

Progression of myopia among undergraduate students in central China

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Abstract

• **AIM:** To investigate the progression of myopia and risk factors among university students in central China.

• **METHODS:** A total of 7359 first-year undergraduate students at Huazhong University of Science and Technology in central China were recruited to the study and invited to a centralized clinic for medical examination, including optometry, and re-examined after one year. Correlation analyses were performed to assess the associations between one-year myopia progression and various parameters.

• **RESULTS:** The spherical equivalent refraction for the overall population was -3.14 ± 2.28 D at baseline. The rate of myopia progression over 0.50 D after one year was 41.9%, and the 1-year progression of myopia was -0.47 ± 0.58 D. There was no difference of mean 1-year myopia progression between male and female or difference among age group. The myopia progression of original myopia was severer than progression of new-onset myopia. There was also difference of mean myopia progression among different degrees of myopia at baseline. The under corrected eyes had a higher percentage of myopia progression than well corrected eyes ($\chi^2=7.90$, $P<0.01$). There was no correlation between myopia progression and height, weight, body mass index, hemoglobin (Spearman correlation, $\rho=-0.078$, -0.152 , -0.170 , -0.096 , respectively, all $P>0.05$).

• **CONCLUSION:** Myopes still progress in undergraduate students, especially in high myopes.

• **KEYWORDS:** myopia progression; high myopia; prevalence; undergraduate students

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INTRODUCTION

In recent years, the world has been faced with the myopia rapid growth, especially in east Asia. It is predicted to affect almost a half of the world's population within the next years^[1]. The prevalence of myopia is more than 2 times higher among east Asians than similarly aged white persons, and the prevalence of myopia seems to be increasing most dramatically among younger people in East Asia^[2].

College students comprise a specific population characteristic of academic excellence, and their vision problems are very serious. The prevalence of myopia in university students in China is reported to surpass 90%, and even worse, 19.5% progressed to high myopia and pathologic myopia^[3], which finally leads to irreversible vision loss and hampers their professional development and social competence. Perhaps high level of prolonged near work in and out of class for more than ten years and less time outdoors are the main reasons. The combination of vision impairment from uncorrected myopia and irreversible vision loss from myopia-related complications make accurate estimates of the prevalence and trends critical for planning care and services of college students.

However, existing reports of this problem on college students are still very limited^[3-5]. More importantly, myopia progression among college students had never been estimated in previous studies. We have neglected the prevention and control of myopia among college students for a long time. Normal eye growth in emmetropes is complete by 13 to 15 years of age, so there was considered to be no threat of myopia progression for college students. In fact, due to occupational factors, college students are under high risk of myopia progression.

To evaluate progression among a population of highly educated young adults, we performed a longitudinal study of first-year college students in one of the universities located in central China.

SUBJECTS AND METHODS

Ethical Approval This study was approved by the Human Ethics Committee of Huazhong University of Science and Technology and was carried out according to the tenets of

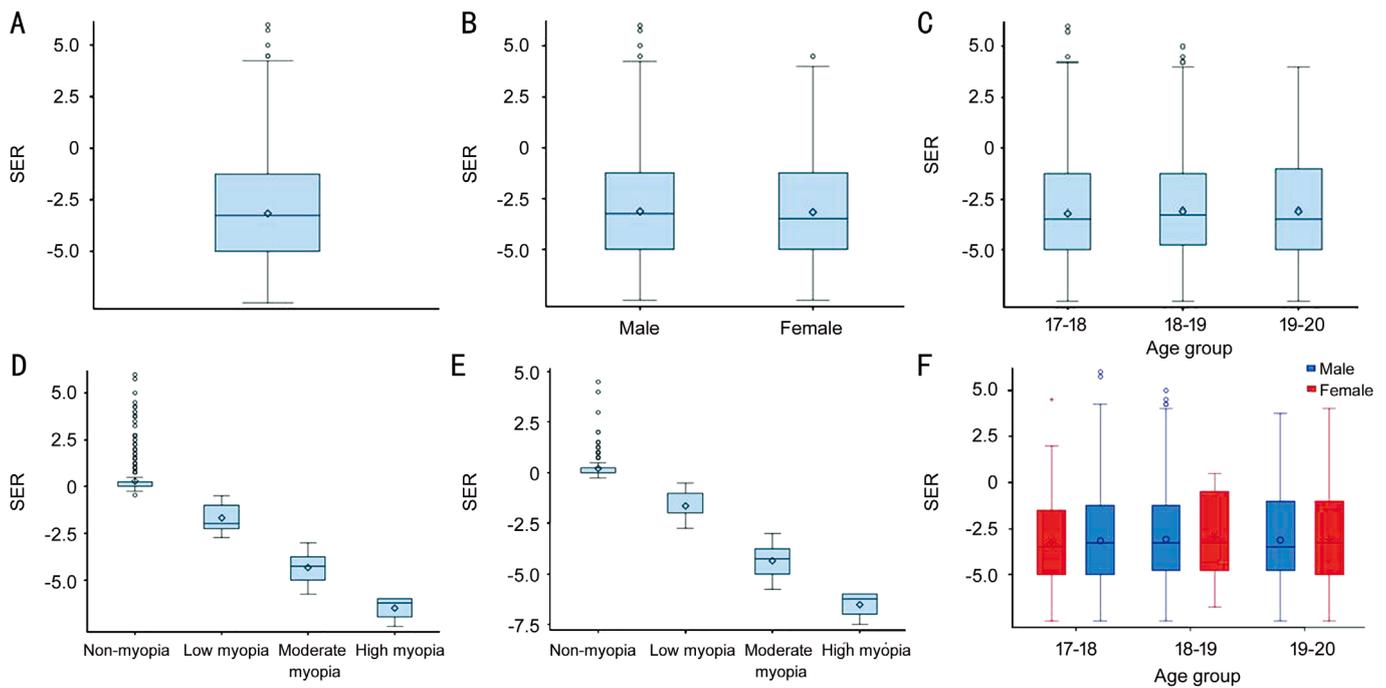


Figure 1 Distribution of SER in the worse eye A: SER for the overall population; B: SER difference between male and female; C: SER difference among age groups; D: SER distribution of male students among non-myopia, low, moderate, and high myopia groups; E: SER distribution of female students among non-myopia, low, moderate, and high myopia groups; F: SER stratified by age and sex. SER: Spherical equivalent refraction.

the Declaration of Helsinki. The purpose of the study was explained, a written informed consent was obtained from each participant, and a self-reported questionnaire survey was administered.

Study Population All the new students of Huazhong University of Science and Technology in Wuhan, Hubei province, were recruited. The university has 30 colleges with about 10 classes in each college and approximately 30 students in each class. Each first-year student had a unique Quick Response (QR) Code to ensure correct identification. The same cohort of students were re-examined after a period of one year. Participants were excluded if their refraction check was invalid or loss to follow-up or had a medical history of eye diseases, and refractive correction surgery.

Eye examination was conducted by two experienced ophthalmologists and two qualified optometrists from the Ophthalmology Department of Tongji Hospital. All subjects underwent a measurement of uncorrected distance visual acuity (UCDVA) at 5 m (standard logarithmic visual acuity E chart) and slit lamp. Refractive error (RE) of each subject was measured by the automatic refractometer (AR-600; Nidek Ltd., Tokyo, Japan) without cycloplegia. The spherical equivalent refraction (SER) was calculated by adding together the spherical refraction and half the cylindrical refraction.

Data for blood pressure, height, and weight, and hemoglobin came from the new entrance medical examination at the baseline. Height and weight data were then used to determine each participant's body mass index (BMI).

Statistical Analysis Statistical analyses were conducted using the statistical package for IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY, USA). The correlations between myopia progression and the various parameters considered in this study were assessed using the Spearman's rank correlation coefficient test. Parameters that showed a univariate association with P value less than 0.05 were selected as candidate variates for multivariate analysis. Continuous variables were presented using the weighted mean and standard deviation (SD) or median with interquartile range (IQR) in case of variables not distributed normally, and categorical variables were represented as percentages. A P value less than 0.05 was considered as statistically significant.

RESULTS

A total of 7359 students were enrolled in the study. The response rate based on the number of validated examinations was 85.2% ($n=6270$), of which 67.6% ($n=4542$) were male participants, and 32.4% ($n=1728$) were females. The mean age of the students was 18.1 ± 0.7 y at baseline.

Distribution of Spherical Equivalent Refraction at Baseline The distribution of SER at baseline is shown in Figure 1A. SER for the overall population did not demonstrate normal distribution (Kolmogorov-Smirnov test, $P=0.008$). The distribution of SER was positively skewed. There was significant difference between the left and right eye (Wilcoxon signed-ranks and Mann-Whitney U tests, $P=0.001$). The baseline SER from the worse eye of each student was used for analysis.

Table 1 The mean myopia progression after one year stratified by age and groups

Sex	Non-myopia (SER>-0.5 D)	Low myopia (-3.0<SER≤-0.5 D)	Moderate myopia (-6.0<SER≤-3.0 D)	High myopia (SER≤-6.0 D)
Male	-0.25±0.48	-0.49±0.52	-0.40±0.33	-0.65±0.59
Age 17-18y	-0.27±0.49	-0.51±0.74	-0.36±0.53	-0.65±0.87
Age 18-19y	-0.21±0.36	-0.50±0.57	-0.43±0.41	-0.61±0.96
Age 19-20y	-0.24±0.41	-0.43±0.39	-0.41±0.73	-0.67±0.77
Female	-0.27±0.43	-0.42±0.51	-0.46±0.33	-0.62±0.49
Age 17-18y	-0.31±0.38	-0.48±0.58	-0.51±0.76	-0.57±0.91
Age 18-19y	-0.25±0.40	-0.44±0.61	-0.36±0.23	-0.62±0.77
Age 19-20y	-0.26±0.65	-0.37±0.44	-0.47±0.58	-0.64±0.83
Total	-0.25±0.33	-0.45±0.78	-0.48±0.45	-0.64±0.80

SER: Spherical equivalent refraction.

Myopia was defined as SER<-0.5 D. The overall prevalence of myopia was 83.9% (95%CI: 82.8% to 84.8%). SER for the overall population was -3.25 (3.75) D or -3.14±2.28 D.

Spherical Equivalent Refraction Stratified by Age, Sex and Groups There was no significant difference in SER between the male -3.13±2.27 D and female -3.17±3.09 D (Wilcoxon signed-ranks and Mann-Whitney *U* tests, *P*=0.917; Figure 1B), nor any significant difference in SER among students 17-18 years of age (male: -3.16±2.28 D, female: -3.23±2.29 D), 18-19 years of age (male: -3.07±2.26 D, female: -2.97±2.35 D), and 19-20 years of age (male: -3.10±2.36 D, female: -3.23±2.29 D, Kruskal-Wallis *H*, *H*=1.213, *P*=0.324; Figure 1C, 1F).

The students were divided in to four groups: non-myopia (SER less than -0.5 D), low myopia (SER between -0.5 and -3.0 D), moderate myopia (SER between -3.0 and -6.0 D), high myopia (SER greater than -6.0 D). There was no statistically significant difference in distribution between males and females ($\chi^2=0.354$, *P*=0.242; Figure 1D, 1E).

Myopia Progression Myopia progression was defined as the difference between the SER at the baseline and at the one-year follow up. The rate of myopia progression over 0.50 D among undergraduate students in central China was 41.9%. The mean myopia progression after one year stratified by age and groups was shown in Table 1.

SER for the overall population did not demonstrate normal distribution (Kolmogorov-Smirnov test, *P*=0.035). There was no difference of mean myopia progression between male (-0.47±0.40 D) and female (-0.49±0.35 D; Wilcoxon signed-ranks and Mann-Whitney *U* tests, *P*=0.315), nor difference among age group (Kruskal-Wallis *H*, *H*=1.687, *P*=0.324).

The myopia progression of original myopia was severer than progression of new-onset myopia (non-myopia at the baseline; Wilcoxon signed-ranks and Mann-Whitney *U* tests, *P*=0.008). There was also difference of mean myopia progression among different degrees of myopia at baseline (Kruskal-Wallis *H*, *H*=18.273, *P*=0.032). Per pairwise comparisons, there was a statistically significant difference between moderate and severe

groups (Mann-Whitney *U* test, *U*=33, *P*=0.021), and mild and severe groups (Mann-Whitney *U* test, *U*=53, *P*=0.008).

Correction Status in Myopia Subjects The under corrected refractive error was defined as improvement of at least two lines in visual acuity of the better eye with the best possible refraction correction compared with the habitual visual acuity. Table 2 shows the percentage of myopia progression of different correction status. A total of 2450 subjects (46.6% of all myopia subjects) experienced myopia progression of over 0.50 D change of SER in one year. The well corrected eyes had a lower incidence of myopia progression than under corrected eyes ($\chi^2=7.90$, *P*=0.004).

Correlation Analysis Spearman correlation coefficients (ρ) were calculated between myopia progression and height, weight, BMI, and hemoglobin to explore the relationship between myopia progression and physical parameters. There was no correlation between myopia progression and these parameters (Table 3). The correlation between myopia progression and myopia diopter at baseline was marginally significant in female ($\rho=-0.204$, *P*=0.058).

DISCUSSION

In our study, we confirmed the rate of myopia progression among undergraduate students in central China was 41.9%, which is considerably higher than the prevalence in young adult military Chinese men (27.3%)^[6], or children aged 4-17 years old (35.0%)^[7]. The population with a higher level of education and academic achievement was revealed to be associated with myopia, because these people are more inclined to spend more time at near work and less time in outdoor activity^[8]. A literature review found that children with higher Intelligence Quotient scores tend to be more myopic, but near work could be a possible confounding factor^[9]. There is no doubt that college students constitute a population of higher education level than the average. Moreover, the samples in our study were from a top-ranking university. Another possible explanation is that college students are exposed to excessive electronic screens because of occupational need.

Table 2 Percentage of myopia progression and correction status

Myopia	Total	Corrected	Well corrected	Under corrected	χ^2	P
Mild myopia	657 (36.8)	590 (37.7)	533 (39.0)	77 (39.3)	0.01	0.922
Moderate myopia	1270 (49.1)	1153 (46.0)	1013 (45.7)	140 (49.1)	0.85	0.312
High myopia	523 (62.4)	408 (46.2)	321 (43.2)	87 (63.5)	19.52	0.001
Total	2450 (46.6)	2151 (43.5)	1867 (43.1)	304 (49.1)	7.90	0.004

Myopia progression was defined as the difference between the spherical equivalent refraction at the baseline and at the one-year follow up over 0.50 D. Chi-squared tests were used to compare the percentage of myopia progression between well corrected eyes and under corrected eyes.

Table 3 Correlation between myopia progression and height, weight, BMI, hemoglobin and myopia diopter at baseline

Parameters	Mean	SD	Median	95%CI	ρ	P
Male						
Height	169.44	9.10	169.10	60.33, 63.76	0.026	0.690
Weight	62.05	13.68	60.00	168.30, 170.58	0.100	0.118
BMI	21.50	3.71	20.68	21.03, 21.96	0.103	0.105
Hemoglobin	6.69	1.46	6.64	6.51, 6.87	-0.002	0.970
Myopia diopter	131.62	17.79	135.00	129.39, 133.85	0.022	0.730
Female						
Height	169.37	9.26	168.40	58.05, 63.99	-0.078	0.474
Weight	61.02	13.95	58.80	167.40, 171.35	-0.152	0.160
BMI	21.10	3.46	20.51	20.36, 21.84	-0.170	0.116
Hemoglobin	6.71	1.52	6.57	6.38, 7.03	-0.096	0.427
Myopia diopter	132.77	18.31	137.00	128.87, 136.67	-0.204	0.058
Age 17-18y						
Height	169.28	9.04	168.90	59.85, 63.31	-0.060	0.398
Weight	61.58	12.44	60.10	168.03, 170.54	0.028	0.692
BMI	21.40	3.40	20.93	20.93, 21.87	0.041	0.561
Hemoglobin	6.76	1.49	6.75	6.55, 6.96	-0.003	0.960
Myopia diopter	132.63	17.31	137.00	130.22, 135.04	-0.044	0.532
Age 18-19y						
Height	169.95	9.73	169.40	59.38, 66.44	0.136	0.219
Weight	62.91	16.16	59.10	167.82, 172.07	0.115	0.300
BMI	21.55	4.01	20.34	20.68, 22.43	0.105	0.345
Hemoglobin	6.60	1.49	6.50	6.28, 6.92	-0.074	0.507
Myopia diopter	132.27	18.41	135.00	128.25, 136.29	-0.035	0.752
Age 19-20y						
Height	169.09	8.57	168.40	56.60, 64.84	-0.035	0.808
Weight	60.72	14.49	57.95	166.65, 171.52	-0.124	0.391
BMI	21.09	4.00	20.42	19.96, 22.23	-0.145	0.314
Hemoglobin	6.61	1.43	6.45	6.20, 7.01	-0.028	0.846
Myopia diopter	128.50	19.37	130.00	123.00, 134.01	0.034	0.812

SD: Standard deviation; CI: Confidence interval; BMI: Body mass index.

The 1-year progression of myopia in this study was -0.47 ± 0.58 D, which is lower than those reported in different clinical trials conducted in Chinese school children with reported values varying from -0.63 to -2.00 D per year^[10]. Normal eye growth in emmetropes is complete by 13 to 15 years of age. All the population in this study are adolescences aged 17 years or older, however, showed a rate of myopia development similar to that of teenager. It has been suggested that this continued axial elongation may be because of active sclera tissue remodeling and consequent lens thinning and

vitreous chamber elongation^[11].

This study showed the rate of myopia progression varied with myopia status at baseline, but not with age or gender. Other studies documented that females were more likely to develop myopia than males, because they spent more time reading and doing near work^[12]. The reasons may be that the male and female subjects in our research were susceptible to occupational myopia. The high myopia rate of female students was slightly greater than that of males (14.1% vs 13.8%), but still there was no significant difference. In addition, myopia

develops rapidly at younger ages, but in this study, there was no difference among age groups, the reasons may be that the subjects in this study had completed their eyeball development and the age range was small.

Previous studies have only focused on the rate of myopia, but each diopter matters in controlling myopia. In this study, SER for the overall population was -3.14 ± 2.28 D, and the 1-year progression in moderate myopia was -0.48 ± 0.45 D. Bullimore and Brennan^[13] showed that each diopter increase in myopia was associated with a 67% increase in the prevalence of myopic maculopathy. And 3-diopter myopia was defined as moderate myopia, which also has a risk for myopic maculopathy and early age-related maculopathy^[14]. Even if slowing their myopic progression just by 1 D during childhood should lower the risk^[15].

Of particular concern is that the prevalence of high myopia in this study was 14.1%, which corresponded to several previous reports among university students (7.9% to 16.6% in Fenghua City^[16], and 19.5% in Shanghai^[3]), was twice as much as that of the general adult population (7.0% in the Korean adult population^[17]). To make matters worse, we found that individuals with a higher degree of myopia had greater myopia progression compared to those with a mild degree of myopia. The exact mechanism on why high and severe myopes progress at a faster rate compared to that of mild myopes is not clear, an indirect relation can be speculated towards an association with the earlier age of onset of myopia^[18]. Researchers attribute the epidemic to the high educational pressures and limited time outdoors in the university population, rather than to genetically elevated sensitivity^[19]. Therefore, the lifestyle modification is crucial in the prevention and control of high myopia.

The ratio of spectacle ownership was 87.6% in mild myopia subjects indicating an unsatisfactory corrective status of first year university students. And unprofessional optometry and lack of regular examination of visual acuity result in an under corrected rate of 11.8%. Qian *et al*^[20] showed that among multiethnic school students aged 5-16 years old in rural China, there was a high ratio of needing for spectacles (68.3%) and a very low ratio of spectacle ownership (18.9%). Wang *et al*^[21] reported similar results in schools for children in Shanghai, China. The main reasons for their reluctance to prescribe spectacles were increased cost, inadequate information, and aesthetic reasons.

A widespread opinion is that wearing spectacles may be harmful to our eyes leading rapidly increasing of refractive error. This attitude prevents full correction of myopia students, even if they had medium or high myopia and suffered from blurred vision. In this study, the under corrected eyes had a higher percentage of myopia progression than well corrected eyes. It was consistent with some literature, which indicated

that improving optical corrections and visual behavior to generate inhibitory signals for eye growth in the retina^[22]. But there is no strong evidence of benefits from un-correction, monovision or over-correction^[23].

Time spent outdoors and the level of education have been confirmed to be associated with myopia progression by mainstream studies^[24-28], but other risk factors such as height and weight are less clear. As our participants had the same level of education and performed the same intensity of near work, we were concerned more in examining the association between myopia progression and the following body factors among undergraduate students. Joseph *et al*^[29] showed that increasing height was associated with higher odds of myopia in children aged 7-14y, because axial length was positively correlated with body height and weight. Tideman *et al*'s^[30] results coincide with this conclusion. But in this survey the body height, weight and BMI were not associated with myopia. The underlying reason could be that unlike children at the age of puberty, the link between axial length and body height in undergraduate students, was reduced due to their arrested development (in height). Hemoglobin combines with oxygen and carries it around the body and could reflect athletic ability^[31], but it had no correlation with myopia progression in this study.

The major strengths of the current study are the research design, which enabled us to analyze the natural progression of college students in a large cohort and the relatively low drop-out rate. The limitation of the study is the lack of data on axial length and other ocular parameters. We did not take standardized measurements of cycloplegic refractive error, however, this study was to compare the change of refractive error of the same subjects, so the pseudo myopia by accommodative spasm would have not affected the reliability. In summary, our study demonstrated a high prevalence of myopia progression among undergraduate students similar to school children. We also found high myopes progressed at a faster rate compared to that of mild myopes in undergraduate students. Moreover, the under corrected eyes had a higher percentage of myopia progression than well corrected eyes. Concerning that race is a critical factor in various ocular parameters^[32], future studies are needed to evaluate racial background and its association with myopia progression in future studies.

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REFERENCES

- 1 Shan M, Dong Y, Chen J, Su Q, Wan Y. Global tendency and frontiers of research on myopia from 1900 to 2020: a bibliometrics analysis. *Front Public Health* 2022;10:846601.
- 2 Chen YX, Liao CM, Tan Z, He MG. Who needs myopia control? *Int J Ophthalmol* 2021;14(9):1297-1301.

- 3 Sun J, Zhou J, Zhao P, Lian J, Zhu H, Zhou Y, Sun Y, Wang Y, Zhao L, Wei Y, Wang L, Cun B, Ge S, Fan X. High prevalence of myopia and high myopia in 5060 Chinese university students in Shanghai. *Invest Ophthalmol Vis Sci* 2012;53(12):7504-7509.
- 4 Huang L, Kawasaki H, Liu Y, Wang Z. The prevalence of myopia and the factors associated with it among university students in Nanjing: a cross-sectional study. *Medicine (Baltimore)* 2019;98(10):e14777.
- 5 Loman J, Quinn GE, Kamoun L, Ying GS, Maguire MG, Hudesman D, Stone RA. Darkness and near work: myopia and its progression in third-year law students. *Ophthalmology* 2002;109(5):1032-1038.
- 6 Lee YY, Lo CT, Sheu SJ, Yin LT. Risk factors for and progression of myopia in young Taiwanese men. *Ophthalmic Epidemiol* 2015;22(1):66-73.
- 7 Tricard D, Marillet S, Ingrand P, Bullimore MA, Bourne RRA, Leveziel N. Progression of myopia in children and teenagers: a nationwide longitudinal study. *Br J Ophthalmol* 2022;106(8):1104-1109.
- 8 Williams KM, Bertelsen G, Cumberland P, et al. Increasing prevalence of myopia in Europe and the impact of education. *Ophthalmology* 2015;122(7):1489-1497.
- 9 Czepita D, Lodygowska E, Czepita M. Are children with myopia more intelligent? A literature review. *Ann Acad Med Stetin* 2008;54(1):13-16; discussion 16.
- 10 McBrien NA, Adams DW. A longitudinal investigation of adult-onset and adult-progression of myopia in an occupational group. Refractive and biometric findings. *Invest Ophthalmol Vis Sci* 1997;38(2):321-333.
- 11 Jonas JB, Jonas RA, Bikbov MM, Wang YX, Panda-Jonas S. Myopia: histology, clinical features, and potential implications for the etiology of axial elongation. *Prog Retin Eye Res* 2022:101156.
- 12 Hyman L, Gwiazda J, Hussein M, Norton TT, Wang Y, Marsh-Tootle W, Everett D. Relationship of age, sex, and ethnicity with myopia progression and axial elongation in the correction of myopia evaluation trial. *Arch Ophthalmol* 2005;123(7):977-987.
- 13 Bullimore MA, Brennan NA. Myopia control: why each diopter matters. *Optom Vis Sci* 2019;96(6):463-465.
- 14 Ludwig CA, Shields RA, Chen TA, Powers MA, Wilkin Parke D 3rd, Moshfeghi AA, Moshfeghi DM. A novel classification of high myopia into anterior and posterior pathologic subtypes. *Graefes Arch Clin Exp Ophthalmol* 2018;256(10):1847-1856.
- 15 Morgan IG, French AN, Ashby RS, Guo X, Ding X, He M, Rose KA. The epidemics of myopia: aetiology and prevention. *Prog Retin Eye Res* 2018;62:134-149.
- 16 Chen M, Wu A, Zhang L, Wang W, Chen X, Yu X, Wang K. The increasing prevalence of myopia and high myopia among high school students in Fenghua City, eastern China: a 15-year population-based survey. *BMC Ophthalmol* 2018;18(1):159.
- 17 Lee DC, Lee SY, Kim YC. An epidemiological study of the risk factors associated with myopia in young adult men in Korea. *Sci Rep* 2018;8(1):511.
- 18 Hwang HS, Chun MY, Kim JS, Oh B, Yoo SH, Cho BJ. Risk factors for high myopia in Koreans: The Korea National Health and Nutrition Examination Survey. *Curr Eye Res* 2018;43(8):1052-1060.
- 19 Jiang Y, Wang D, Han X, Liao C, Li Z, Scheetz J, Jong M, Sankaridurg P, He M. Visual impairment in highly myopic eyes: The ZOC-BHVI High Myopia Cohort Study. *Clin Exp Ophthalmol* 2020;48(6):783-792.
- 20 Qian DJ, Zhong H, Nie Q, Li J, Yuan Y, Pan CW. Spectacles need and ownership among multiethnic students in rural China. *Public Health* 2018;157:86-93.
- 21 Wang X, Yi H, Lu L, Zhang L, Ma X, Jin L, Zhang H, Naidoo KS, Minto H, Zou H, Rozelle S, Congdon N. Population prevalence of need for spectacles and spectacle ownership among urban migrant children in Eastern China. *JAMA Ophthalmol* 2015;133(12):1399-1406.
- 22 Sun YY, Li SM, Li SY, Kang MT, Liu LR, Meng B, Zhang FJ, Millodot M, Wang N. Effect of uncorrection versus full correction on myopia progression in 12-year-old children. *Graefes Arch Clin Exp Ophthalmol* 2017;255(1):189-195.
- 23 Logan NS, Wolffsohn JS. Role of un-correction, under-correction and over-correction of myopia as a strategy for slowing myopic progression. *Clin Exp Optom* 2020;103(2):133-137.
- 24 Fan DS, Lam DS, Lam RF, Lau JT, Chong KS, Cheung EY, Lai RY, Chew SJ. Prevalence, incidence, and progression of myopia of school children in Hong Kong. *Invest Ophthalmol Vis Sci* 2004;45(4):1071-1075.
- 25 Verkicharla PK, Kammari P, Das AV. Myopia progression varies with age and severity of myopia. *PLoS One* 2020;15(11):e0241759.
- 26 Matsumura S, Lanca C, Htoon HM, Brennan N, Tan CS, Kathrani B, Chia A, Tan D, Sabanayagam C, Saw SM. Annual myopia progression and subsequent 2-year myopia progression in Singaporean children. *Transl Vis Sci Technol* 2020;9(13):12.
- 27 Karthikeyan SK, Ashwini DL, Priyanka M, Nayak A, Biswas S. Physical activity, time spent outdoors, and near work in relation to myopia prevalence, incidence, and progression: an overview of systematic reviews and meta-analyses. *Indian J Ophthalmol* 2022;70(3):728-739.
- 28 Sallam MA, Mohammed MA, Karrar MM, Ghoneim EM. Stay-at-home myopia among school children during the COVID-19 pandemic. *Med Hypothesis Discov Innov Optom* 2022;3(2):48-54.
- 29 Joseph S, Krishnan T, Ravindran RD, Maraini G, Camparini M, Chakravarthy U, Ravilla TD, Hutchings A, Fletcher AE. Prevalence and risk factors for myopia and other refractive errors in an adult population in southern India. *Ophthalmic Physiol Opt* 2018;38(3):346-358.
- 30 Tideman JW, Polling JR, Vingerling JR, Jaddoe VW, Williams C, Guggenheim JA, Klaver CC. Axial length growth and the risk of developing myopia in European children. *Acta Ophthalmol* 2018;96(3):301-309.
- 31 Steiner T, Maier T, Wehrli JP. Effect of endurance training on hemoglobin mass and VO_{2max} in male adolescent athletes. *Med Sci Sports Exerc* 2019;51(5):912-919.
- 32 Heidary F, Gharebaghi R, Wan Hitam WH, Shatriah I. Nerve fiber layer thickness. *Ophthalmology* 2010;117(9):1861-1862.