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Study on the prevalence of myopia and its associated factors in China: a systemic review

X.-X. WE[1], L.-L. YU[2], A.Z.A. MAJID[3], Y. XU[3]

[1]Krirk University, Anusaowaree Bangkhen, Bangkok, Thailand
[2]Department of Physical Education, Changsha Normal University, Changsha, Hunan, China
[3]School of the The Arts, Universiti Sains Malaysia, Penang, Malaysia

Abstract. – OBJECTIVE: Myopia is becoming more common, a significant public health issue everywhere, including in China. There needs to be a comprehensive analysis of the evidence about the extent of myopia in Chinese schoolchildren, despite earlier studies showing a growing frequency in China. Therefore, the frequency of myopia in Chinese schoolchildren is examined in this study with supporting data and a meta-analysis.

MATERIALS AND METHODS: The 2022 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards were used for this research. From January 1, 2015, to December 31, 2022, five computerized bibliographic databases, including PUBMED, Scopus, Web of Science, ProQuest, and China Index Medicus, were reviewed and aimed at investigating myopia's prevalence in China. The studies' methodological quality was evaluated. Myopia is defined as a refractive error. Data were collected according to gender, age, and refraction method. The prevalence was calculated through a meta-analysis.

RESULTS: Data from 11 quality-assessed studies, with a total of 1,013,206 adolescents, were included. Hanting District children had an overall myopia prevalence of 45.47%, but Changyi children had a myopia prevalence of 82.37%. In general, 48.56, 47.30, and 31.62% of elementary, middle, and higher school pupils had mild myopia, compared to 1.12, 8.89, and 20.12% who had high myopia. Children aged 7-9 years old experienced the largest overall increase in the prevalence of myopia. For girls and boys, the prevalence of higher myopia was 7.59% and 6.43% ($p<0.001$). Yet, the spherical equivalent (SE) dropped as students' ages and grades rose. Myopia prevalence rises as students age and grade.

CONCLUSIONS: The recent findings revealed that myopia predominated among schoolchildren in Weifang. It steadily grew through age, in addition to it being more common in Changyi neighborhoods. Females had a greater frequency of myopia than males.

Key Words:
Myopia, Myopic macular degeneration, Prevalent disorders, Myopia prevention.

Introduction

One of the most prevalent disorders, myopia, is the leading global reason for poor vision in children and adolescents[1]. Myopic macular degeneration and retinal detachment are two major pathologic occurrences that can arise from high myopia and cause permanent visual loss[2]. Almost 1.4 billion people had myopia worldwide in 2000; by 2050, it is expected to increase to 4.8 billion[3]. The cost of impaired distant vision brought on through uncorrected myopia was predicted to entail a growing global lost productivity of US $244 billion in 2015[4]. Because of the impact of inherited traits and environmental circumstances, myopia is still highly prevalent among teenagers and young children worldwide, particularly in Asia[5].

Like other East Asian nations, China has a high rate of myopia prevalence, which is rising annually[6,7]. According to a national survey[8] conducted in China in 2014, 80% of students who have completed 12 years of education are currently myopic, with 10-20% having extreme myopia. Myopia among many school-aged children in China has been the subject of numerous cross-sectional school-based studies. However, relatively few large-scale studies[9] cover the entire city level in this age group, even though policymakers must carefully consider the estimates of myopia to make the right choices.

The frequency of myopia in children between the ages of 5 and 17 varies from 1.2% in the Mechi Zone of Nepal to 73.0% in South Korea[4,5]. Including an average age of 18.5±0.7 years, Chinese

Corresponding Author: Yang Xu, Ph.D; e-mail: xuyang@student.usm.my

high school students' prevalence of myopia grew from 79.5% to 87.7% over a 15-year period[6]. Myopia was only reported[7] to be prevalent in South African schoolchildren aged 5 to 15 in 2.9% of cases when retinoscopy and 4.0% when utilizing auto-refraction. According to Grzybowski et al[5], at the age of 15, this incidence increased to 9.6%.

Due to related ocular health issues and vision impairment, the rise in myopia prevalence will have a substantial financial influence. Uncorrected myopia of 1.50D to 4D can considerably impair vision and be a causal factor in both blindness and mild visual impairment[8]. Increased myopia, usually characterized as a spherical equivalent >5D[4,9,10] of myopia, even though the meanings used for grade myopia are variable[3,11], raises the possibility of potentially blinding ocular pathologies, including retinal holes, retinal tears, retinal degeneration, retinal detachment, and myopic macular degeneration. Myopia significantly affects society, the economy, the mind, and development[12]. Refractive errors, especially myopia, are expected to cost the economy over US$ 202 billion annually[13], significantly more than other eye illnesses.

Myopia is becoming more common, which has prompted research into its potential causes. This research has major factors: the involvement of nature (genetic factors) and nurture (environmental impacts and lifestyle). To comprehend how myopia develops is also being investigated in order to control it. Adolescents in Southeast Asia spend a disproportionate amount of time undertaking work, as shown by epidemiological research, and this has been linked to an increase in myopia[14]. There needs to be more clarity regarding the extent of the myopia problem among African school-aged children and its progress over time due to the wide regional variances in urbanization, social position, sociocultural practices, and education levels[15].

Due to China's growing urbanization, people's lifestyles and behavior have changed during the past several decades[15]. China's urban population increased by 2,000% from 27 million in 1950 to 567 million in 2015, and 50% of the country's people now reside in one of the continent's 7,617 urban agglomerations with a population of 10,000 or more[16]. As a result, compared to previous generations, China's youth and youngsters are progressively participating in indoor and close-by job actions[16,17]. Children work hard at school for long periods, and as technology advances, they increasingly utilize mobile devices for gaming and other pursuits[18,19]. Several elements may encourage the onset or advancement of myopia.

Although other regions of the globe have seen a rise in myopia prevalence, East Asian nations have a higher prevalence of the condition. Several blinding problems, including cataracts, glaucoma, retinal detachment, and myopic macular degeneration, can arise from myopia, especially high myopia[9]. These circumstances may have severe social and financial repercussions[10,11]. At this time, the majority of epidemiology investigations[18] on myopia in Chinese children and adolescents have concentrated on the prevalence of myopia in addition to the associated risk factors amongst some of the randomly selected students.

Unfortunately, it is still being determined how common and high myopia is in certain educational institutions through demanding educational programs and excellent educational achievement. It is imperative to analyze the latest data on the prevalence of myopia and its associated comorbidities in significant Chinese educational institutions. This examination is necessary to address the existing gaps in epidemiological investigations pertaining to myopia. By doing so, valuable guidance and a theoretical framework can be provided to effectively prevent and manage myopia in children and adolescents. Furthermore, this approach can help mitigate the financial and social burdens associated with this condition.

Materials and Methods

Study Design

A systematic review and meta-analyses were carried out in agreement through the Preferred Reporting Items for Systematic Reviews (PRISMA) Statement.

Search Strategy

The Medline, SCOPUS, EMBASE, ISI Web of Science (WOS), and PubMed databases were all electronically searched. Searches were performed from the beginning of each database to December 2022. Following the investigation, 4,240 articles, in all, were identified. A total of 1,641 duplicate articles were removed. Two investigators independently conducted the selection. 2,599 articles were obtained after removing duplicates. The authors screened and excluded studies based on titles and abstracts, which were unmatching. After further evaluation, the study considered 41 studies, and finally, 11 were selected for this systematic review.

Inclusion and Exclusion Criteria

Research with a precise definition of refractive errors, publications with data on the frequency of refractive errors in Chinese children under the age of 18, studies with a sample size of about least 1,000 individuals, and investigations based on populations or schools with clearly defined sampling strategies were all included in this systematic review. Since age-defined subgroups from studies with sample sizes under 1,000 would be too small to estimate the prevalence of refractive errors reliably, these investigations were not included. The following were the exclusion requirements: 1) surveys from hospitals or clinical settings; 2) studies that were only carried out in one school; 3) refractive error measurements based on visual acuity; 4) mislaid or inadequate information; 5) clear restrictions in statistical analysis or design; 6) multiple studies utilizing a single population without supplying further details. On December 31, 2022, the investigation was completed.

Data Extraction

Only English-language literature was included in the searches. Two researchers extensively examined 11 studies[11-21] which satisfied the inclusion criteria after the selection process. The following is a list of the extracted data from these articles: 1) study characteristics, including author, study year, study methodology, and whether or not mydriatics were used in the refraction. 2) The population characteristics being investigated, including the sample size, age range, district, region (rural *vs.* urban), and the proportion of female participants.

Results

The procedure for choosing the literature is depicted in Figure 1. The results of the literature search revealed 4,240 records. Following the selection, 11 studies with 1,013,206 participants were added for the qualitative synthesis[11-21]. An overall 1,013,206 (95.6% participation rate) participants who were spread over 17 districts/counties and 861, 313, and 80 elementary, middle, and high schools completed all of the study's exams out of the 1,059,838 individuals who were qualified to take part. Boys comprised 532,851 of the study participants or 50.28% of the total. The median age ranged from 5 to 20 years, or 11.57±3.36. Table I lists the fundamental aspects of this re-

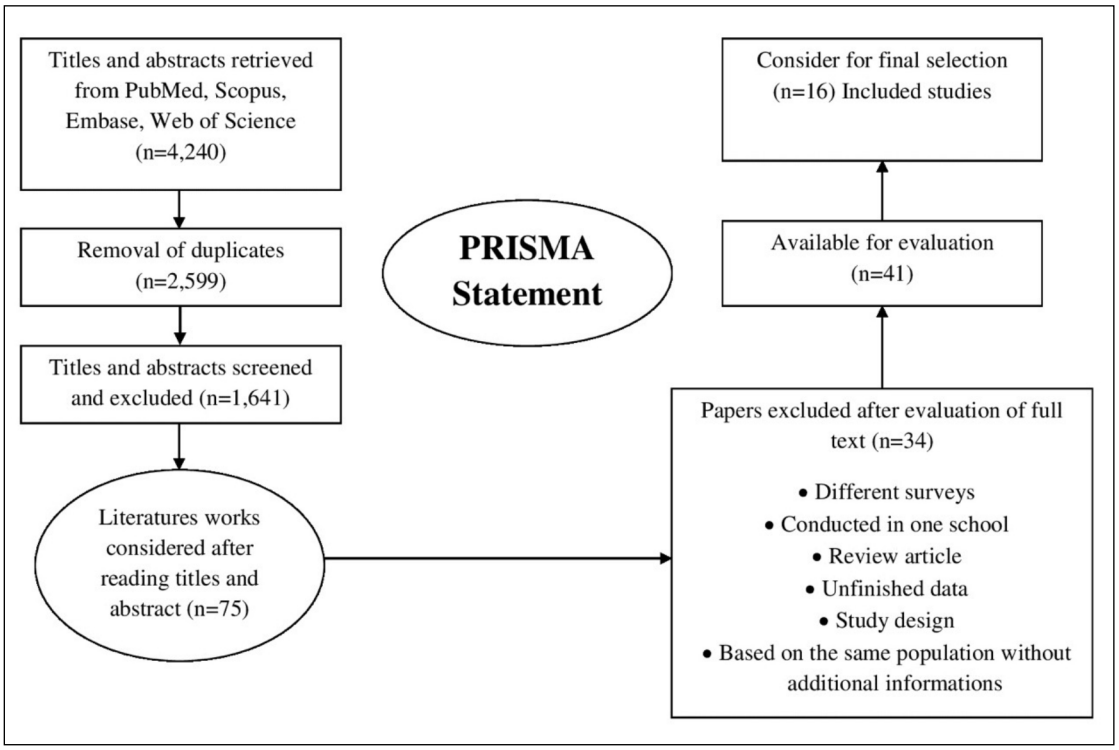

Figure 1. PRISMA diagram of this study.

search as well as the prevalence and criteria of myopia. Figure 2 shows the comparative quality assessment score of the studies included.

The prevalence rate is segmented by age and gender in Table I. Compared to boys, girls exhibit a lower SE ($p<0.001$). Females had a higher likelihood of boys having intermediate and high myopia ($p<0.001$). Yet, compared to boys, girls were less expected to have low myopia ($p<0.001$). The number of people with low myopia was 44.96% overall, over 50% in the 9-12 age range. 6.98% of people had high myopia, with the 17-18 age groups having the highest frequency (more than 20%). However, 12.70% of people had high myopia, with the 16-18 age groups having over 30% as the maximum occurrence.

Discussion

Other studies[21] have shown the occurrence and distribution of myopia among young people in China. The study involved over one million children and teenagers aged 5-20, mainly living in urban and suburban regions of the country. The research produced three main findings: firstly, the total prevalence of myopia was 75.35%. Secondly, girls had a higher proportion of moderate and severe myopia but a lower incidence of low myopia. Lastly, low myopia was higher in primary and secondary school students, while high myopia was more prevalent in high school students. This research provides preliminary results that will strengthen the myopia monitoring system and enable its spread to more cities nationwide[3-18].

Myopia inhibition and management are currently part of China's national strategy. Because the nation's future is tied to young people's perspectives, disease prevention must be given top priority by the entire society[19]. In the past, cycloplegia refraction was used in population-based investigations in China[19]. According to Dong et al[12], the collective prevalence of myopia amongst individuals aged 3 to 18 was 32.96%, and they predicted that among Chinese children and adolescents aged 3 to 19 in 2050, the prevalence of myopia would be around 84%. The prevalence of total myopia amongst adolescents aged 5 to 20 in our study, however, ranged from 45.47% to 82.37%, which was greater than that reported by Dong et al[12].

According to Thorn et al[22], cycloplegia refraction may cause this discrepancy. Furthermore, we predicted that the real myopia prevalence scenario by 2050 may be worse than those predictions[22]. Furthermore, we predicted that the real myopia prevalence scenario by 2050 may be worse than those predictions[13,20]. Myopia and high myopia were identified in a recent population-based screening process[13] in Wenzhou that included a million scale children and teenagers. Another analysis was conducted to compare the results with those of the Wenzhou study by Xu et al[13]. Myopia was more prevalent overall (63.91%) than

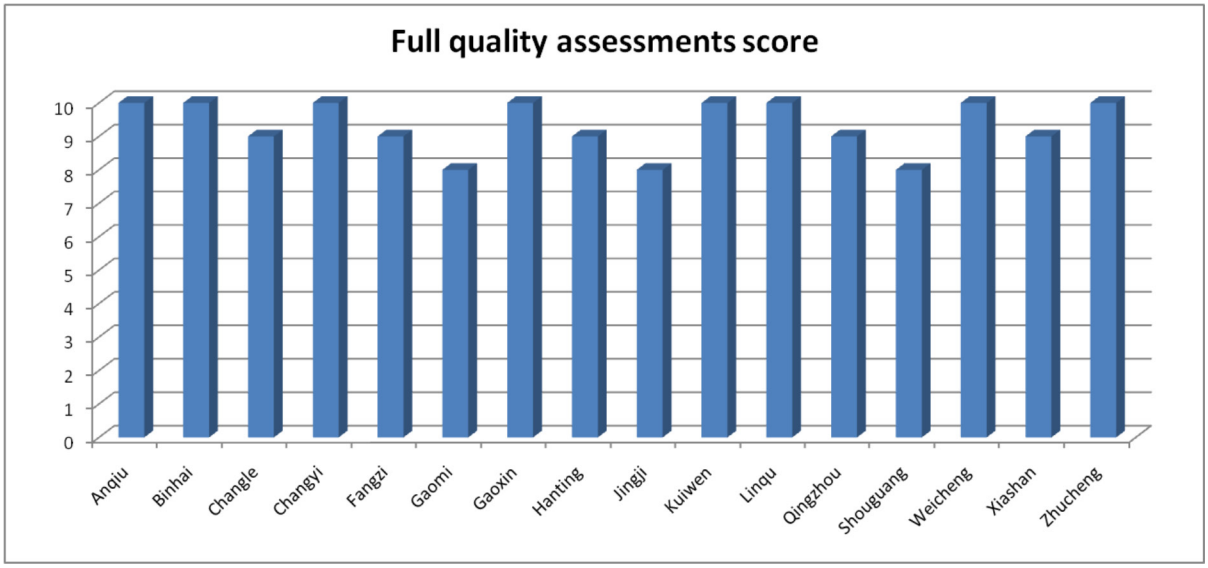

Figure 2. Full-quality assessment score obtained by the investigations of the studies that were included in the systemic review.

Table I. Features of the investigations that were included in the systemic review that estimated the prevalence of myopia in China[11-21].

Locations	Counts	Myopia (%)	Low Myopia (%)	Moderate Myopia (%)	High Myopia (%)	Full quality assessments score
Anqiu	95,447	73.66	46.35	25.68	7.28	10
Binhai	17,077	72.59	42.14	26.36	9.43	10
Changle	85,405	77.06	45.42	27.47	8.92	9
Changyi	56,451	77.05	46.07	28.01	8.29	10
Fangzi	37,544	69.91	45.78	23.33	6.79	9
Gaomi	103,310	72.45	47.55	23.79	7.11	8
Gaoxin	37,908	58.61	42.72	17.44	5.49	10
Hanting	18,793	41.21	29.12	13.14	3.21	9
Jingji	15,836	57.94	46.00	16.46	3.14	8
Kuiwen	47,293	56.70	43.74	16.05	3.89	10
Linqu	82,069	69.95	49.18	21.27	6.09	10
Qingzhou	89,234	64.76	45.53	20.69	5.54	9
Shouguang	135,171	68.47	42.78	23.98	7.47	8
Weicheng	50,204	61.05	44.47	18.52	4.79	10
Xiashan	22,498	69.42	45.25	23.81	5.94	9
Zhucheng	118,966	75.82	43.75	27.95	9.37	10
Total	1,013,206					

among the participants aged 6 to 20 in Wenzhou (55.83%)[22].

Further research[23] revealed that myopia and high myopia were more common in Weifang than in Wenzhou for different genders, ages, and educational levels. The fundamental cause of these variances, related to lifestyle, the amount of work required for studies, or genetic makeup, is unknown. Further myopia studies at the city level are required to provide evidence for prevention[24].

According to our research, the Hanting District has a substantially lower rate of myopia. Hanting District in Weifang City has been chosen as an area of economic development. Compared to families with higher socioeconomic status, children from lower-income families and mothers with less education tended to develop myopia more frequently[14]. Most of those residing in the Hanting District are adolescents with significant levels of education and per capita income. A possible explanation of myopia's low prevalence is that this segment of the inhabitants places supplementary emphasis on the anticipation and management of children's myopia. In particular, participants from Changle County, Changyi County-city, and Zhucheng County-city had levels of myopia higher than 80%. Thus, it is also highly important and merits attention to avoid myopia in rural areas and urban-rural edges[15].

Another school-based cross-sectional investigation[16] conducted in Chengdu with children aged 3 to 14 years old showed that females had a higher probability than boys to have low myopia (28.4 *vs.* 25.0%), although extreme myopia (9.5 *vs.* 10.1%) and moderate myopia (9.5 *vs.* 10.2%) were more common across both genders. In line with earlier research[17,18], the prevalence of myopia was overall higher in females in our study than in males. In contrast, our study found that the prevalence of myopia was lower in females than in males but females had a higher proportion of moderate and high myopia[16,24]. Overall, females had a higher probability of having myopia, and the prevalence of extreme myopia in Weifang had a significant role in this disparity. Our results were in line with those of Li et al[18], who found that females had a higher probability of having moderate or high myopia, contrary to Wang et al[16] findings. They ccategorized myopia in children aged 3-14, but our cross-sectional survey covered children and adolescents aged 5-20[16,25].

Considering the severity of myopia, excessive myopia can lead to consequences that are dangerous to the eye's health, such as rhegmatoge-

nous retinal detachment (RRD), choroid neovascularization (CNV), and macular hemorrhage (MH)[19,20]. Consequently, public health must prevent and manage the development and progression of extreme myopia. According to our observations, high myopia increases with age, and SE tends towards getting more myopic, which aligns with earlier research[6,21]. High school students also have a greater possibility of suffering from severe myopia than elementary or intermediate school children, as they have a higher probability of having minor or moderate myopia[22]. Consequently, this shows that we should concentrate on the early detection and management of higher myopia on behalf of high school children to avoid producing complications[21,22]. The control of low and moderate myopia should be given additional consideration among primary and middle school pupils to prevent the development of high myopia. Our study's advantages include a sizable sample size, multidimensional structures, and an observation of the entire city, and our findings provide some inspiration for the next research[23].

The prevalence of myopia amongst school-age children in China and its dissimilarity through age, gender, refraction method and other patterns are estimated for the first time in this systematic review[24]. As previously said, associated with further areas like Southeast Asia, the frequency of myopia in China seems low. In order to solidify our understanding of myopia epidemiology within this particular group, forthcoming prevalence investigations could utilize the initial data from our current study as a foundational reference point for comparative purposes[25]. This systematic review also revealed that, compared to cycloplegic refraction, non-cycloplegic refraction overstated the prevalence of myopia and produced further erratic estimations of refractive errors. Researchers and decision-makers may need to be more informed about how myopia prevalence data from non-cycloplegic refraction are interpreted. Thus, it is advised that any studies examining the prevalence of myopia in children employ cycloplegic refraction.

Conclusions

The study concluded that complete myopia affects children and adolescents between the ages of 6 and 20 at startlingly high rates. The Hanting economic development zone had the lowest prevalence of myopia among students. Boys are less prone than girls to experience myopia, especially severe myopia. During aging, overall and higher myopia prevalence increases, while SE tends to grow increasingly myopic. It is necessary to act to prevent the increase of myopiaas it is becoming more prevalent among high school students.

Conflicts of Interest

All the authors declare that there is no conflict.

Authors' Contributions

All the authors of this manuscript have contributed equally to this work.

ORCID ID

Xu Yang: 0000-0003-4009-0402.

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Ethics Approval and Informed Consent

Not applicable.

References

1) Morgan IG, OhnoMK, Saw SM. Myopia. Lancet 2012; 379: 1739-1748.
2) 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: 728-739.
3) Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmol 2016; 123: 1036-1042.
4) Naidoo KS, Fricke TR, Frick KD, Jong M, Naduvilath TJ, Resnikoff S. Potential lost productivity resulting from the global burden of myopia: systematic review, meta-analysis, and modelling. Ophthalmol 2019; 126: 338-346.

5) Grzybowski A, Kanclerz P, Tsubota K, Lanca C, Saw SM, A. review on the epidemiology of myopia in school children worldwide. BMC Ophthalmol 2020; 20: 27.
6) Singh NK, James RM, Yadav A, Kumar R, Asthana S, Labani S. Prevalence of myopia and associated risk factors in schoolchildren in North India. Optom Vis Sci 2019; 96: 200-205.
7) Adhikari S. Myopia in school children from the high mountain region of Nepal. Nepal J Ophthalmol 2013; 5: 246-249.
8) Mountjoy E, Davies NM, Plotnikov D, Smith GD, Rodriguez S, Williams CE, Guggenheim JA, Atan D. Education and myopia: assessing the direction of causality by mendelian randomization. BMJ 2018; 5: 361-388.
9) Ganapati, NE, Ganapati, S. Enabling participatory planning after disasters: A case study of the World Bank's housing reconstruction in Turkey. J Am Planning Assoc 2008; 75: 41-59.
10) Verhoeven VJ, Wong KT, Buitendijk GH. Visual consequences of refractive errors in the general population. Ophthalmol 2015; 122: 101-109.
11) Chua S, Foster PJ. The Economic and Societal Impact of Myopia and High Myopia. Springer, Singapore 2019; 53-63.
12) Naidoo KS, Fricke TR, Frick KD. Potential Lost Productivity Resulting from the Global Burden of Myopia: Systematic Review, Meta-analysis, and Modeling. Ophthalmol 2019; 126: 338-346.
13) Dong L, Kang YK Li Y, Wei WB, Jonas JB. Prevalence and time trends of myopia in children and adolescents in China. A systemic review and meta-analysis. Retina 2020; 40: 399-411.
14) Xu L, Zhuang Y, Zhang G, Ma Y, Yuan J, Tu C. Design, methodology, and baseline of whole city-million scale children and adolescents myopia survey (CAMS) in Wenzhou, China. Eye Vis 2021; 8: 31.
15) Rothman KJ, Greenland S, Lash TL. Types of epidemiologic studies. Modern epidemiology. 2nd ed: Lippincott Raven 1998; p.74-75.
16) Enthoven CA, Mölenberg FJM, Tideman JWL, Polling JR, Labrecque JA, Raat H. Physical activity spaces not effective against socioeconomic inequalities in myopia incidence: the generation R study. Optom Vis Sci 2021; 98: 1371-1378.
17) Chen H, Liao Y, Zhou W, Dong L, Wang W, Wang X. The change of myopic prevalence in children and adolescents before and after the COVID-19 pandemic in Suqian, China. PLoSOne 2022; 17: e0262166.
18) Wang J, Liu J, Ma W, Zhang Q, Li R, He X. Prevalence of myopia in 3–14-year-old Chinese children: a school-based cross-sectional study in Chengdu. BMC Ophthalmol 2021; 21: 318.
19) Zhao X, Lu X, Yu L, Zhang Y, Li J, Liu Y, Yang G, Wang Y, Zhang W, Du Z. Prevalence of myopia and associated risk factors among key schools in Xi'an, China. BMC Ophthalmol 2022; 22: 519.
20) Sitzia J, Wood N. Response rate in patient satisfaction research: an analysis of 210 published studies. Int J Quality Health Care 1998; 10: 311-317.
21) Wong YL, Saw SM. Epidemiology of pathologic myopia in Asia and worldwide. Asia Pac J Ophthalmol 2016; 5: 394-402.
22) Thorn F, Chen J, Li C, Jiang D, Chen W, Lin Y. Refractive status and prevalence of myopia among Chinese primary school students. Clin Exp Optom 2020; 103: 177-183.
23) Sanfilippo PG, Chu BS, Bigault O, Kearns LS, Boon MY, Young TL, Hammond CJ, Hewitt AW, Mackey DA. What is the appropriate age cut-off for cycloplegia in refraction? Acta ophthalmologic 2014; 92: e458-e462.
24) Zhang J, Li Z, Ren J, Wang W, Dai J, Li C, Huang X, Sun X, Liu L, Wang C. Prevalence of myopia: A large-scale population-based study among children and adolescents in weifang, China. Front Public Health 2022; 10: 924566.
25) Li Y, Liu J, Qi P. The increasing prevalence of myopia in junior high school students in the Haidian District of Beijing, China: a 10-year population-based survey. BMC Ophthalmol 2017; 17: 88.