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Development and Application of a Smartphone-Based App for Screening Myopia and Astigmatism in Elementary School Students

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Abstract

This study aimed to develop a smartphone-based application for visual acuity and astigmatism screening among elementary school students and to investigate the prevalence and progression patterns of these refractive problems across different grades and genders. The application was developed using the Uni-App framework, integrating standardized logarithmic visual acuity charts and astigmatism screening diagrams. A total of 904 students from grades 1 to 6 were recruited. Self-administered tests were performed under standardized conditions. Data on visual acuity and astigmatism were collected over six months and analyzed by grade and gender. The overall prevalence of myopia was 56.1% (507/904). Myopia prevalence increased markedly with grade, from 37.4% in Grade 1 to 81.1% in Grade 6. A significant gender disparity was observed in Grade 6, where 91.9% of girls and 70.8% of boys had myopia. Astigmatism prevalence also increased with grade, from 29.8% to 57.5%, largely driven by its comorbidity with myopia. In summary, the Eye-Health application proved to be an effective tool for large-scale, school-based vision screening. The findings highlight a critically high and grade-dependent prevalence of refractive errors among Chinese elementary school students, with girls being particularly vulnerable in higher grades. The findings of this study provide evidence-based references for families, schools, and health departments to formulate targeted prevention and control strategies, thereby facilitating early warning and tailored interventions.

Keywords

Elementary school students; Myopia; Astigmatism; Smartphone-based App.

1. INTRODUCTION

Vision problems, particularly myopia (nearsightedness) and astigmatism, represent significant and growing public health challenges among children and adolescents worldwide. The definition of myopia and high myopia (HM) is spherical equivalence (SE) of −0.50 diopters (D) or less and SE −5.00 D or −6.00 D, respectively. Intense close reading, insufficient outdoor time spent and too much screen exposure, which will cause sustained tension and spasm of the ciliary muscle and trigger compensatory elongation of the eye axis, may be more likely to develop myopia. Astigmatism, which frequently coexists with myopia, refers to a refractive state where the eye has different refractive powers along different meridians. When parallel light rays pass through the eye's refractive system, they cannot form a single focal point; instead, they form two mutually perpendicular focal lines. Typically, astigmatism is caused by genetic factors, but it can also be caused by eye diseases and bad eye-using habits.

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In many Asian countries including China, there is a trend of an early onset of myopia in childhood fueled in part by educational demands, and more than half of school-aged students are affected, with approximately 80% myopic by the end of schooling [1-3]. According to a summary of 145 studies regarding the global prevalence of myopia, there are approximately 1950 million with myopia (28.3% of the global population), and this numbers is predicted to increase to 4758 million (49.8% of the global population) by 2050 [4]. Astigmatism affects an estimated 14.9% of children and a significant 40.4% of adults [5-7]. Therefore, it is important for primary school students to be aware of the dangers of myopia and astigmatism and their own visual condition conveniently, and thus to protect their eyes consciously.

Although a number of vision testing applications and software currently exist, many have significant limitations. These include lack of device-specific calibration, unclear instructions regarding testing distance, and improper scaling of visual charts across different screen sizes, all of which may compromise measurement accuracy. Moreover, busy schedules often discourage parents from seeking regular hospital-based vision detection for their children.

In an educational outreach program, we observed that a large number of students wore glasses, and many others squinted to see the blackboard clearly. This motivated us to develop a more reliable and accessible vision screening tool. The wide use smartphones has opened up new possibilities for health monitoring. Accordingly, this study aimed to design and develop a mobile application that integrates vision and astigmatism screening functions suitable for school-based vision screening that allows children and teenagers to easily check their visual acuity and detect signs of refractive problems even without professional optometric services. In addition, this study aims to determine the prevalence and annual progression of myopia and astigmatism among primary school students in China and to identify critical age periods associated with rapid changes in visual health.

2. METHODS

2.1. Design and development of Eye-Health Screening Application

The application was named as Eye-Health Screening App and designed with a multi-functional homepage, allowing users to navigate through different sections via intuitive swiping gestures. Its core vision screening module utilizes a standard logarithmic visual acuity chart, identical to those employed in clinical settings. To ensure measurement accuracy, the chart's size is fixed and non-scalable. When the device is positioned 50 centimeters from the user's eyes, the chart displays at a proportional size equivalent to the standard physical chart, thereby maintaining testing reliability.

The application was developed using the Uni-App framework to achieve cross-platform compatibility and integrated visual acuity and astigmatism screening functions. The front-end interfaces - including login, home page, vision testing, astigmatism screening, eye protection knowledge sections, detailed content pages, and post-test feedback - were implemented using a combination of basic and advanced programming constructs. Elements such as class-based components, sets, and user authentication logic were employed to build a responsive and interactive user experience.

User input and test results collected from the front end are transmitted and stored in a structured back-end database, also constructed within Uni-App. Two main databases were designed: one for user profile management and another for storing screening records and historical data.

For vision screening, a digital version of a standard logarithmic visual acuity chart was implemented. The astigmatism screening module incorporates a radial dial pattern similar to those used in clinical settings. To ensure standardized testing conditions, the application

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requires that tests be performed on mobile devices with the screen brightness set to maximum. Users are instructed to maintain a distance of 50 centimeters between the device and their eyes and to cover one eye during testing using their hand. Clear on-screen guidelines are provided before each test to facilitate correct self-assessment. The following is the download link for the application: http:// 58.56.87.194:57880 /modules /open /sltj.apk.

In addition to core screening functions, user engagement was enhanced through supplementary features. These include an eye health knowledge base and instructional videos and instructions on eye exercises. The interface was iteratively refined to improve aesthetic quality and usability, encouraging prolonged and repeated use of the application.

2.2. Participant Recruitment

Elementary school children from grades 1 to 6 were recruited. Participants were recruited through two ways. First, students were reached via an educational outreach program in which the study team was involved. Second, to broaden the sample size and diversity, the app was made available on the official website of an ophthalmology hospital (Jinan Eye Hospital, Shandong, China), where age-eligible primary school students were encouraged to download and use it for self-screening. This study included 904 primary school students aged from 6-13 years old including 450 boys and 454 girls distributed in grade 1 to 6.

2.3. Vision and astigmatism Screening and Data Collection

Vision and astigmatism data were collected over a six-month period from students in grades 1-6. All children underwent comprehensive vision examinations using Eye-Health program. In addition, general information including age, gender, and grade level was collected alongwith screening results to support subsequent statistical analysis. The application underwent iterative modifications to enhance its usability and accuracy. Redundant sections were removed, and several modules were consolidated to improve navigability and practicality. The interface design was continuously optimized – particularly the background styling – to minimize visual distraction and ensure clarity, thereby reducing potential interference during testing and providing users with a more consistent and reliable self-screening experience. Upon completion of data collection, the subjects were grouped based on gender, age and vision conditions. The proportions within each category were subsequently calculated.

3. RESULTS

3.1. Function of Eye-Health Screening software

The Eye-Health Screening application features a multi-section home interface, allowing users to navigate through various functions via swiping gestures. The vision screening module incorporates a standard logarithmic visual acuity chart, identical to those used in clinical settings. To ensure accuracy, the chart size remains fixed and is proportionally equivalent to a standard chart when viewed from a distance of 50 centimeters. The astigmatism screening module presents users with a radial line diagram. Users are instructed to indicate whether all lines appear equally clear, thereby facilitating preliminary self-assessment of refractive error. A color vision testing function is also integrated, wherein users identify numbers embedded within Ishihara-style plates. Failure to correctly identify figures triggers an algorithm that suggests possible types of color vision deficiency.

Beyond screening utilities, the application offers comprehensive educational resources. These include sections dedicated to fundamental eye protection knowledge, updates on relevant government policies and recommendations, and instructional videos demonstrating evidence-based eye exercises. Among these exercises, one module guides users to track a moving on-screen dot to help stimulate tear secretion and reduce eye fatigue, while other videos

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provide routines for myopia and dry eye prevention. All visual content and medical resources were obtained and verified in collaboration with Jinan Eye Hospital.

User data collected during screenings are securely transmitted to a backend database developed using Uni-App. Users retain control over whether their data are stored, with clear options provided for consent prior to submission.

3.2. Prevalence of myopia

Among 904 primary school students, 507 students suffered from myopia. Of these, 268 were girls, accounting for 59% of all girl participants, while 239 were boys, representing 53.1% of all boys, which was slightly lower than that of girls. Details are presented in Table 1. It was observed that the total number of students with myopia increased with grade level. Specifically, the proportion of students with myopia in each grade was as follows: Grade 1: 37.4%; Grade 2: 42%; Grade 3: 50.7%; Grade 4: 60.4%; Grade 5: 76.1%; Grade 6: 81.1%. The prevalence of myopia reached 76.1% in fifth-grade students and rose to 81.1% in sixth-grade students (Fig.1). When stratified by gender, myopia prevalence also increased with grade in both males and females.

Based on the data presented, the most severe decline in visual acuity among primary school students occurred in Grade 6, particularly among female students. The overall myopia prevalence reached 81.1% in sixth graders, representing the highest rate across all grades. Furthermore, a significant gender disparity was observed within this grade: 91.9% of female students were diagnosed with myopia, compared to 70.8% of males. This suggests that Grade 6 (typically 11-12 years old) is a critical period for rapid vision deterioration, with females being more disproportionately affected. This sharp increase highlights Grade 6 as the grade with the most serious vision health challenges, warranting targeted intervention strategies.

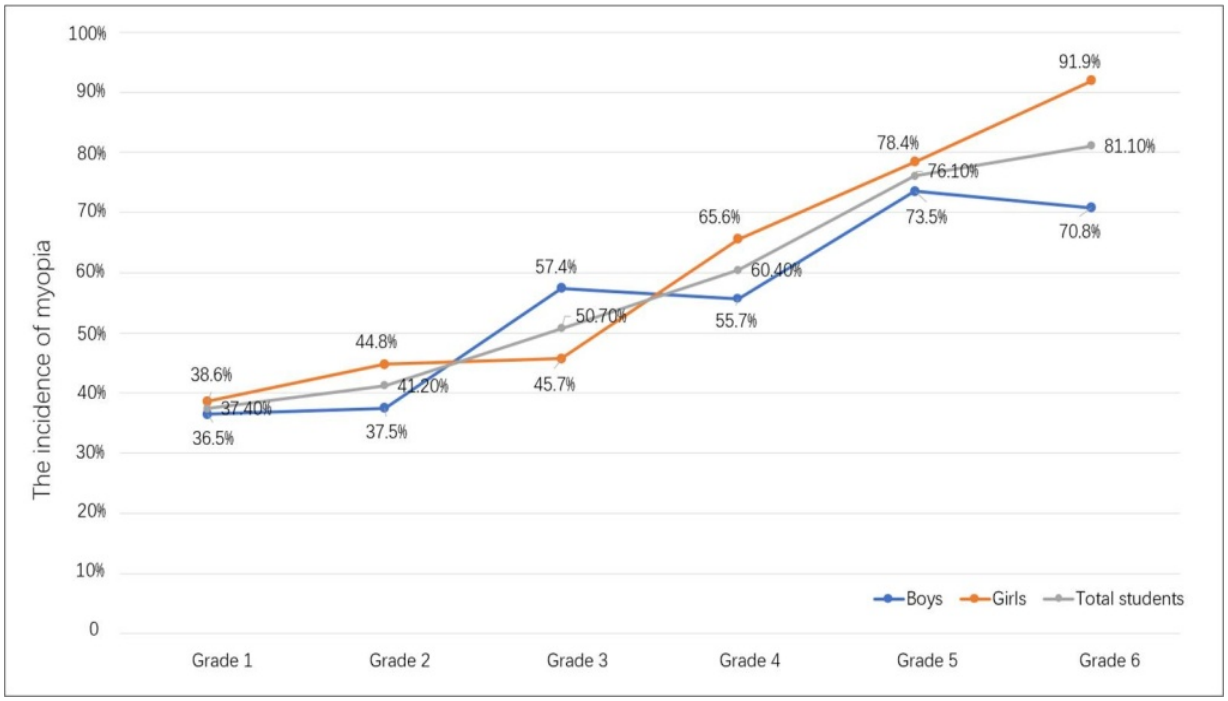

Figure 1. Myopia among 904 elementary school students in grades 1-6

Among female students, the prevalence of myopia increased by 19.9% from Grade 3 to Grade 4, by 12.8% from Grade 4 to Grade 5, and by 13.5% from Grade 5 to Grade 6. These results indicate a pronounced deterioration in visual acuity starting from Grade 3, suggesting that this period marks a critical phase for the progression of myopia in girls. Among boys, the prevalence

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of myopia increased by 19.9% from Grade 2 to Grade 3 and by 17.8% from Grade 4 to Grade 5. In higher grades, a noticeable difference emerged: among sixth-grade students, the prevalence of myopia was 70.8% in males compared to 91.9% in females, indicating a significantly higher rate among female students at this level (Fig.1).

3.3. Prevalence of astigmatism

The analysis of astigmatism prevalence revealed a clear upward trend with increasing grade level. The overall rate of astigmatism rose from 29.8% in Grade 1 to 57.5% in Grade 6. Notably, the proportion of students with astigmatism alone remained relatively stable across grades (ranging from 6.3% to 13.4%), while cases of astigmatism coexisting with myopia increased significantly—from 20.6% in Grade 1 to 51.2% in Grade 6. These results indicate that astigmatism becomes notably more prevalent in higher grades, and that its increase is largely associated with the presence of myopia. In addition, it was found that the incidence of astigmatism in students in grade 3 was significantly higher than that in grade 2 (Fig.2).

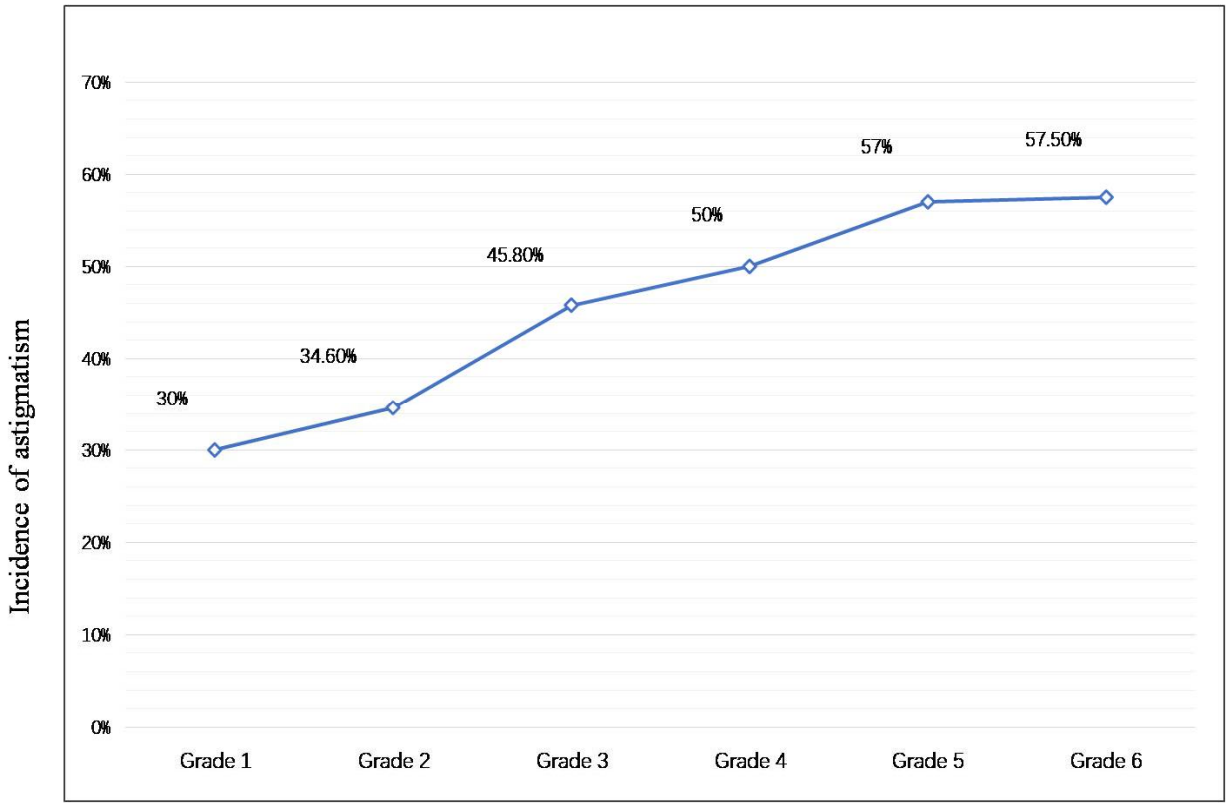

Figure 2. Astigmatism among 904 elementary school students in grades 1-6

3.4. Prevalence of both myopia and astigmatism

Analysis of the combined data on myopia and astigmatism revealed a strong positive association between the two conditions. The proportion of students with both myopia and astigmatism increased substantially with grade level, increasing from 20.6% in Grade 1 to 51.2% in Grade 6. Conversely, the percentage of students with normal vision declined markedly across the same period, from 53.4% to 12.6% (Fig.3). These trends indicate a clear co-occurrence of myopia and astigmatism, suggesting that their prevalence is closely linked and increases significantly throughout primary school.

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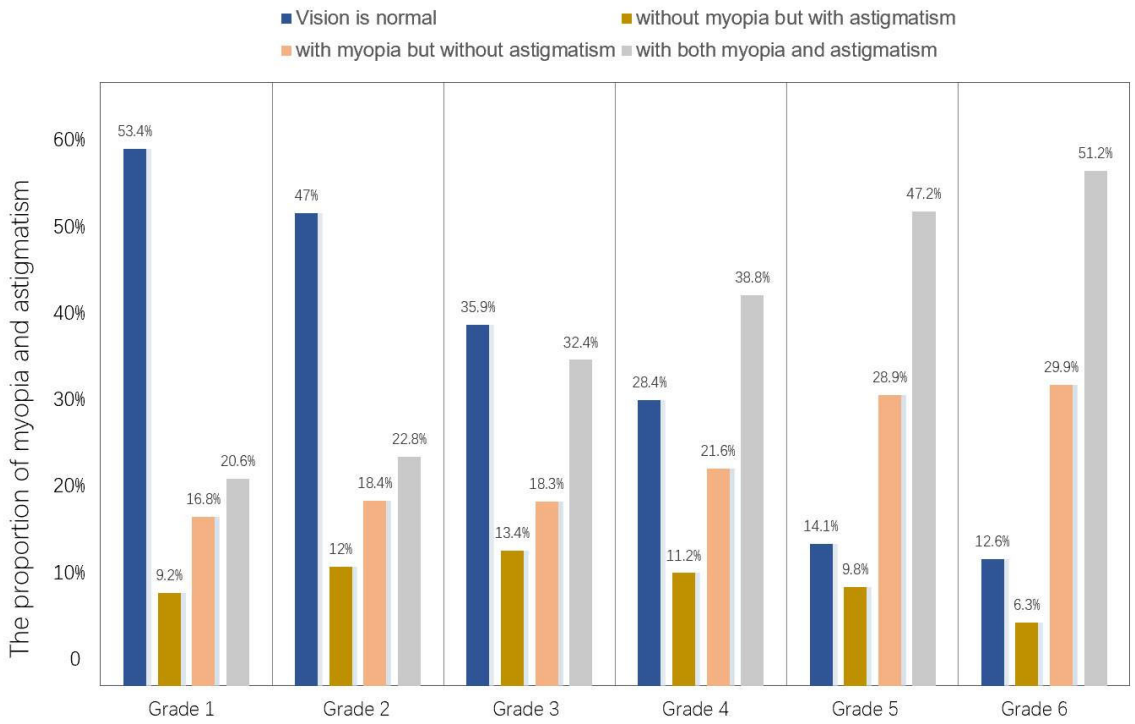

Figure 3. Elementary school students with both myopia and astigmatism in grades 1-6

4. DISCUSSION

The present study developed a smartphone-based application, named Eye-Health-Screening, for vision screening and employed it to assess the prevalence and progression of myopia and astigmatism among primary school students among primary school students. The results revealed alarmingly high and grade-dependent incidence rates of both myopia and astigmatism, with a particularly sharp increase in myopia from Grade 3 onward, culminating in a prevalence of 81.1% by Grade 6. Furthermore, a strong correlation between myopia and astigmatism was observed, with over half of the sixth-grade students affected by both problems. Notably, gender-specific patterns emerged: girls exhibited a steep increase in myopia from Grade 3 onward, while boys showed significant increases between Grades 2 to 3 and again between Grades 4 to 5.

These findings are consistent with previous reports that visual impairment among children is both serious and age-dependent, due to academic pressures and limited outdoor time are widespread [6-10]. The steep increase in myopia prevalence during primary school underscores the critical importance of regular vision screening–particularly from middle to higher grades–and the value of easy-to-use tools that facilitate early detection. The gender-specific patterns observed further suggest that risk factors may operate differently across subgroups, highlighting the need for tailored prevention strategies.

The analysis revealed a significant increase in the overall prevalence of astigmatism with age. Furthermore, the proportion of students with both myopia and astigmatism increased at a faster rate than those with myopia alone. This pattern is consistent with previous studies [5, 11,12]. The fact that the rise in astigmatism was largely attributable to its co-occurrence with myopia – rather than an increase in astigmatism alone – supports the notion that the two conditions often develop synergistically, possibly due to shared risk factors such as prolonged close reading and limited outdoor exposure. This accelerating trend aligns with the previous findings that axial elongation in myopic eyes may alter corneal curvature, thereby inducing or aggravating astigmatism [13]. Similarly, Liang et al. reported that astigmatism, particularly oblique and against-the-rule types, may contribute to myopic progression by imposing

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additional blur and accommodative stress [11]. Therefore, the concurrence and mutual exacerbation of myopia and astigmatism highlight the importance of integrated vision health interventions. Early and combined screening for both conditions is strongly recommended, particularly in populations with high myopia prevalence.

The application developed in this study offers a feasible, low-cost, and scalable approach to school-based vision screening. Its accessibility can help overcome barriers associated with traditional clinic-based examinations, especially for resource-limited populations. However, certain limitations should be acknowledged. Self-administered testing may introduce measurement variability, and the absence of cycloplegic refraction means that the results represent suspected rather than clinically confirmed cases. Future efforts should focus on validating the app's accuracy against standard optometric equipment and incorporating more robust data.

5. CONCLUSIONS

In conclusion, this study not only provides a practical tool for large-scale vision screening but also delivers compelling evidence regarding the progression patterns of myopia and astigmatism in primary school students. These insights reinforce the urgency of implementing early and gender-sensitive interventions during key school years to mitigate visual health deterioration in children.

REFERENCES

[1] Chua SY, Ikram MK, Tan CS, et al. Relative contribution of risk factors for early-onset myopia in young Asian children. Growing up in Singapore towards healthy outcomes study group, Invest Ophthalmol Vis Sci.,vol. 56(2015), 8101-7. doi: 10.1167/iovs.15-16577.

[2] Wu PC, Huang HM, Yu HJ, Fang PC, Chen CT: Epidemiology of myopia, Asia Pac J Ophthalmol (Phila), vol.5(2016), 386-393. doi:10.1097/ APO.0000000000000236.

[3] Chen Z, Gu D, Wang B, et al. Significant myopic shift over time: Sixteen-year trends in overall refraction and age of myopia onset among Chinese children, with a focus on ages 4-6 years, J Glob Health, vol.13(2013), 04144. doi: 10.7189/jogh.13.04144.

[4] Wong, C. W.; Brennan, N.; Ang, M: Introduction and overview on myopia: a clinical perspective. In updates on myopia: A Clinical Perspective, Edition 1; Ang, M., Wong, T. Y., Eds.; Springer Singapore: Singapore, 2020, pp 1-26.

[5] Hashemi H, Fotouhi A, Yekta A, Pakzad R, Ostadimoghaddam H, Khabazkhoob M. Global and regional estimates of prevalence of refractive errors: systematic review and meta-analysis, J Curr Ophthalmol., vol.30(2017), 3-22. doi:10.1016/j.joco.2017.08.009

[6] Kam KW, Shing E, Zhang Y,et al. Prevalence and severity of astigmatism in children after COVID-19., JAMA Ophthalmol., vol.143(2025):383-391. doi: 10.1001/ jamaophthalmol. 2025.0205.

[7] Zhang L, Zeng L, Ye Y, et al. Refractive and corneal astigmatism in Chinese 4-15 years old children: prevalence and risk factors, BMC Ophthalmol., vol.23(2023):449. doi: 10.1186/ s12886-023-03201-y.

[8] Wang J, Li Y, Musch DC, Wei N, et al. Progression of Myopia in School-Aged Children After COVID-19 Home Confinement, JAMA Ophthalmol., vol. 139(2021): 293-300. doi: 10.1001/jamaophthalmol.2020.6239.

[9] Zong Z, Zhang Y, Qiao J, Tian Y, Xu S: The association between screen time exposure and myopia in children and adolescents: a meta-analysis, BMC Public Health, vol. 24(2024), 1625. doi: 10.1186/ s12889-024-19113-5.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202510_11(10).0002

[10] Khalaf AM, Alhazimi AY, Almaymuni KK, Alsubaie NA: Prevalence of myopia among schoolchildren and the mpact of increased screen time: A Systematic Review, Cureus,vol.16(2024), e66815. doi: 10.7759/cureus.66815.

[11] Liang D, Du B, Leung TW, et al. Impact of astigmatism on axial elongation in school-age children: a five-year population-based study in Tianjin, China, Invest Ophthalmol Vis Sci. , vol.65(2024),45. doi: 10.1167/iovs.65.13.45.

[12] Kaye SB, A Patterson: Association between total astigmatism and myopia, J Cataract Refract Surg. , 1997. PMID: 9456407

[13] Read SA, Vincent SJ, Collins MJ: The visual and functional impacts of astigmatism and its clinical management, Ophthalmic Physiol Opt. , vol.34(2014), 267-94. doi: 10.1111/opo.12128.