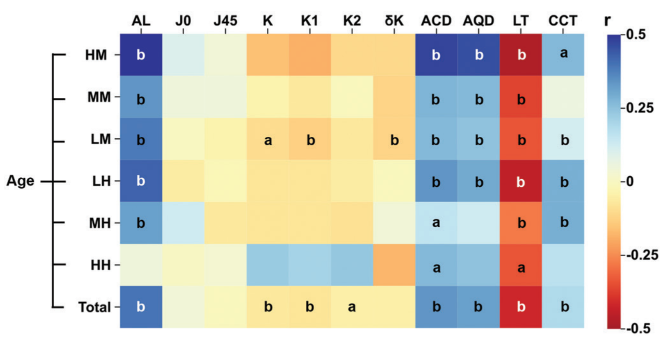

Figure 2 Partial correlation analysis between age and ocular refractive parameters Stratified by refractive status, spherical equivalent power was used as a control factor to analyze the partial correlation between age and ocular refractive parameters. Refractive status included HM, MM, LM, LH, MH, and HH. HM: High myopia; MM: Moderate myopia; LM: Low myopia; LH: Low hyperopia; MH: Moderate hyperopia; HH: High hyperopia; AL: Axial length; J0/J45: Jackson cross-cylinders (J0/J45); K: Mean meridian; K1: Flat meridian; K2: Steep meridian; δK: Difference between K1 and K2 (*i.e.*, corneal astigmatism); ACD: Anterior chamber depth; AQD: Aqueous depth; LT: Lens thickness; CCT: Central corneal thickness; r: Correlation coefficient. [a]P<0.05; [b]P<0.01.

The cornea contributes substantially to the refractive power of the eye. During embryonic development, the cornea initially assumes a steeply curved spherical shape and rapidly flattens to reach a relatively stable curvature at approximately 2 years old, likely regulated by the relationship between the corneal curvature and anterior chamber diameter[15-16]. In this study, among those with low myopia, 7- to 12-year-old had significantly lower K1 values than younger age groups, which is consistent with previous findings. The peripheral corneal thickness decreased slightly with age, whereas nonsphericity increased[17]. Hussein *et al*[18] reported that children aged 5-9y had a greater CCT than those younger than 4y; however, whether this trend continues after 9 years old remains unclear. Haider *et al*[19] reported that the average CCT in Caucasian and African-American children aged 10-18y was higher than that in younger children. This study revealed that CCT in the younger age group was significantly lower than that in the other groups. A high corneal curvature and increased corneal refractive power can lead to refractive myopia. Children with myopia exhibited greater corneal curvature than those with hyperopia[20]. Similarly, we found children with higher hyperopia had lower K, K1, and K2 values. For every 1.00-D shift toward myopia, the cornea thins by 1 μm, but while this difference is statistically significant, it may not be clinically relevant[21].

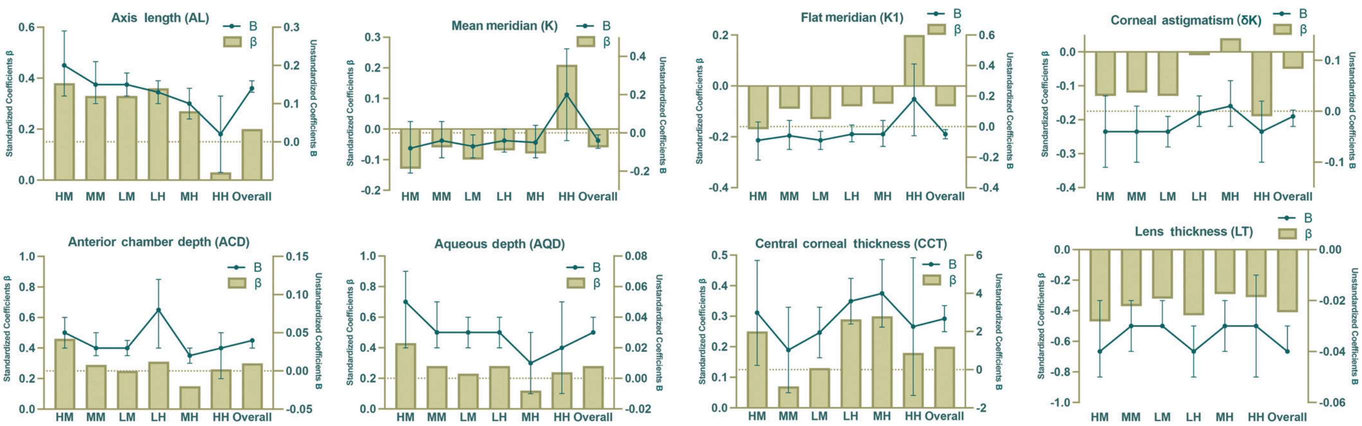

Figure 3 Multiple linear regression analysis of ocular refractive parameters with age as one of the function factors Stratified by refractive status, the regression models of ocular refractive parameters were established by age, sex, and spherical equivalent, and the standard regression coefficients of each parameter in each stratification were compared. The refractive status included HM, MM, LM, LH, MH, and HH. HM: High myopia; MM: Moderate myopia; LM: Low myopia; LH: Low hyperopia; MH: Moderate hyperopia; HH: High hyperopia; *B*: Unstandardized coefficients (95% confidence interval); *β*: Standardized coefficients; AL: Axial length; K: Mean meridian; K1: Flat meridian; δK: Difference between K1 and K2 (*i.e.*, corneal astigmatism); ACD: Anterior chamber depth; AQD: Aqueous depth; LT: Lens thickness; CCT: Central corneal thickness.

Table 3 Multiple linear regression analysis of SE power stratified by age groups

Items	Low age group (3-6y)[a]				Medium age group (7-9y)[b]				High age group (10-12y)[c]			
	B (95%CI)	*β*	*t*	*P*	*B* (95%CI)	*β*	*t*	*P*	*B* (95%CI)	*β*	*t*	*P*
Sex	0.95 (0.62, 1.28)	0.12	5.67	<0.001	1.06 (0.78, 1.35)	0.15	7.38	<0.001	1.26 (0.89, 1.63)	0.17	6.75	<0.001
AL	-2.65 (-2.78, -2.52)	-0.95	-40.44	<0.001	-2.18 (-2.29, -2.06)	-0.91	-36.95	<0.001	-2.04 (-2.17, -1.91)	-0.91	6.75	<0.001
LT	-2.14 (-3.16, -1.12)	-0.11	-4.12	<0.001	-1.10 (-1.99, -0.22)	-0.06	-2.44	0.015	-0.77 (-1.85, 0.32)	-0.04	-1.39	0.166
Intercept	66.67 (60.58, 72.75)		21.53	<0.001	53.33 (48.56, 58.10)		21.95	<0.001	50.32 (44.26, 56.38)		16.34	<0.001

The regression models constructed for all age groups were identical, incorporating sex, AL, LT, and ACD as variables and SE power as the dependent variable. The *P* values for ACD in all models were >0.05. SE: Spherical equivalent; *B* (95%CI): Unstandardized coefficients (95% confidence interval); *β*: Standardized coefficients; AL: Axial length; LT: Lens thickness; CCT: Central corneal thickness. [a]The coefficients of determination were 0.802; [b]The coefficients of determination were 0.765; [c]The coefficients of determination were 0.790.

The lens, with its gradient refractive index and accommodative capability, plays a crucial role in refractive development. LT gradually increases before birth but decreases with age until approximately 10-12y[22], following a U-shaped curve with a trough in children with myopia at approximately 10 years old[23]. A thinner lens led to an increase in the ACD, directly affecting the eye's total refractive power; a deeper anterior chamber increases the distance between the cornea and the lens, reducing the eye's total refractive power[24]. This study of children aged 3-12y showed that as age increased, LT decreased, whereas ACD and AQD increased, which is consistent with the results of previous studies. Moreover, we found that ACD was most affected by age in children with high myopia, with regression coefficients similar to those for LT. This suggests that in children with high myopia, aging primarily affects changes in LT and ACD.

A stable negative correlation exists between the refractive power of the lens and the AL of the eye[25-26]. The CLEERE study revealed that after accounting for the effect of vitreous chamber depth on lens refractive power, the compensatory mechanism of the lens was disrupted when myopia occurred, indicating that the lens no longer thinned or flattened, and its refractive power ceased to decrease[27]. The SCORM study observed eye growth curves in children aged 6-10y. Xiong *et al*[28] found that there is accelerated loss of lens power in emmetropia and early stage of myopia. These findings indicate that the baseline lens refractive power was lower in the group with newly developed myopia and that the refractive power of the lens further decreased, as assessed during follow-up. In this study, the LT of the moderate- and mild-myopia groups were significantly thinner than those of the other groups, with the moderate-myopia group demonstrating the thinnest lenses, which also showed a biphasic pattern in the ACD and AQD. Consistent with previous studies, this finding suggests that the pattern of lens change may be influenced by the development of myopia.

The AL of the eye is an important indicator of refractive development and is characterized by a rapid initial growth rate.

At birth, the average eye AL is approximately 17 mm, which increases rapidly within the first year of life, followed by a decrease in the growth rate. Between 2 and 12y, the length of the anterior segment remains relatively stable, whereas AL continues to increase, reaching an average of approximately 23 mm in adolescence[29-30]. In this study, mean AL was 22.44, 23.41, and 23.97 mm in children aged 3-6, 7-9, and 10-12y, respectively, consistent with a previous study on Chinese children[31]. In this study, we found that aging had the greatest effect on LT, even greater than AL. During eye development, there was no correlation between the volume changes in the anterior and posterior segments of the eye[32]. Age was independently correlated with ACD and LT. In adults with myopia, the collagen fibers in the posterior sclera were thinner, whereas those in the anterior sclera remained normal, leading to differences in the shape of the vitreous cavity compared with normal eyes[33-34].

This suggests that the refractive status of younger children is determined by both the lens and eye axis, whereas that of older children is primarily influenced by the eye axis. This phenomenon may be attributed to the non-synergistic changes in the lens and eye axes mentioned earlier as well as the loss of coordination in the compensatory mechanism between the two as age increases. Further research is required to elucidate the role of ocular biometric parameters in determining the total refractive power of the eye and the mechanisms through which these parameters mutually influence each other.

Notably, the measurements of ocular biometric parameters in this study were performed without paralyzing the ciliary muscle; therefore, the influence of accommodation on the measurement results cannot be ruled out, especially for parameters such as LT and ACD[35]. This study used the IOLMaster 700, which utilizes advanced swept-source optical coherence tomography technology for measurements such as LT. However, in young patients, those with poor fixation, or those with large deviations between the visual and optical axes, measurement errors may still have occurred[36]. Therefore, we conducted three valid measurements for all participants, which may have contributed to reducing errors to a certain extent, and there were differences in the distribution of refractive status among the different age groups in the population. The proportion of children with myopia, especially moderate to high myopia, was relvatively low in the 3- to 6-year-old age group, whereas the 10- to 12-year-old age group included fewer cases of hyperopia, especially of moderate-to-high degree. This intergroup imbalance may have affected the results of the statistical analysis. In addition, owing to the limited number of children with high hyperopia, further investigations are required to validate the conclusions drawn from this group.

Our study represents a cross-sectional description of ocular parameters stratified by refractive status in different age groups (3-12y). These strata share similar characteristics and trends. Children with myopia show increased ACD, AQD, and corneal astigmatism with age, whereas children with hyperopia experience a reduced degree of hyperopia and increased ACD, AQD, and corneal thickness, except in high hyperopia, where changes are limited to AL and LT. At the same refractive status, LT is most affected by aging and becomes thinner with age. Refractive development in younger children is influenced by both the eye axis and crystalline lens, whereas in older children, it is more influenced by the eye axis. Therefore, LT and refractive power may play important roles in both normal visual development and the progression of myopia in young children, and more research is needed to validate the underlying driving mechanisms.

ACKNOWLEDGEMENTS

Data Availability Statement: The anonymized data scales used to support the findings of this study are available from the corresponding author upon reasonable request.

Foundation: Supported by the National Natural Science Foundation of China (No.82171093).

Conflicts of Interest: Ye CY, None; **Liu YJ,** None; **Xing WQ,** None; **Shang JM,** None; **Xu YF,** None; **Qu XM,** None.

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