

Evaluation of pre-myopia risk factors in children aged 6-10 years: pediatric vision screening

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ABSTRACT

Background: The aim of this study was to evaluate pre-myopia risk factors in children aged 6–10 years and to investigate whether a simple risk-based questionnaire could help identify children at increased risk of pre-myopia in primary healthcare settings.

Methods: This cross-sectional study was conducted in Erzurum, Türkiye, over a three-week period beginning on October 28, 2025. A total of 652 children were invited to participate in the study; those with active visual complaints and those not within the 6–10 age range were excluded. A total of 453 children who met the inclusion criteria were analyzed. Based on questionnaire scores, low-, medium-, and high-risk groups were formed; biometric measurements of 44 children in the high-risk group who attended the examination were evaluated. The relationships between risk groups and demographic variables were analyzed using the chi-square test, and the relationship between biometric parameters and SE was assessed using Pearson correlation. An AL/CR ratio ≥ 2.90 was accepted as the biometric high-risk threshold. Sample adequacy was verified using G*Power 3.1.

Results: The mean age was 7.91 ± 1.26 years, and 51.7% of participants were male. The mean AL/CR ratio in the examined children was 2.90 ± 0.12 . SE values ranged from -0.50 to $+0.50$ D, indicating that all examined children were within the refractive pre-myopia range. No significant correlation was found between questionnaire risk score and AL/CR ratio (Pearson $r = -0.08$, $p = 0.666$) or SE (Pearson $r = -0.11$, $p = 0.535$). Questionnaire risk score was not a significant predictor of an AL/CR ratio ≥ 2.90 in univariable logistic regression analysis (OR = 1.14, 95% CI: 0.64–2.03; $p = 0.67$).

Conclusion: The findings suggest that a simple risk-based questionnaire may assist primary care physicians in identifying children who could benefit from ophthalmologic evaluation. Further validation studies are required before routine implementation.

Keywords: Child, pre-myopia, refractive error, primary health care, screening

Introduction

The prevalence of myopia worldwide has shown a dramatic increase in recent years. Predictions estimate that by 2050, approximately half of the

world's population will be myopic. Considering the difficulties in preventing myopia progression, it is evident that especially high myopia will predispose individuals to serious complications such as retinal detachment, glaucoma, and macular

degeneration.^[1,2] For these reasons, detecting the presence of risk factors and identifying myopia in its early developmental stages (pre-myopia) will provide a significant advantage in preventing the onset of myopia by allowing the implementation of various preventive interventions. The literature reports that numerous factors contribute to the development of myopia, including parental myopia, the effects of sunlight and light intensity and diversity, prolonged accommodative effort, near work, and increased screen exposure.^[3,4] Children with a family history of myopia, those who spend limited time outdoors, or those with more than two hours of daily screen exposure are known to be in the high-risk group for myopia.^[5]

The definition of pre-myopia includes individuals at increased risk for developing myopia, with cycloplegic spherical values between +0.75 diopters and -0.50 diopters. This refractive state is important in childhood as an early indicator of progressive myopia.^[6] Studies state that pre-myopic individuals have a high probability of developing myopia in the future, and an early onset of myopia—meaning reduced hyperopic reserve—is associated with a faster progression.^[7,8] It is thought that refractive values close to emmetropia in childhood may be a strong predictor of future myopia.^[9]

The National Vision Screening Program implemented by the Turkish Ministry of Health in 2018 aims to contribute to the early diagnosis of visual disorders in childhood and is carried out through primary healthcare services.^[10] Within the scope of the program, the visual levels of children in certain age groups are evaluated in family health centers, and those found to have reduced vision are referred to ophthalmology clinics. However, the screening only detects children with visual impairment, which leads to certain cases being overlooked. The current program does not include a specific risk assessment for myopia,

lifestyle counseling, or behavioral preventive factors. Detecting myopia at a preventable stage—prior to its development—could mean a 2–3 year gain in myopia control.^[11] Studies have shown that proven interventions are critical in delaying the onset of myopia in at-risk children.^[12]

Therefore, developing short risk assessment methods for screening in primary care and adding a pre-myopia-focused formula to the national screening protocol may significantly strengthen preventive services. Additionally, ensuring bidirectional communication between ophthalmologists and family physicians will support continuity of follow-up after evaluation. The aim of this study was to evaluate genetic and environmental risk factors associated with myopia in children aged 6–10 years, and to detect pre-myopia through refractive and biometric measurements in high-risk children.

Materials and Methods

This study was conducted over a three-week period starting on October 28, 2025. Parents of eligible children aged 6–10 years were invited to complete an online questionnaire using Google Forms. The questionnaire was designed to be completed by the parents or legal guardians of children aged 6–10 years. A total of 652 children with no vision-related complaints were included. Children with a previous diagnosis of myopia, a history of ocular disease, or current spectacle use were excluded.

Data were collected using an 11-item questionnaire designed to assess pre-myopia risk. Demographic characteristics and factors such as parental myopia, daily outdoor time, uninterrupted screen time, compliance with the 20-20-20 rule (looking at an object approximately 20 feet [6 meters] away for at least 20 seconds after every 20 minutes of near work), and social jet lag (weekday–weekend sleep time difference) were evaluated (Table 1).

Table 1. Pre-myopia risk assessment questionnaire.

Question / Variable	Response Options	Score
1. Does your child have any vision-related complaints?	☐ Yes ☐ No	–
2. Child's age	☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 years	–
3. Sex	☐ Female ☐ Male	–
4. Are the mother and/or father diagnosed with myopia?	No	0
	One parent	1
	Both parents	2
5. Daily outdoor time	0–60 min	3
	60–120 min	2
	120–180 min	1
	≥180 min	0
6. Average uninterrupted screen time per sitting	0–20 min	0
	20–40 min	1
	40–60 min	2
	≥60 min	3
7. Adherence to the 20-20-20 rule	Regularly follows	0
	Occasionally	1
	Rarely or never	2
8. Weekday–weekend sleep onset difference (social jet lag)	<1 hour	0
	1–2 hours	1
	2–3 hours	2
	>3 hours	3
9. Has your child had an eye examination in the past 12 months?	☐ Yes ☐ No	–
10. Would you like to receive information about pre-myopia assessment?	☐ Yes ☐ No	–
11. Phone number (optional)		–

* The questionnaire was completed by parents or legal guardians of children aged 6–10 years. The questionnaire score was calculated by summing the scores of the risk-related items. Higher total scores indicated a greater estimated risk of pre-myopia. Based on the total score, children were classified as low risk (0–4 points), moderate risk (5–7 points), and high risk (≥8 points).

According to total scores, 0–4 was classified as “low risk,” 5–7 as “moderate risk,” and ≥8 as “high risk.” Children classified as high risk according to the questionnaire were referred to the ophthalmology clinic for cycloplegic refraction and ocular biometry. Cycloplegia was induced with 1% cyclopentolate hydrochloride. Three drops were instilled into each eye at 5-minute intervals, and cycloplegic refraction was performed 60 minutes after the final drop. Cycloplegic refraction was measured using an autorefractometer (Topcon KR-800, Topcon Corporation, Tokyo, Japan). Spherical equivalent refraction (SER) was calculated as the spherical value plus half of the cylindrical value.

According to the International Myopia Institute criteria, eyes with an SER between -0.50 D and $+0.75$ D were considered to be in the pre-myopia range. Axial length (AL) and corneal radius (CR) were measured using the LenStar LS 900 optical biometer (Haag-Streit AG, Köniz, Switzerland). The device automatically performs repeated measurements and provides the average value once acceptable measurement quality is achieved. An AL/CR ratio ≥ 2.90 was used as a predefined biometric risk threshold in the present analysis. To avoid inter-eye correlation, only one eye from each participant was included in the statistical analysis.^[13]

Ethical approval for the study was obtained from the Clinical Research Ethics Committee of Erzurum of the University of Health Sciences [Decision no: 2025-10-277; Date: 27.10.2025], and written informed consent was obtained from all parents. The study was planned as a cross-sectional analytic study. A power analysis using the G*Power 3.1 program, based on values reported in the literature, assumed an effect size of $w = 0.30$ (medium effect). For a 95% confidence level ($\alpha = 0.05$) and 80% power ($1-\beta = 0.80$), the minimum required sample size was calculated as $n = 88$. The number of participants exceeded this, and thus the sample size was considered statistically sufficient.

Statistical analysis

Statistical analyses were performed using IBM SPSS version 21.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean $\pm$ standard deviation (SD), and categorical variables as numbers and percentages. Data from all 453 children were used to summarize demographic characteristics, questionnaire responses, and risk categories. Associations between categorical variables were analyzed using the chi-square test. Biometric analyses, including axial length (AL), corneal radius (CR), AL/CR ratio, and spherical equivalent refraction (SER), were performed only in the 44 children who attended the ophthalmologic examination. The relationship between questionnaire risk score and the biometric parameters (AL/CR ratio and SER) was evaluated using Pearson and Spearman correlation analyses. Univariable logistic regression analysis was used to examine the association between questionnaire risk score and an AL/CR ratio ≥ 2.90 . Results are presented as odds ratios (ORs) with 95% confidence intervals (95% CIs). A p value of <0.05 was considered statistically significant.

Results

A total of 652 children were invited to participate in the study. Of these, 596 had no vision-related complaints. Thirty-eight children were excluded because they were outside the 6–10-year age range, and 105 were excluded because they reported current spectacle use despite indicating no vision-related complaints on the questionnaire. As a result, 453 children were included in the final analysis. Based on the questionnaire scores, 104 children were classified as high risk and referred for ophthalmologic examination. Of these, 44 attended the examination and underwent cycloplegic refraction and ocular biometry. The mean age of participants was 7.91 ± 1.26 years; 51.7% were male, 48.3% were female. Parental myopia was absent in 65.3%, present in one parent in 28.3%, and in both parents in 6.4%. Daily outdoor time was reported as 0–1 hour in 17.7%, 1–2 hours in 34.7%, 2–3 hours in 21.4%, and ≥ 3 hours in 26.3% of children. Uninterrupted screen time was reported as 0–20 min in 20.5%, 21–40 min in 38.4%, 41–60 min in 26.7%, and ≥ 60 min in 14.3%. Only 9.9% regularly followed the 20-20-20 rule, while 47.9% occasionally and 42.2% rarely or never complied. Weekday-weekend sleep time differed by less than 1 hour in 64.5% of children and by 1–2 hours in 30.7%. Information included in this study, including the Pre-Myopia Risk Assessment Questionnaire as well as the demographic characteristics and lifestyle-related factors of the participating children, is presented in Table 1 and Table 2.

The mean total questionnaire risk score was 5.06 ± 2.06 . Based on the questionnaire scores, 170 children (37.5%) were classified as low risk, 179 (39.5%) as moderate risk, and 104 (23.0%) as high risk. The distribution of questionnaire risk scores and risk categories is summarized in Table 3. Forty-four of the 104 high-risk children underwent biometric examination. Mean AL was 22.59 ± 1.00 mm, CR was 7.79 ± 0.24 mm, the AL/CR ratio was

Table 2. Demographic characteristics and lifestyle factors of the children participating in the study.

Variable	n (%) / Mean $\pm$ SD
Total sample [n]	453
Age [years]	7.91 $\pm$ 1.26
Sex	
Male	234 (51.7)
Female	219 (48.3)
Parental history of myopia	
None	296 (65.3)
One parent	128 (28.3)
Both parents	29 (6.4)
Daily outdoor time	
0–1 hour	80 (17.7)
1–2 hours	157 (34.7)
2–3 hours	97 (21.4)
>3 hours	119 (26.3)
Uninterrupted screen time	
0–20 min	93 (20.5)
21–40 min	174 (38.4)
41–60 min	121 (26.7)
>60 min	65 (14.3)
Adherence to the 20-20-20 rule	
Always	45 (9.9)
Sometimes	217 (47.9)
Rarely/Never	191 (42.2)
Sleep-onset difference [weekday–weekend]	
<1 hour	292 (64.5)
1–2 hours	139 (30.7)
2–3 hours	17 (3.8)
>3 hours	5 (1.1)

2.90 $\pm$ 0.12, and spherical equivalent (SE) was -0.05 ± 0.42 D. AL/CR ratios ranged from 2.68 to 3.07, whereas SE ranged from -0.50 to $+0.50$ D, with all SE values remaining within the pre-myopia range. An AL/CR ratio ≥ 2.90 was observed in 25 children (56.8%). Correlation analysis demonstrated no significant association between questionnaire risk score and either the AL/CR ratio (Pearson $r = -0.08$, $p > 0.05$; Spearman's $\rho = -0.067$, $p = 0.666$) or SE (Pearson $r = -0.11$, $p > 0.05$; Spearman's $\rho = -0.096$, $p = 0.535$). Logistic regression analysis also showed that questionnaire risk score was

Table 3. Distribution of questionnaire risk categories and demographic associations.

Variable	n (%) / Mean $\pm$ SD
Risk score, mean $\pm$ SD	5.06 $\pm$ 2.06
Risk categories	
Low (0–4 points)	170 (37.5)
Moderate (5–7 points)	179 (39.5)
High (≥ 8 points)	104 (23.0)

not significantly associated with an AL/CR ratio ≥ 2.90 (OR = 1.14, 95% CI: 0.64–2.03; $p = 0.67$). The biometric characteristics of the examined high-risk children are presented in Table 4.

Table 4. Biometric characteristics, correlation analyses, and logistic regression results in children who underwent ophthalmologic examination.

Variable	Mean ± SD / n (%)
Axial length (AL), mm	22.59 ± 1.00
Corneal radius (CR), mm	7.79 ± 0.24
AL/CR ratio	2.90 ± 0.12
Spherical equivalent (SE), D	-0.05 ± 0.42
AL/CR range	2.68–3.07
SE range	-0.50 to +0.50
AL/CR ≥2.90	25 (56.8)

AL, axial length; CR, corneal radius; SE, spherical equivalent.

Discussion

A screening questionnaire based on risk factors associated with myopia development in childhood was administered. Results indicated that most children spent 1–3 hours outdoors daily, whereas uninterrupted screen time was usually 20–40 minutes. Compliance with the 20-20-20 rule was low, and most children had less than a one-hour difference in sleep onset time between weekdays and weekends. Risk score distribution showed that the majority of children fell into the moderate- and high-risk categories. One of the main findings of this study was the absence of a significant correlation between questionnaire risk scores and either the AL/CR ratio or spherical equivalent. This finding does not necessarily reduce the value of the questionnaire. Rather than reflecting the severity of biometric changes, the questionnaire was designed to identify children who may be at increased risk of developing pre-myopia based on behavioral and familial risk factors. In addition, biometric measurements were available only in the subgroup of children who attended the ophthalmologic examination, which may have limited the ability to detect significant correlations. Therefore, the questionnaire appears to be more useful as a practical screening tool for identifying children who should undergo further ophthalmologic evaluation than as a predictor of the magnitude of biometric changes.

Studies have reported increasing prevalence of myopia and pre-myopia in school-age children, particularly in education systems with intense near work.^[1] Near work and screen time increase myopia risk, whereas outdoor activities have a protective effect.^[14-17] Behavioral models including irregular sleep, academic workload, and limited outdoor time have been defined, especially in East Asian populations.^[16,18] Research has consistently shown an inverse relationship between outdoor activities and myopia risk. Yang et al. stated that increased outdoor time may prevent myopia development by supporting ocular health and slowing progression.^[19,20] Sunlight may influence biochemical processes in the eye by increasing dopamine release and supporting correct muscle function. Exposure to high levels of natural light plays an important role in preventing the development of myopia.^[20,21] School-based interventions aimed at increasing outdoor time have also been shown to reduce the incidence of myopia in children.^[17,22] This association is further supported by meta-analyses, systematic reviews, and large population-based studies.^[23-25] In addition to the duration of outdoor exposure, daylight characteristics and broader environmental and lifestyle factors may also influence refractive development^[26,27].

Studies show that family history is strongly linked to myopia development. Wang et al. found that individuals with a family history of myopia had a higher risk compared to those without.^[28] Low et al. reported that genetic factors may play a more significant role than environmental influences.^[29] Although myopia has strong genetic foundations, interaction with environmental factors is also crucial. Children with myopic parents progress faster when exposed to prolonged near work.^[29,30] The risk is higher when both parents are myopic. These findings increase the importance of genetic factors and highlight the role of family history in risk evaluation.

In 2023, Chen et al. examined the relationship between hyperopia reserve and future myopia risk in Chinese children. They reported that mean SE values shifted toward myopia and onset age decreased, with increasing pre-myopia rates in children aged 4–6.^[12] A negative correlation was found between SE below +1.50 D and rapid increase in myopia risk. Wang et al. reported age-specific normative values for hyperopia reserve that may facilitate early identification of children at increased risk of myopia.^[31] The CLEERE Study identified cycloplegic spherical equivalent refractive error as the strongest single predictor of future myopia onset^[9]. Longitudinal CLEERE data also demonstrated that refractive error became progressively less hyperopic and axial length increased during the years preceding myopia onset^[32].

The Turkish National Screening Program mainly focuses on amblyopia, strabismus, and pronounced refractive errors.^[10] Limitations include variability in screening quality, interpretation differences, and lack of risk-based classification involving family history, outdoor time, screen exposure, or sleep rhythm. A strength of this study is demonstrating that a short, easy questionnaire in primary care can identify high-risk pre-myopia candidates. Programs in countries like China, Singapore, and Taiwan integrate risk factor evaluation and outdoor counseling.^[16,33] The questionnaire in this study could be integrated into national screening programs.

The strengths of this study include its relatively large sample size and the use of a simple screening questionnaire. The main limitation is that ophthalmologic examinations were performed only in children classified as high risk, so the diagnostic performance of the questionnaire could not be fully assessed. In addition, this was a single-center study without long-term follow-up. Future studies including all risk groups are needed.

In conclusion, this study described the distribution of pre-myopia risk factors among children aged 6–10 years and demonstrated that a simple questionnaire can be used to stratify children according to their estimated pre-myopia risk in a primary healthcare setting. Although no significant association was found between questionnaire scores and ocular biometric parameters in the examined subgroup, children classified as high risk exhibited ocular characteristics compatible with pre-myopia. Therefore, the questionnaire may represent a practical and low-cost screening tool to assist primary care physicians in identifying children who could benefit from ophthalmologic evaluation. However, further prospective studies including children from all risk groups, together with formal validation of the questionnaire, are required before routine clinical implementation.

Ethical approval

This study has been approved by the Scientific Research Ethics Committee of the University of Health Sciences, Erzurum Medical Faculty (approval date 08.10.2025, number 2025/10-277). Written informed consent was obtained from the participants.

Author contribution

The authors declare contribution to the paper as follows: Study conception and design: ESU; data collection: BU,EDK; analysis and interpretation of results: ESU; draft manuscript preparation: BU,EDK. All authors reviewed the results and approved the final version of the article.

Source of funding

The authors declare the study received no funding.

Conflict of interest

The authors declare that there is no conflict of interest to disclose.

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