Myopia Progress and Related Factors in School-Aged Children in Qingdao

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Research Article

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Abstract

Purpose

Objective to investigate the progress and related factors for myopia in school-aged children in the Economic and Technological Development Zone of Qingdao.

Methods

A total of 320 myopic students (aged 10-15 years; grade 3 to 8), who were willing to cooperate for a long time follow-up, were enrolled in the longitudinal survey. Participants underwent a comprehensive ophthalmic examination included uncorrected visual acuity, corrected visual acuity, slit lamp examination, and cycloplegic autorefraction in January 2017 and 2019, respectively. At the end of the follow-up, the information of near work, outdoor activities and other related factors were collected through a questionnaire. Qualified questionnaires were obtained in 296 (92.50%) students. All the data were entered, cleaned and analyzed by EpiData3.0. SPSS 20.0 statistical software was used for data general description, univariate and multiple logistic regression analysis.

Results

1. The baseline mean spherical equivalent of all students decreased from -2.29±1.16D in 2017 to -3.45±1.34D at the end of 2 years follow-up in 2019. The annual average growth of myopia was -0.58D (t=7.708, P<0.001). The growth rate of myopia in Grade 6 was faster than that in other grades, and the difference was statistically significant (F=8.236, P=0.003).

2. Both boys and girls showed significant myopia progress after 2 year follow-up. (Boys: t=6.342, P<0.001; Girls: t=4.888, P<0.001). However, we have not found significant difference in the growth rate between them.

3. The proportion of two myopic parent was the highest in this sample, followed by one myopic parent, and no myopic parent was the lowest ($c2$=27.919, P<0.001).

4. The higher the grade, the more time the students spend on near work (F=2.988, P=0.012) and the less time they spend on outdoor activities. (F=2.290, P=0.046). We did not find that the myopia progression was related with Age, Sex, Parent myopia, Near work time and Outdoor activity time.

Conclusions

In this study, the Grade 6 adolescents had relatively rapid progression for myopia than other age groups. There was no significant difference in the progression of myopia between girls and boys. We did not find that the progression of myopia was related with Age, Sex, Parental myopia, Near work time and Outdoor activities time.

Introduction

With the increasing prevalence of myopia, it has become a major problem affecting the health of adolescent students in the world [1]. Only in developing countries, more than 500 million myopic students have not been examined and corrected[2]. Due to the limitation of diagnosis and treatment, myopia, especially high myopia, has caused a series of social problems[3]. Many scholars had done a lot of research on this serious problem, but the specific pathogenesis was still unclear. In addition, although there were effective means to correct myopia, such as frame glasses, contact lenses, refractive surgery and so on, we still did not have a completely effective method to control the progression of myopia. Recent studies demonstrated that the younger the onset of myopia, the faster the progression of myopia, and the greater the possibility of high myopia[4]. However, it was well known that a series of complications such as retinal degeneration, retinal detachment, open-angle glaucoma and cataract caused by high myopia increased the risk of low vision and blindness[5]. Morgan et al. considered that the increased incidence of high myopia in Asia was mainly due to the high prevalence of myopia during their teenage years, and the change of environmental factors might be the main reason for this result[6].

Previous studies mainly focused on horizontal studies, while longitudinal studies were relatively rare at present. Moreover, because there was no standard myopia epidemiological questionnaire, the results of previous studies were controversial [7–11]. A high-quality myopia epidemiological questionnaire designed by the Sydney Myopia Study [SMS] had been adopted by many research teams in recent years[12]. Among them, the Anyang Childhood Eye Study [ACES] conducted by a Chinese scholar, had used a similar questionnaire[13]. By comparing the results of SMS, he proposed the hypothesis that near work related behavior might play a more important role in the occurrence and progression of myopia. In terms of epidemiological investigation, this comparative study was of great value. Therefore, we also chosed this questionnaire and obtained more accurate and reliable results by comparing with other previous research results. The results were reported as follows.

Methods

Study Participants

Subjects were drawn from our previous study, which was a longitudinal part based on horizontal research. The study design, procedures, and characteristics were reported elsewhere [14]. In brief, 320 myopic teenagers, aged 10 to 15 years, were enrolled. Students who failed to follow up on schedule were excluded. Finally, a total of 296 eligible subjects (150 [50.68%] boys) completed the study. There were 42 students in 10 years old, 50 in 11 years old, 50 in 12 years old, 48 in 13 years old, 55 in 14 years old, and 51 in 15 years old, respectively. From January 2017 to January 2019, we completed a two-year follow-up.

Selection criteria: 1) myopic students aged 10–15 years in primary and secondary schools; 2) best corrected visual acuity > 0.1; 3) excluding eye trauma, strabismus, amblyopia, congenital cataract,

congenital glaucoma and other serious ophthalmic,systemic and mental diseases; 4) students and their parents who voluntarily accepted the survey.

Ethics Statement

The study was approved by the Ethics Committee of the Review Board of affiliated hospital of Qingdao University and adhered to the Declaration of Helsinki. Written, informed consent was obtained from their parents or guardians.

Examination

A comprehensive eye examination, including measurement of visual acuity, color vision, assessment of ocular motility, slit-lamp examination, autorefraction, cycloplegic autorefraction and fundus examination were performed at baseline and end of one-year follow-up, respectively. To allay parents' worries and reduce potential side-effects, we finally chosed Compound Tropicamide Eye Drops (0.5% tropicamide and 0.5% Norepinephrine hydrochloride mixture, Shenyang Xingqi Pharmaceutical Co., Ltd.) as cycloplegic agent. Refraction was performed using an a binocular open-field autorefractor (RM-8000A, Topcon, Japan) before and after cycloplegia. Cycloplegic autorefraction was performed after instilling 3 drops of Compound Tropicamide Eye Drops 5 min apart. Extra tropicamide (1 or 2 drops) was also used in some children to obtain adequate mydriasis (a minimum pupil diameter of 6 mm and having absence of any pupillary light reflex).

Questionnaire Survey

The drafts were revised and adjusted through discussions with student representatives and their guardians. The main contents of this research included information collection of related factors such as parents' myopia, near work time and outdoor activity time. The reliability of the questionnaire has been verified in the previous cross-sectional survey[14]. For example, if we choosed to play basketball for 1 to 2 hours a day, we recorded 1.5 hours a day; if the running time is less than 1 hour a day, then we record 0.5 hours, and the outdoor activity time accumulated for the above time.

Quality Control

All examinations were performed by the same senior clinical ophthalmologist. The students completed the questionnaires on the spot under the supervision of their parents.

Definitions and Data analysis

Relevant definitions and standards have been elaborated in the previous cross-sectional survey[14]. Myopia progression was defined as the difference between baseline mydriatic optometry and mydriatic optometry after 2 year.

Statistical analysis

Statistical analysis was performed using SPSS20.0 (SPSS for Windows, version 20.0, IBM-SPSS, Chicago, Illinois, USA). Univariate and multiple logistic regression analysis were used to evaluate the

related factors of myopia progression. Odds ratios (*OR*) and their 95% confidence intervals (*CI*) were presented. A p value < 0.05 was considered to indicate significance.

Result

Progression of myopia after 2 year follow-up

The baseline SE value of myopia was: -2.29 ± 1.16 D. After 2 year's follow-up, the SE value was: -3.45 ± 1.34D. The annual average growth was of about − 0.58 D ($t = 7.708$, $P < 0.001$). Among them, the fastest grade of myopic progression was grade 6 and the difference was statistically significant ($F = 8.236$, $P = 0.003$). (Fig. 1)

Progression of myopia of different genders

The baseline SE value of myopia for boys was − 2.22 ± 1.08 D. After 2 year follow-up, the SE value was − 3.38 ± 1.16 D. For girls, the baseline SE value of myopia was − 2.36 ± 1.28 D. After 2 year follow-up, the SE value was − 3.52 ± 1.39 D. Both boys and girls showed significant myopia progression after 2 year follow-up (Boys: $t = 6.342$, $P < 0.001$; Girls: $t = 4.888$, $P < 0.001$). There was no significant difference in baseline SE between boys and girls ($t = 0.873$, $P = 0.384$) and there was still no significant difference after 2 year follow-up ($t = 0.538$, $P = 0.591$). (Fig. 2)

Distribution of parental myopia in different age groups

The results showed that the proportion of two parent myopia group was the highest in different groups, followed by one parent myopia group, and no parent myopia group was the lowest. ($\chi 2 = 27.919$, $P < 0.001$). (Fig. 3)

Near work and outdoor activities time in different age group

The higher the grade, the more time the students spend on near work ($F = 2.988$, $P = 0.012$) and the less time they spend on outdoor activities. ($F = 2.290$, $P = 0.046$). (Table 1)

Table 1
Near work and outdoor activities time in different age group.

Age	Number (n)	Near work time (h/d)	Outdoor activities time (h/d)
10	42	3.18 ± 1.42	2.24 ± 1.28
11	50	3.24 ± 1.76	2.18 ± 1.64
12	50	3.32 ± 1.48	2.38 ± 1.56
13	48	3.26 ± 1.52	1.86 ± 1.22
14	55	4.16 ± 1.64	1.92 ± 1.34
15	51	4.52 ± 1.68	1.74 ± 0.86
		$F = 2.988$, $P = 0.012$	$F = 2.290$, $P = 0.046$

Associations between myopia progression and possible risk factors

In univariate analysis, we found that the progression of myopia was only related to two parental myopia (OR = 1.68, 95% CI: 1.22–2.13, P = 0.042), but not to age, gender, one parent myopia, near work time and outdoor activity time. When we put these factors into multiple regression model for further analysis, we did not find any relationship between myopia progression and these factors. (Table 2)

Table 2
Associations between myopia progress and possible risk factors.

Variables	Univariate analysis			Multivariate analysis		
	OR	OR(95% CI)	P	OR	OR(95% CI)	P
Age	1.02	0.84–1.24	0.243	0.94	0.62–1.32	0.424
Sex						
Boys	1			1		
Girls	1.14	0.78–1.51	0.321	1.06	0.67–1.32	0.537
Parental myopia						
None	1			1		
One myopic	1.21	0.56–1.74	0.342	1.14	0.74–1.84	0.533
Two myopic	1.68	1.22–2.13	0.042*	1.58	0.76–2.16	0.164
Near work						
near work time (h/d)	1.36	0.52–1.64	0.567	1.28	0.64–1.68	0.376
Outdoor activities						
Outdoor activity time (h/d)	0.74	0.34–1.16	0.536	0.87	0.56–1.36	0.132

* indicates a significant statistical significance ($P < 0.05$).

Disscussion

From an optical point of view, we can well explain the role played by various optical elements of eyeball, that is, eye axis growth is the main cause of myopic progression. Controlling the growth of eye axis is the most important means to control the progression of myopia[15, 16]. It is well known that high myopia can easily lead to many complications, and eventually lead to serious visual impairment[17, 18]. A large-scale cross-sectional epidemiological survey of myopia in Shanghai found that the prevalence of high myopia among college students in China was as high as 10%-20%[19]. Previous studies have shown that the age of 9 to 16 is the fastest growing period of myopia in adolescents[20]. Given the reliability of the longitudinal study and the growing period of myopia, it is extremely significant for us to conduct this longitudinal study on adolescents aged 10–15.

Donovan et al[4] compared the progression of myopia among adolescents (9.3 years old) in Asian urban areas with that in Europe. They found that the progression of myopia among adolescents in Asia was faster (-0.82D vs. -0.55D), and the progression speed of myopia decreased significantly with the increase of age. Hong Kong scholars reported that the annual growth of myopic adolescents was − 0.63D, while

those who were not myopic was − 0.29D[21]. The Singapore Cohort Study of the Risk Factors for Myopia (SCORM) found that the annual growth rates of myopia in adolescents aged 7–9 years were − 0.80D, − 0.66D and − 0.57D[22], respectively. Thorn et al[23] found that the evolution of myopia follows the rule that there was no myopia in the early stage, the occurrence of myopia was in the student period, and finally myopia was stable. After at least six years of follow-up, the Correction of Myopia Evaluation Trial (COMET)[24] found that the average age at which myopia slowed down was 11.95 years old, the average age at which myopia was stable was 15.61 years old. In addition, they compared the stable time and myopia degree of five different races, and found that African-Americans had the earliest stabilization of myopia, and the myopia degree was the lowest. In this study, there was significant myopia progression in all age groups after two-year follow-up, with an average increase of − 0.56D. The myopia progression in 6th grade was the fastest ($F = 8.236$, $P = 0.003$). However, age was not a risk factor for myopia progression (*OR* = 0.94, *95% CI*: 0.62–1.32, $P = 0.424$). By comparing with the domestic and foreign literatures mentioned above, we can draw the following conclusions: In recent years, the progression of myopia among Chinese adolescents has obviously accelerated; the age of 13 may be a turning point in the progression of myopia; and the stable age of myopia was over 15 years old. Although compared with other ethnic adolescents in Europe and America, Chinese Han adolescents was indeed developing faster, this rapid growth might not be explained only by genetic factors. The social, living, learning and other environmental factors might be the important factors contributing to this difference.

At present, the role of gender in the progression of myopia was still controversial. A longitudinal studies of Australian adolescents aged 12 and 17 showed that girls' myopia progressed faster[25]. The COMET[24] found that boys' myopic progression was about 0.16D slower than girls' each year. They suggested that if gender played a role in myopia, they would occur in the early stage of myopia, and it would not last long. Some scholars have explained that this may be related to the faster and earlier growth of girls, the relatively rapid development of eyeball and their susceptibility to environmental factors, as well as the fact that girls were quiet, eager to learn and having less outdoor sports than boys[26, 27]. In this study, although we found that both boys and girls showed significant myopia progression after 2 year follow-up. the SE of both boys and girls decreased significantly after two year of follow-up, the growth rate between them was not significant.We believe that the hypothesis of COMET is reasonable. Due to the old age of the adolescents selected in this study, the progression of myopia might be less affected by gender.

Similar to our previous cross-sectional study, the proportion of two parent myopia was still the highest, followed by one parent, and no parent myopia was the lowest ($\chi^2 = 27.919$, P 0.001). In addition, in our previous cross-sectional studies, although we did not find a correlation between one parent myopia with the prevalence of myopia, there was a positive correlation between two parent myopia with it. However, in the longitudinal study, we found there was no significant correlation between the progression of myopia and one parent myopia (*OR* = 1.14, *95% CI*: 0.74–1.84, $P = 0.532$) and two parent myopia (*OR* = 1.58, *95% CI*: 0.76–2.16, $P = 0.163$). Perhaps we can hypothesize that the effect of parent myopia on children might only occur in the initial stage of myopia. With the deepening of myopia, the impact would be less obvious.

By comparison, we found that the results of this study on near work and outdoor activity time were in good agreement with those reported in ACES[13]. A meta-analysis of seven cross-sectional studies reported a 2% reduction in the odds of myopia per additional hour of time spent outdoors per week[5]. A three-year prospective study in Guangzhou found that a 40-minute outdoor activity class added to each school day could effectively reduce the incidence of myopia(30.4% vs 39.5%); however, they did not find that such interventions reduced the growth of myopia[28]. Other studies have suggested that there might be a threshold of 10 to 14 hours spent outdoors per week required to prevent myopia[29, 30]. In our cross-sectional study, outdoor activity time was an independent protective factor for myopia[14]. However, in the longitudinal study, we did not find that the progression of myopia was related with near work time and outdoor activity time. Thus, our results are basically consistent with the above results. Perhaps, outdoor activities could only slow down the onset of myopia, but it has no effect on the progression of myopia. It was also possible that the effect of outdoor activities on the progression of myopia needed to reach a certain threshold. In other words, the threshold for controlling myopia progression might be higher for children who were already myopic. However, due to the influence of learning pressure, outdoor activity time of Chinese adolescents was far from the threshold.

At present, the influence of near work on myopia progression was still controversial. In this study, we still haven't found that near work time could effect the progression of myopia. Perhaps, the hypothesis that near work related behavior played a more important role in the occurrence and progression of myopia in ACES might be reasonable[13]. This provided a good direction for our further research. Although the design of this experiment was precise, there was still a memory bias in the information collected through the questionnaire. Recently, an intelligent, wearable, and real-time myopia monitoring device “Clouclip-(TM)” developed by Aier ophthalmology school of Central South university and China Glasson Technology Co., Ltd had aroused widespread concern. It would be of great help to myopia prevention and control.

Conclusion

In general, we learned the myopia progression of 10–15 year old myopic students in this area. Furthermore, we found that the 13-year-old adolescents had relatively rapid progression for myopia than other age groups. There was no difference in the growth rate of myopia progression between boys and girls. We did not find that the progression of myopia were related with Age, Sex, Parent myopia, Near work time and Outdoor activity time.

Declarations

Ethics approval and consent to participate

The study protocol follows the Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects and it was approved by ethical committee of the Affiliated Hospital of Qingdao

University, China. Written informed consent was obtained from all guardians of participating students who took part in the study.

Consent for publication

The manuscript is approved by all authors for publication.

Availability of data and material

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

Competing interests

The authors state that there are no conflicts of interest regarding the publication of this article.

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None.

Authors' contributions

Jintao Sun was responsible for the conception and design of this survey. Yuanyuan Liu, Yan Zhang, Jie Zhang acquired, analyzed and interpreted the data. Meng An wrote the draft. Chengye Che revised the manuscript critically. All authors have read and approved the final manuscript.

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Figures

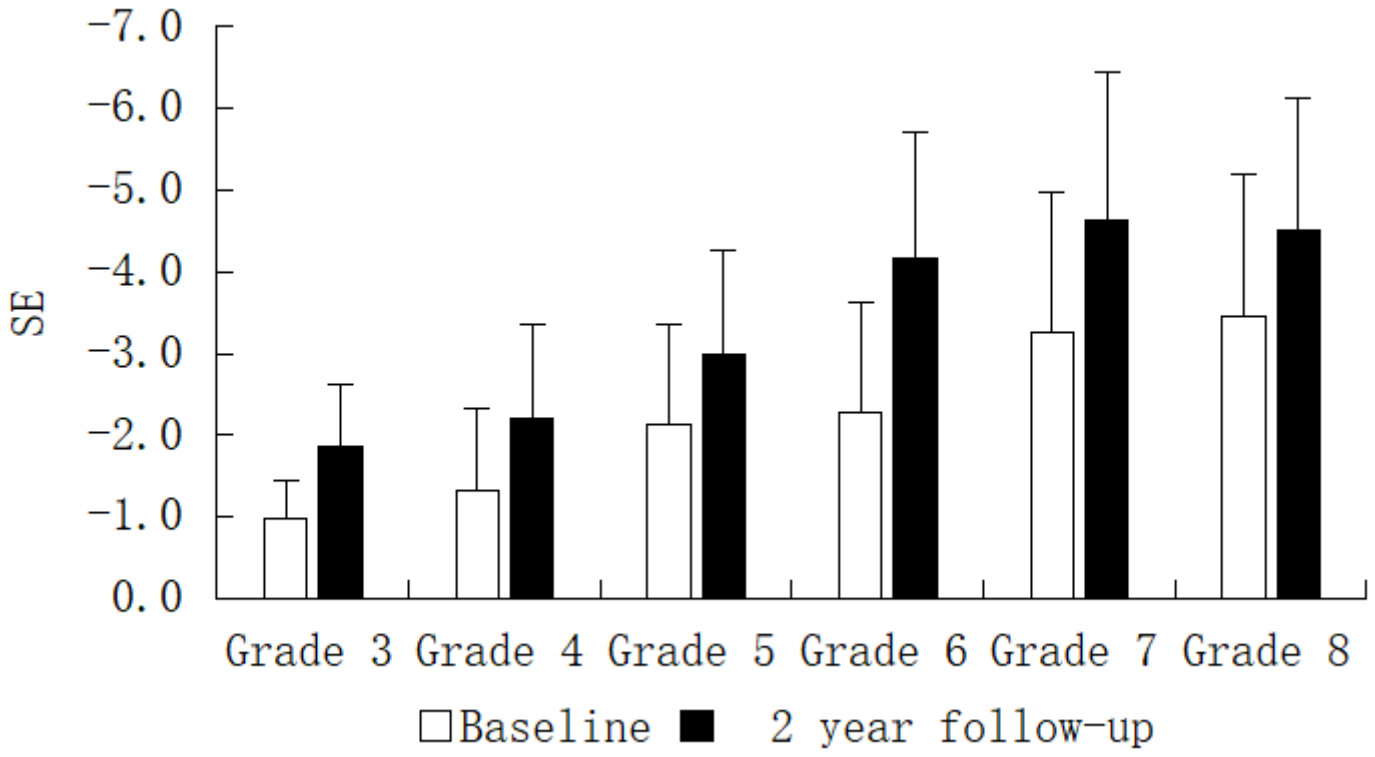

Figure 1

Progress of myopia after 2 year follow-up.

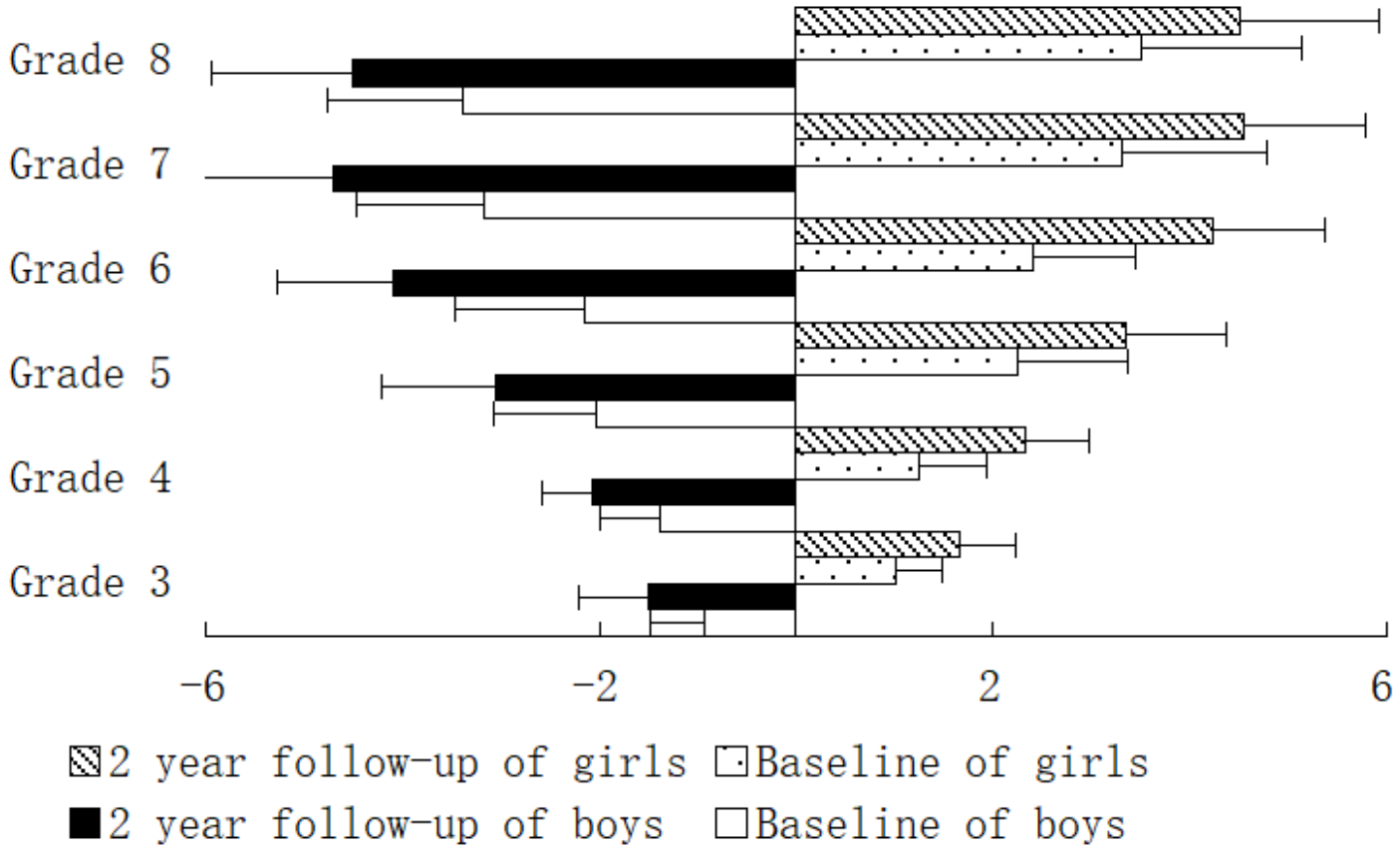

Figure 2

Progress of myopia of different genders.

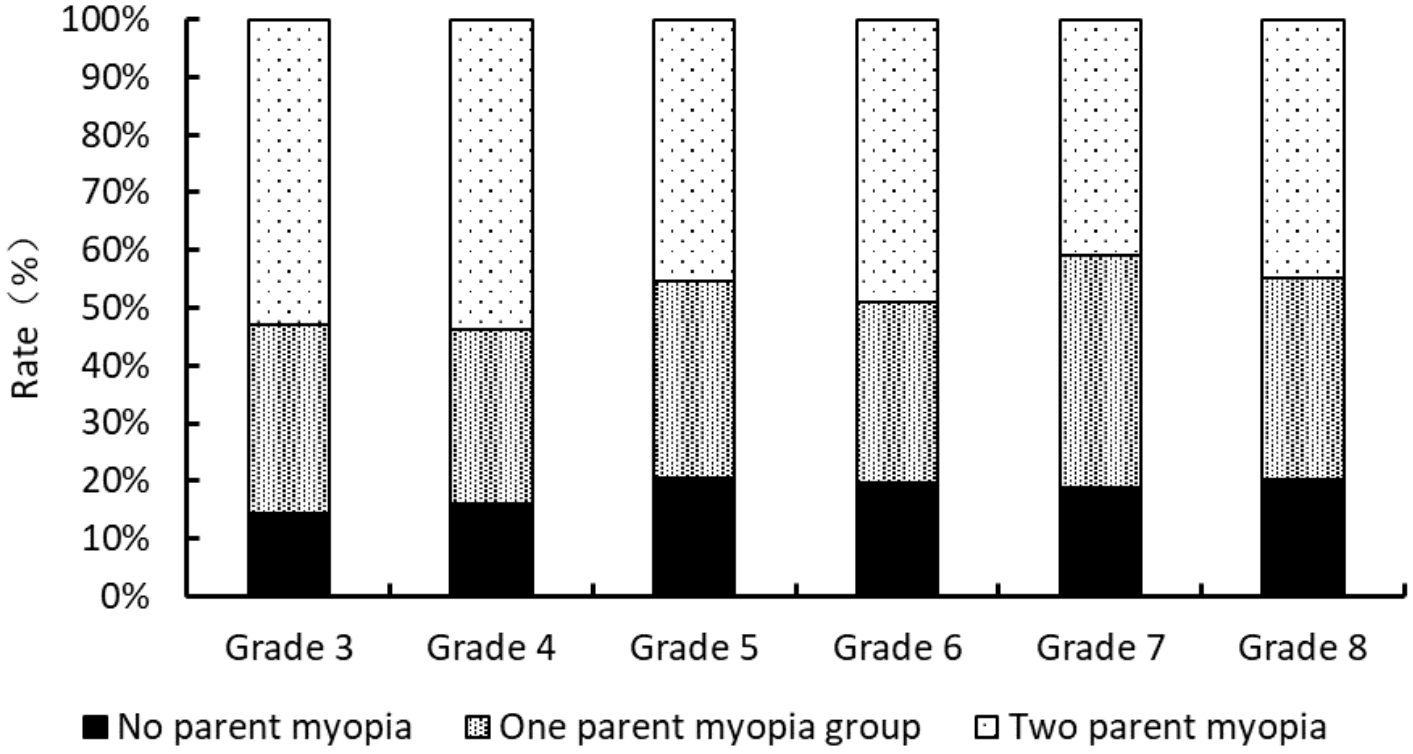

Figure 3

Distribution of parental myopia in different age group.