The Study of Ocular Parameters in Low to Moderate Myopic Chinese Children Age Between Eight to Eighteen-year-old

Zhengxuan Li
Lu Sun
Hongxin Song (songhongxin2012@ccmu.edu.cn)

Research Article

Keywords: Myopia, Corneal parameters, Overnight orthokeratology lens, cornea

Posted Date: April 4th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-736271/v2

Abstract

Purpose

The primary aim of this study was to analyze the distribution of ocular parameters of children aged from eight to eighteen-year-old with low to moderate myopia as well as offer useful information for the design and clinical fitting of ortho-k lens in China.

Methods

In this retrospective study, we collected data of 300 subjects (600 eyes) age between eight to eighteen-year-old from the myopic control outpatient clinic at Beijing Tongren Hospital, Beijing, China. The spherical equivalent (SE), axial length (AL), central corneal thickness (CCT), anterior chamber depth (ACD), corneal endothelial cell density (CECD), corneal diameter (CD), simulated K (Sim K) were collected from all the subjects and analyzed.

Results

The mean of SE for all subjects was − 3.12 ± 1.21D, the median was − 3.16D. The mean of AL for all subjects was 24.72 ± 0.83 mm, the median was 24.72 mm. The mean of CCT for all subjects was 537.8 ± 29.82 μm, the median was 538.17 μm. The mean of CECD for all subjects was 3340.3 ± 352.6 cells/mm^2, the median was 3357.77 cells/mm^2. The mean of ACD for all subjects was 3.71 ± 0.21 mm, the median was 3.69 mm. The mean of CD for all subjects was 12.15 ± 1.67 mm, the median was 12.05 mm. The mean of flat K was 42.80 ± 1.29, the median was 42.81. The mean of steep K was 43.76 ± 1.37, the median was 43.76.

Conclusions

This study provided the distribution of ocular parameters to offer useful information for diagnosis of many eye conditions. Meanwhile, the distribution of ocular parameters of children aged from eight to eighteen-year-old with low to moderate myopia is beneficial to make the application of overnight orthokeratology lens more appropriate and effective.

Background

Together with the sclera, the cornea forms the outermost layer. Cornea, as one of the most essential links, must ensure its transparency, so there is no blood vessel in the cornea tissue.[1, 2] Blood vessels end at the limbus of the cornea to form a vascular network, and nutrients expand into the cornea from of the eyeball-fibrous tunic. Cornea with aqueous humor, lens, vitreous body constitutes the indispensable way for light to enter the inner eyes. The five layers of the cornea are: epithelium, lamina elastica anterior,

stroma, lamina elastica posterior and endothelium.[3–5] The ocular parameters are of great significance for diagnosis of keratoconus, glaucoma, diabetes and other systemic diseases manifests in eyes. [6]

Myopia is the most universal ocular refractive disorder all over the world, especially in China. It was reported that myopia prevalence was 80–90% in young adults, and 10–20% young adults developed into high myopia.[7–9] National prevalence of myopia increased from primary to high school continued the same trend.[10–13] Overnight orthokeratology (ortho-k) lens has been regarded as a safe and effective method to control the myopia progression. Therefore, understanding the distribution of ocular parameters in low to moderate myopic Chinese adolescents is important in ortho-k lens design and fitting. Ocular parameters has been studied in adults in different population, such as in Caucasians, Nigerians and Chinese.[14–16] Chan and colleagues studied the corneal parameters in Chinese children aged between six and twelve years old in Hongkong where is southern part of China in 2012, and this study mainly focused on the corneal anterior parameters, also this study was performed almost ten years ago, many ocular parameters in population may have changed .[17] To provide more detailed ocular information, we collected the ocular parameters of children aged from eight to eighteen-year-old with low to moderate myopia from Beijing Tongren Hospital myopic control clinic, Beijing, China, and we analyzed the ocular parameters distribution in these subjects. The distribution of ocular parameters will provide useful information for the design and application of the ortho-k lens in China.

Methods

Subjects' data were collected from the children who came to the myopic control clinic at Beijing Tongren Hospital between January 2018 and July 2019. The inclusion criteria were children age between eight to eighteen-year-old, with no history of contact lens worn, and free of history of intraocular surgery or ocular trauma, with myopia no more than − 6.00 D and astigmatism (negative cylinder) lower than − 3.50 D. Best corrected vision was 20/20 or better. The study adheres to the Declaration of Helsinki and was approved by Beijing Tongren Hospital Review Board and Ethics Committee.

IOL-Master (Carl Zeiss, Germany) was used in axial length measurement and corneal diameter, corneal topography (Medmont E300 topography, Medmont Pty Ltd, Vermont, VIC, Australia) was used to collect the cornea topography data. Corneal endothelium density was measured by a noncontact specular microscope Topcon Robo SP-9000 (Konan, Hyogo, Japan). Statistical analysis was performed using SPSS 19.0 (SPSS, Inc, Chicago, IL, USA). All data were presented in the shape of the mean ± Std Dev. All distributions were shown in the form of a box graph.

Results

Three hundred subjects' data were collected in our study. Figure 1 shows the distribution of spherical equivalent (SE), axial length (AL), central corneal thickness (CCT), corneal endothelial cell density (CECD), anterior chamber depth (ACD), corneal diameter (CD) and simulated K (Sim K).

The mean of SE for all subjects was − 3.12 ± 1.21D, the median was − 3.16 D. The mean of AL for all subjects was 24.72 ± 0.83 mm, the median was 24.72 mm. The mean of CCT for all subjects was 537.8 ±

29.82 μm, the median was 538.17 μm. The mean of CECD for all subjects was 3340.3 ± 352.6 cells/mm^2, the median was 3357.77 cells/mm^2. The mean of ACD for all subjects was 3.71 ± 0.21 mm, the median was 3.69 mm. The mean of CD for all subjects was 12.15 ± 1.67 mm, the median was 12.05 mm. The mean of flat K for was 42.80 ± 1.29, the median was 42.81. The mean of steep K for was 43.76 ± 1.37, the median was 43.76. (Table 1) In the comparison of different genders and ages (Table 2&3), no statistical significance has been found (P > 0.05).

Table 1
The results of the ocular parameters of the subjects

	spherical equivalent (SE, D)	axial length (AL, mm)	central corneal thickness (CCT, μm)	corneal endothelial cell density (CECD, cells/mm^2)	anterior chamber depth (ACD, mm)	corneal diameter (CD, mm)	simulated K (Sim K)	
							Flat K	Steep K
Mean	-3.12 ± 1.21	24.72 ± 0.83	537.8 ± 29.82	3340.3 ± 352.6	3.71 ± 0.21	12.15 ± 1.67	42.80 ± 1.29	43.76 ± 1.37
Median	-3.164	24.72	538.17	3357.77	3.69	12.05	42.81	43.76

Table 2
The distribution of the ocular parameters in male and female subjects

	SE (D)	AL (mm)	CCT (μm)	CECD (cells/mm^2)	ACD (mm)	CD (mm)	Sim K	
							Flat K	Steep K
Male(N = 174)	-3.15 ± 1.16	24.5 ± 0.75	535.07 ± 32.81	3380.74 ± 241.32	3.72 ± 0.23	11.97 ± 0.32	42.96 ± 1.28	43.91 ± 1.41
Female(N = 126)	-3.19 ± 1.21	25.0 ± 0.78	540.93 ± 29.84	3296.94 ± 29.84	3.68 ± 0.18	12.15 ± 0.32	42.52 ± 1.21	43.44 ± 1.29
P	0.366	0.675	0.289	0.483	0.132	0.645	0.976	0.424

SE = spherical equivalent, AL = axial length, CCT = central corneal thickness, CECD = corneal endothelial cell density, ACD = anterior chamber depth, CD = corneal diameter, Sim K = simulated K.

Table 3
The distribution of the above ocular parameters by decade of age

	SE (D)	AL (mm)	CCT (μm)	CECD (cells/mm^2)	ACD (mm)	CD (mm)	Sim K	
							Flat K	Steep K
Age ≤ 10(N = 180)	-3.02 ± 1.23	24.59 ± 0.81	536.38 ± 30.86	3375.24 ± 243.59	3.72 ± 0.23	11.97 ± 0.32	42.96 ± 1.28	43.91 ± 1.41
Age > 10(N = 120)	-3.39 ± 1.12	24.96 ± 0.74	539.08 ± 32.98	3299.99 ± 243.45	3.68 ± 0.18	12.15 ± 0.32	42.52 ± 1.21	43.44 ± 1.29
P	0.381	0.428	0.098	0.563	0.151	0.898	0.986	0.927

SE = spherical equivalent, AL = axial length, CCT = central corneal thickness, CECD = corneal endothelial cell density, ACD = anterior chamber depth, CD = corneal diameter, Sim K = simulated K.

Discussion

To make the application of overnight orthokeratology lens in China become more appropriate and effective

With the increase of the pace of life and the pressure of the learning, the myopia rate of Chinese children has been presented a sharp rise in the recent years. Reducing and controlling the myopia progression has become a hot topic among researchers all over the world. [18–20] Overnight orthokeratology lens is an effective method in slowing down the progression of myopia. As an external object flatten the central portion of the cornea, the fitting of overnight orthokeratology lens needs the precise data of the ocular parameters of patients, especially for the juveniles who are in the period of growth and development. [21–26]

The main application market of contact lenses was for conveniently refractive correction and cosmetic reason. Therefore, the target customers of contact lens are designed for adults, the research and application of ocular parameters are also based on their data.[17] However, with the prevalence of myopia development, especially the high incidence rate of myopia in East Asia, Overnight orthokeratology lens has gradually become an effective means to control the development of myopia.[27, 28, 9]

In this study, statistical analysis was conducted in groups of different genders (males, 126 subjects with 252 eyes; females, 174 subjects with 348 eyes), simultaneously in age divided younger or equal to ten years old (180 subjects with 360 eyes) and older than ten years old (120 subjects with 240 eyes). No statistical significance was found in the above conditions.

Overnight orthokeratology lens, as a contact lens which were placed against the surface of the cornea, are worn at night and take off during the daytime. The distribution of these ocular parameters is benefit for the first best fitting of overnight orthokeratology lens. The axial elongation is an important factor for

evaluating the progression of myopia, while the elongation of the AL does not mean the severity of myopia because there is also a physiological increase in adolescents.[29–32] Studying the distribution of AL in adolescents is helpful to understand the physiological axial growth.

The fitting of ortho-k lens requires accurate measurements of ocular parameters to achieve a proper lens fitting, the variation of ocular parameters was crucial for the practitioner to select the appropriate ortho-k lens. Most of the lenses now offered by manufacturers are based on the corneal profile of Caucasian adults, and repeated adjustments and lens fitting due to the improper lens would cost tremendous money and time.[9, 30, 27] Our study provides the distribution of ocular parameters in low to moderate myopic Chinese adolescents; therefore, it can provide useful information for contact lens design for Asian children.

To compare with previous studies of different race.

Although the distribution of the corneal parameters of Asians, Caucasians, Africans and Arabian have well manifested in the range of adults in the past 20 years (Table 4), there was still a shortage of large sample aimed at children. The retrospective study found that Asians have smaller corneal diameter than Caucasians and Africans. The corneal diameter in our study is larger than previous study indicating there may be ocular parameters changes during the past decade. Previous studies demonstrate that Chinese children have thinner central corneal thickness than others, no conspicuous difference with the results of our study. The data of characteristics of the corneal endothelial cell density was similar with previous studies.

Table 4
The comparison of ocular parameters with previous studies of different race. (NR = Not reported)

Authors	Race	Number of eyes	Age	Gender	CD (mm)	CCT (μm)	CECD (cells/mm^2)
Rufer et al(2005)[30]	Caucasians	743	10–80	Male & Female	11.71 ± 0.42	NR	NR
Ashaye et al(2006)[31]	Africans	684	0-0.65	Male & Female	10.26 ± 0.59	NR	NR
Pinero et al(2008)[32]	Caucasians	60	20–51	Male & Female	11.76 ± 0.52(OCT) 12.25 ± 0.49(CT)	NR	NR
Hashemi et al(2010)[33]	Iranians	800	≥ 14	Male & Female	11.68	NR	NR
Iyamu & osuobeni (2012)[34]	Africans	130	20–79	Male & Female	11.39 ± 0.69	548.97 ± 34.28	NR
Sanchis-gimeno et al (2012)[15]	Caucasians	379	18–53	Male & Female	11.9 ± 0.2	559 ± 18	NR
Zha et al(2013)[35]	Chinese	129	NR	Male & Female	10.57 ± 0.34	NR	NR
Kohnen et al(2004)[36]	Caucasians	52	NR	Male & Female	12.17 ± 0.45(IOL Master) 11.84 ± 0.41 (Orbscan)	NR	NR
Dinc et al(2010)[37]	Turks	80	NR	Male & Female	11.87 ± 0.35(IOL Master) 11.65 ± 0.32 (Orbscan)	NR	NR
Shimmy et al(2003)[38]	African-Americans Asians Caucasians	118 172 1482 204	37.20 ± 9.78 34.48 ± 7.30 38.10 ± 9.86 34.21 ± 9.40	Male & Female	NR	535.46 ± 33.40 549.79 ± 32.30 552.59 ± 34.50 551.1 ± 35.54	NR

Authors	Race	Number of eyes	Age	Gender	CD (mm)	CCT (μm)	CECD (cells/mm^2)
Altinok et al (2007)[39]	Turks	276 349	44.1 ± 16.6 41.0 ± 16.9	Male Female	NR	552.2 ± 35.9 552.3 ± 35.4	NR
Casson et al (2008)[40]	Burmese	1909	56.2 ± 11.5	Male & Female	NR	521.9 ± 33.3	NR
Sardiwalla et al (2012)[15]	South African Blacks & Indians	100 100	20.1 ± 1.6	Male & Female	NR	512.4 ± 38.9 526.5 ± 37.2	NR
Shao et al (2007)[41]	Chinese	100 100	14 ± 2 24 ± 2	Male & Female	NR	NR	3308 ± 356 2988 ± 243

Table4. The comparison of ocular parameters with previous studies of different race (see Additional table 4)

NR=Not reported

Conclusion

In conclusion, our study provides the distribution of ocular parameters in low to moderate myopic Chinese adolescents to offer useful information for the design and clinical fitting of ortho-k lens in China.

List Of Abbreviations

SE
spherical equivalent
AL
axial length(B)
CCT
central corneal thickness
CECD
corneal endothelial cell density(D)
CD
corneal diameter(E)
ACD
anterior chamber depth(H)

Sim K
simulated K

Declarations

Ethics approval

The study adheres to the Declaration of Helsinki and was approved by Beijing Tongren Hospital Review Board and Ethics Committee.

Availability of data and materials

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

Competing Interest

No conflicting relationship exists for any author.

Funding

No funding

Authors' contribution

Li, Sun and Song were primarily responsible for experimental concept and design. Li and Sun performed data acquisition and analysis, as well as drafting of the manuscript. Li was also involved in data analysis. All authors reviewed and approved the final manuscript.

Consent for publication

Not applicable.

References

1. Meek KM, Knupp C (2015) Corneal structure and transparency. Prog Retin Eye Res 49:1–16. doi:10.1016/j.preteyeres.2015.07.001
2. Doughty MJ, Jonuscheit S (2019) Corneal structure, transparency, thickness and optical density (densitometry), especially as relevant to contact lens wear-a review. Cont Lens Anterior Eye 42 (3):238–245. doi:10.1016/j.clae.2018.11.014
3. Eghrari AO, Riazuddin SA, Gottsch JD (2015) Overview of the Cornea: Structure, Function, and Development. Prog Mol Biol Transl Sci 134:7–23. doi:10.1016/bs.pmbts.2015.04.001
4. DelMonte DW, Kim T (2011) Anatomy and physiology of the cornea. J Cataract Refract Surg 37 (3):588–598. doi:10.1016/j.jcrs.2010.12.037

5. Zhang B, Xue Q, Li J, Ma L, Yao Y, Ye H, Cui Z, Yang H (2019) 3D bioprinting for artificial cornea: Challenges and perspectives. Med Eng Phys 71:68–78. doi:10.1016/j.medengphy.2019.05.002
6. Ma J, Wang Y, Wei P, Jhanji V (2018) Biomechanics and structure of the cornea: implications and association with corneal disorders. Surv Ophthalmol 63 (6):851–861. doi:10.1016/j.survophthal.2018.05.004
7. Tay SA, Farzavandi S, Tan D (2017) Interventions to Reduce Myopia Progression in Children. Strabismus 25 (1):23–32. doi:10.1080/09273972.2016.1276940
8. Morgan IG, French AN, Ashby RS, Guo X, Ding X, He M, Rose KA (2018) The epidemics of myopia: Aetiology and prevention. Prog Retin Eye Res 62:134–149. doi:10.1016/j.preteyeres.2017.09.004
9. Cho P, Tan Q (2019) Myopia and orthokeratology for myopia control. Clin Exp Optom 102 (4):364–377. doi:10.1111/cxo.12839
10. Liu HH, Xu L, Wang YX, Wang S, You QS, Jonas JB (2010) Prevalence and progression of myopic retinopathy in Chinese adults: the Beijing Eye Study. Ophthalmology 117 (9):1763–1768. doi:10.1016/j.ophtha.2010.01.020
11. He M, Zeng J, Liu Y, Xu J, Pokharel GP, Ellwein LB (2004) Refractive error and visual impairment in urban children in southern china. Invest Ophthalmol Vis Sci 45 (3):793–799. doi:10.1167/iovs.03-1051
12. Zhang M, Li L, Chen L, Lee J, Wu J, Yang A, Chen C, Xu D, Lam DS, Sharma A, Griffiths S, Gao Y, Congdon N (2010) Population density and refractive error among Chinese children. Invest Ophthalmol Vis Sci 51 (10):4969–4976. doi:10.1167/iovs.10-5424
13. David Troilo KTaEH (2009) Imposed Anisometropia, Accommodation, and Regulation of Refractive State. 86:31–39
14. Mashige KP (2013) A review of corneal diameter, curvature and thickness values and influencing factors*. African Vision and Eye Health 72 (4). doi:10.4102/aveh.v72i4.58
15. Sanchis-Gimeno JA, Sanchez-Zuriaga D, Martinez-Soriano F (2012) White-to-white corneal diameter, pupil diameter, central corneal thickness and thinnest corneal thickness values of emmetropic subjects. Surg Radiol Anat 34 (2):167–170. doi:10.1007/s00276-011-0889-4
16. Hassan Hashemi MK, Kamran Yazdani, Shiva Mehravaran, Kazem Mohammad, and Akbar Fotouhi, (2010) White-to-White Corneal Diameter in the Tehran Eye Study. clinical science 29:9–12
17. Chan KY, Cheung SW, Cho P (2012) Corneal parameters of six- to 12-year-old Chinese children. Clin Exp Optom 95 (2):160–165. doi:10.1111/j.1444-0938.2011.00682.x
18. Chen C, Cheung SW, Cho P (2013) Myopia control using toric orthokeratology (TO-SEE study). Invest Ophthalmol Vis Sci 54 (10):6510–6517. doi:10.1167/iovs.13-12527
19. Chen Q, Li M, Yuan Y, Me R, Yu Y, Shi G, Ke B (2017) Interaction between Corneal and Internal Ocular Aberrations Induced by Orthokeratology and Its Influential Factors. Biomed Res Int 2017:3703854. doi:10.1155/2017/3703854
20. Chen R, Mao X, Jiang J, Shen M, Lian Y, Zhang B, Lu F (2017) The relationship between corneal biomechanics and anterior segment parameters in the early stage of orthokeratology: A pilot study.

Medicine (Baltimore) 96 (19):e6907. doi:10.1097/MD.0000000000006907

21. Swarbrick HA (2006) Orthokeratology review and update. Clin Exp Optom 89 (3):124–143. doi:10.1111/j.1444-0938.2006.00044.x
22. Cho P, Cheung SW, Edwards M (2005) The longitudinal orthokeratology research in children (LORIC) in Hong Kong: a pilot study on refractive changes and myopic control. Curr Eye Res 30 (1):71–80. doi:10.1080/02713680590907256
23. Walline JJ, Jones LA, Sinnott LT (2009) Corneal reshaping and myopia progression. Br J Ophthalmol 93 (9):1181–1185. doi:10.1136/bjo.2008.151365
24. Kakita T, Hiraoka T, Oshika T (2011) Influence of overnight orthokeratology on axial elongation in childhood myopia. Invest Ophthalmol Vis Sci 52 (5):2170–2174. doi:10.1167/iovs.10-5485
25. Jacinto Santodomingo-Rubido CV-C, Bernard Gilmartin and Ramón Gutiérrez-Ortega (2012) Myopia Control with Orthokeratology Contact Lenses in Spain (MCOS): Refractive and Biometric Changes. The Association for Research in Vision and Ophthalmology
26. Cho P, Cheung SW (2012) Retardation of myopia in Orthokeratology (ROMIO) study: a 2-year randomized clinical trial. Invest Ophthalmol Vis Sci 53 (11):7077–7085. doi:10.1167/iovs.12-10565
27. He M, Du Y, Liu Q, Ren C, Liu J, Wang Q, Li L, Yu J (2016) Effects of orthokeratology on the progression of low to moderate myopia in Chinese children. BMC Ophthalmol 16:126. doi:10.1186/s12886-016-0302-5
28. Cheung SW, Boost MV, Cho P (2019) Pre-treatment observation of axial elongation for evidence-based selection of children in Hong Kong for myopia control. Cont Lens Anterior Eye 42 (4):392–398. doi:10.1016/j.clae.2018.10.006
29. Chen Z, Zhou J, Qu X, Zhou X, Xue F (2018) Effects of orthokeratology on axial length growth in myopic anisometropes. Cont Lens Anterior Eye 41 (3):263–266. doi:10.1016/j.clae.2017.10.014
30. Lipson MJ, Brooks MM, Koffler BH (2018) The Role of Orthokeratology in Myopia Control: A Review. Eye Contact Lens 44 (4):224–230. doi:10.1097/ICL.0000000000000520
31. Kinoshita N, Konno Y, Hamada N, Kanda Y, Shimmura-Tomita M, Kakehashi A (2018) Additive effects of orthokeratology and atropine 0.01% ophthalmic solution in slowing axial elongation in children with myopia: first year results. Jpn J Ophthalmol 62 (5):544–553. doi:10.1007/s10384-018-0608-3
32. Zhang Y, Chen Y (2019) Effect of Orthokeratology on Axial Length Elongation in Anisomyopic Children. Optom Vis Sci 96 (1):43–47. doi:10.1097/opx.0000000000001315

Figures

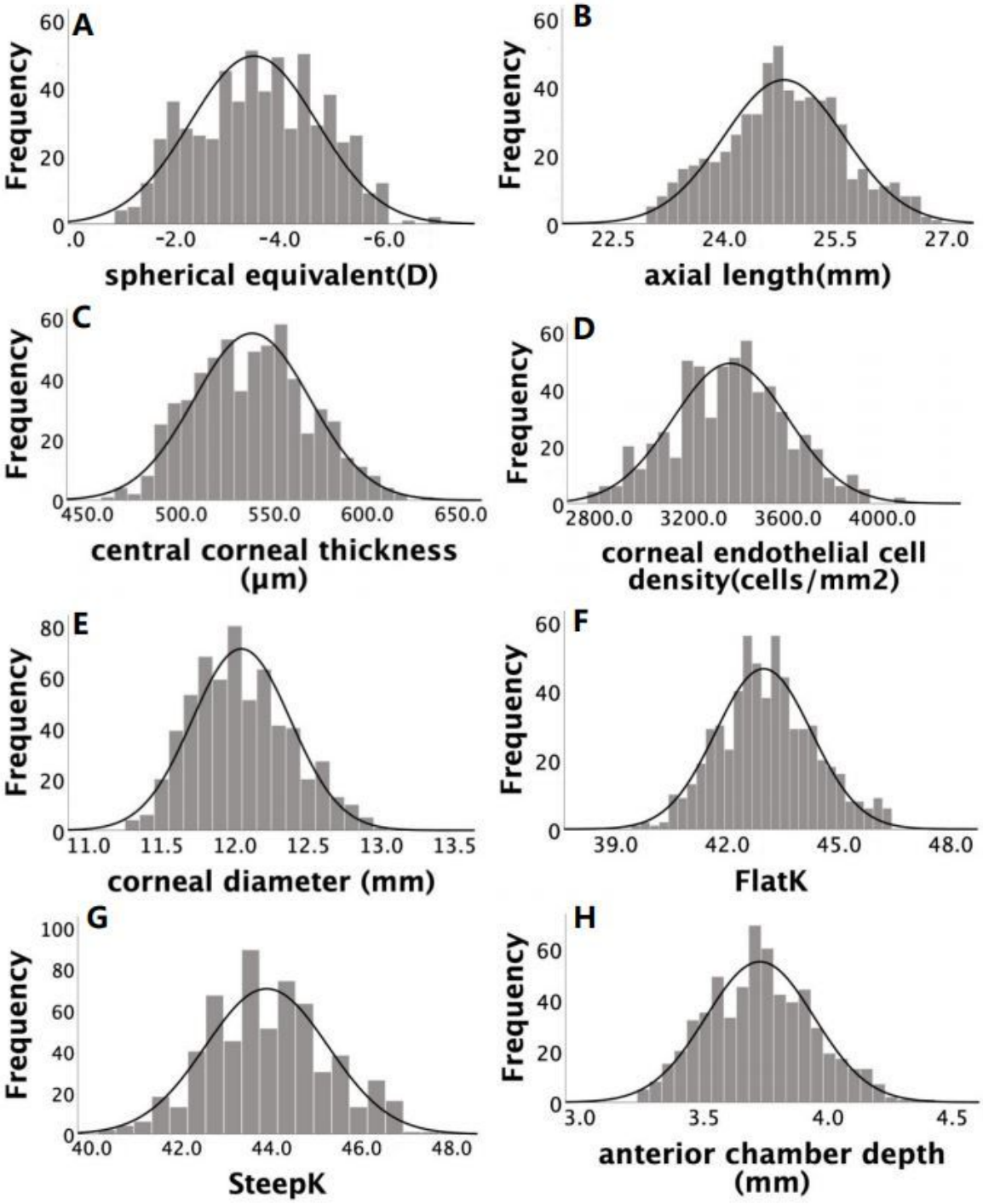

Figure 1

The distribution of spherical equivalent(A), axial length(B), central corneal thickness(C), corneal endothelial cell density(D), corneal diameter(E), Flat K(F), Steep K(G) and anterior chamber depth(H) in Chinese juveniles.