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Association of Indoor and Outdoor Activity Patterns with Myopia Among School-Going Adolescents: A Cross-Sectional Study

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Abstract

Purpose: To evaluate patterns of indoor and outdoor activities and prevalence of myopia among school-aged adolescents and to determine lifestyle variables that may influence refractive status during puberty.

Methods: Schoolchildren aged 11–18 years participated in a cross-sectional questionnaire survey. Structured surveys using Google Form were used to assess demographics, refractive status, spectacle use, outdoor exposure, near-work activities, digital device usage, reading habits, visual behavior and food. Participants were classified according to indoor and outdoor activity habits. Participant characteristics were described using summary statistics. Associations between lifestyle and myopia were assessed by chi-square testing. 'ORs and confidence intervals for selected variables were calculated. Statistical significance was defined as a two-sided $P<0.05$.

Results: The study involved 203 teenagers, 100 of whom completed the indoor activity survey and 103 the outdoor activity survey. Self-reported myopia was 53.0% in the indoor group and 52.4% in the outdoor cohort. There were 55.0% of female participants in the study.

Visual habits are related to myopia. Strong correlation between reading length and prevalence of myopia ($\chi 2=22.20$, $P<0.001$). Higher prevalence of myopia was observed among those who read longer durations. The association between the time spent in outdoor activities and refractive status was also strong (χ 2 = 16.81, $P < 0.001$). This indicates a lower prevalence of myopia among teenagers who spend more time outdoors. Myopia was found to be significantly associated with screen-use behavior, especially in those who reported insufficient visual breaks when using digital devices (χ 2 = 9.04, $P = 0.0026$). Children who spent less time outdoors, more time in near-work activities and more time using digital devices were more myopic.

Conclusion: Lack of outdoor activity time, prolonged near work and excessive screen-based activity are strongly related to myopia in school-aged adolescents. Outdoor exercise and healthy visual habits like frequent breaks while doing close-up work may reduce myopia in this age group. Public health programs aimed at behavioral risk factors may help prevent and control myopia.

Keywords: Myopia; Outdoor activity; Near work; Screen time; Adolescents; Refractive error; Visual behavior; Cross-sectional study.

1. Introduction

Myopia has become one of the most significant public health problems of the twenty-first century. Once thought of as a relatively common refractive error with few long term consequences, myopia is now understood to be a rapidly growing global epidemic affecting children and adolescents in varied geographic areas and socioeconomic circumstances. The prevalence of myopia has increased dramatically in recent decades, especially in East and Southeast Asia, where the prevalence of myopia in school-going children and young adults often exceeds 70–80% . Increasing trends are also noted in many developing countries such as India which raise concerns about future burden of visual impairment and myopia related ocular morbidity.[1,2]

The increasing prevalence of myopia is especially worrying as childhood-onset myopia often progresses through adolescence and may result in high myopia. High myopia is associated with an increased risk of sight-threatening complications such as retinal detachment, myopic macular degeneration, choroidal neovascularization, glaucoma and cataract.[3,4] Thus, the identification of the factors leading to the development of myopia in childhood has become a priority for clinicians, researchers and public health policy-makers around the world.

Myopia development is genetically predisposed, but there is accumulating evidence that environmental and behavioral factors also play an important role in the onset and progression of myopia.[5] The rapid rise in myopia prevalence over such a short time period cannot be attributed to genetic change alone and is thought to be due largely to changes in lifestyle associated with modernization, urbanization and educational pressures.[6] Modern childhood environments are characterized by increased academic demands, prolonged near work activities, extensive use of digital devices, and reduced opportunities for outdoor recreation. The changes have led to extensive investigation of the role of visual behavior and environmental exposure in the development of refractive error.

Among the environmental factors studied, outdoor activity has been consistently shown to be one of the strongest protective factors against myopia development . It has been shown in many epidemiological studies that the risk of myopia is lower in children who spend more time outdoors than in those who spend most of their time indoors .[7,8] Several biological mechanisms have been proposed to account for this protective effect. Exposure to high intensity natural light is thought to increase the release of dopamine in the retina which may prevent the eye from growing too long in the axial direction, a major structural change contributing to the development of myopia.^9^ Outdoor environments also promote a longer viewing distance, thereby decreasing accommodation and the visual stress linked to prolonged near work.[10]

On the other hand, prolonged near work indoors has often been cited as a risk factor for myopia. The constant accommodation and convergence needed for activities like reading, writing, studying, using a smartphone, working on a computer, and extended screen time may lead to changes in ocular growth patterns.[11] The use of smartphones, tablets and digital learning platforms has led to a considerable increase in the time spent on near-work activities by children and adolescents. The COVID-19 pandemic has worsened these trends, with remote learning and less outdoor exposure becoming the norm in many countries.[12, 13] There is growing evidence that increased visual strain and potentially hastening myopic changes in susceptible individuals may be associated with screen use over an extended period of time, decreased viewing distances and lack of visual breaks. [14]

The period of puberty is a particularly important one to study the relation of environmental factors and refractive development. Adolescence is a period of rapid somatic growth, simultaneous hormonal changes and changes in lifestyle behaviors. Ocular growth and axial elongation may still be ongoing during this period and adolescents may be particularly vulnerable to environmental effects on refractive status.[15] During puberty, school-going children are often confronted with increasing academic work, greater exposure to screens, and less involvement in outdoor recreational activities. Such behavioral changes may significantly impact the prevalence and severity of myopia during this critical developmental period.

India is experiencing significant demographic, educational and technological transitions that might be associated with changing patterns of refractive errors among children. Children’s daily activity patterns have changed due to urbanization, competitive academic environments, the ubiquity of smartphones and a growing reliance on digital learning. However, there is limited evidence on the association between indoor and outdoor activities and myopia among Indian adolescents, particularly in the pubertal age group, despite the growing importance of this issue. Understanding these associations is crucial to develop effective preventive strategies and to inform public health interventions aimed at reducing the burden of myopia.

Therefore, the present study was carried out to evaluate the association of indoor and outdoor activity patterns with myopia among school-going adolescents aged between 11 and 18 years. Specifically, the association between outdoor exposure, near-work activities, use of digital devices, reading habits and visual behaviours and self-reported myopia status was examined. The findings may add to evidence-based recommendations for myopia prevention and visual health promotion among school-going children by identifying potentially modifiable lifestyle factors related to myopia.

2. Methods

Study Design and Participants

A cross-sectional questionnaire-based study was conducted to look for association between indoor and outdoor activity patterns and myopia among school-going adolescents. The study population included children and adolescents aged 11–18 years, which corresponds to the pubertal age group, during which ocular growth and refractive changes are known to be influenced by both biological and environmental factors.

Data were collected over six months by means of structured questionnaires, administered through Google Forms. Participants were recruited from school going populations and were invited to participate voluntarily after being informed about the purpose of the study. Responses were anonymous, and no personally identifiable information was collected.

Population of study

The study population included adolescents aged 11-18 years enrolled in schools and willing to participate in the survey. The final analysis included a total of 203 completed responses: 100 respondents in the indoor activity survey and 103 respondents in the outdoor activity survey.

Inclusion criteria.

1. Were between 11 and 18 years of age.
2. Are schooled.
3. Filled out the questionnaire completely.
4. They reported their refractive status and visual habits.

Exclusion Criteria

1. Other ocular diseases reported except refractive errors.
2. History of eye surgery.
3. Amblyopia, strabismus, or other significant ocular pathology reported.
4. Partial questionnaires with a high level of non-response.

Study Instrument

A structured questionnaire was developed based on a review of the published literature of environmental risk factors for myopia. The questionnaire was divided into several parts which assessed demographic data, refractive status, visual habits, indoor activities, outdoor activities and dietary habits.
The questionnaire obtained information on:

- Age and sex.
- Myopia status (self-reported);
- Spectacles use.
- Distance vision uncorrected.
- Duration of outdoor activities on weekdays and weekends.
- Frequency of outdoor recreation.
- Exposure to natural daylight.
- Time spent outdoors viewing objects at a distance.
- Length of daily reading.
- Exposure to screens and use of digital devices.
- Using computers and smart phones.
- When you're looking at a screen, how often do you take breaks?
- Indoor recreational activities.

  Food intake including fruit, vegetable, fish, egg and water.

  Definitions of variables

  Dependent variable

  The main outcome variable was self-reported myopia status, categorized as:

- Near-sighted

- Sub-non-myopic

Myopic individuals were defined as those who reported myopia or the use of spectacles for correction of distance vision.
Independent Variables
The exposure variables of interest were:

Outcome Variable
The primary outcome variable was self-reported myopia status, categorized as:
- Myopic
- Non-myopic

Participants who reported having myopia or using spectacles for distance vision correction were classified as myopic.

Exposure Variables
The primary exposure variables included:

Outdoor Activity Variables
- Outdoor play duration on school days.
- Outdoor play duration on weekends.
- Frequency of outdoor recreation.
- Time spent observing distant objects.
- Exposure to bright outdoor environments.

Outdoor exposure was categorized into:
- Low exposure (<1 hour/day)
- Moderate exposure (1–2 hours/day)
- High exposure (>2 hours/day)

Indoor Activity Variables
- Daily reading duration.
- Smartphone and computer use.
- Online learning activities.
- Television viewing.
- Digital gaming.
- General near-work activities.

Reading duration was categorized as:
- <2 hours/day
- 2–4 hours/day
- 4 hours/day

Digital device use was categorized according to average daily duration.

3. Statistical Analysis and Data Processing

Raw questionnaire data were exported into Microsoft Excel and checked for completeness, duplicate entries and data inconsistencies prior to analysis. Responses were coded and collapsed into clinically meaningful categories for statistical analysis

Participant characteristics were described using descriptive statistics. Categorical variables are presented as frequencies and percentages. Continuous variables were summarized with means and standard deviations, where appropriate.

The associations between myopia and selected lifestyle variables were tested with Pearson's Chi-square test. To estimate the strength of association between visual habits and myopia, odds ratios (ORs) with 95% confidence intervals (CIs) were calculated.

Variables found to be statistically significant in univariate analysis were entered into multivariable logistic regression modeling to identify independent predictors of myopia after controlling for potential confounding factors. Predictor variables included age, gender, time outdoors, time reading, time on screen, and frequency of visual breaks during near work.

A two-tailed P value <0.05 was considered as statistically significant.

Ethical Issues:

Study participation was voluntary. Informed consent was assumed by the completion and submission of the questionnaire. The study was conducted in accordance with the principles of the Declaration of Helsinki for human research. To guarantee confidentiality and privacy of respondents all responses have been anonymized prior to analysis.

4. Results

Participant Characteristics

The final analysis included a total of 203 usable responses. The dataset was verified and confirmed 100 responses from the indoor activity survey and 103 responses from the outdoor activity survey. The participants were school going adolescents of the pubertal age group (11-18 years). Of the study population, 55.0% were females and 45.0% were males.

The self-reported myopia prevalence was comparable in the two datasets. The prevalence of myopia in the indoor activity group was 53.0% (53/100) and 52.4% (54/103) in the outdoor activity group. 38.8% (40/103) of participants in the outdoor activity survey reported spectacle use (Table 1).

Table 1. Baseline Characteristics of Study Participants

Characteristic	Indoor Survey (n=100)	Outdoor Survey (n=103)
Male, n (%)	45 (45.0)	46 (44.7)
Female, n (%)	55 (55.0)	57 (55.3)
Myopic, n (%)	53 (53.0)	54 (52.4)
Non-myopic, n (%)	47 (47.0)	49 (47.6)
Spectacle users, n (%)	—	40 (38.8)

Patterns of Outdoor Activity

Weekday outdoor exposure was generally restricted for outdoor activity survey participants. Over half of the respondents (58.0%) reported spending less than one hour outdoors on school days, and only 16.0% reported spending more than two hours outdoors each day. The percentage of participants who spent at least two hours outdoors during the weekend was quite high (41.0%).

For visual behavior in outdoor activities, 54.0% of participants reported to have always or often looked at distant objects when outdoors. The most reported outdoor activities were photography or vlogging (44%), cricket (43%), outdoor tuition classes (33%), kho-kho (29%) and kite flying (27%).

Screen time and safety concerns were identified as major barriers to outdoor recreation. Thirty-six percent of respondents cited screen exposure as a barrier, and 36% mentioned safety concerns. Other limiting factors mentioned were lack of adequate outdoor space and academic commitments.

Indoor Activity Patterns

Indoor activity assessment showed considerable engagement in near-work and digital activities. The most commonly reported indoor activity was the use of smartphones and computers, with 93% of respondents reporting doing so. Other reported activities were watching YouTube (77%), writing (75%), reading in general (69%), watching television (47%) and playing digital games (45%).

In terms of reading habits, 66% of the participants read less than 2 hours every day while 34% read for 3 or more hours daily. Most of the participants had long duration of exposure to digital devices. About 60% reported more than three hours per day use of computer or laptop.

Only 57.1% of respondents stated they took regular breaks during extended screen use, whereas 42.0% reported continuous screen exposure without prescribed visual rest periods.

Correlation between reading time and myopia

There was a statistically significant association between daily duration of reading and myopia status ($\chi^2 = 22.20$, $P < 0.001$). The prevalence of myopia in those who spent long time reading was significantly higher than that in those who spent short time reading.

The prevalence of myopia increased progressively with duration of reading, indicating that the ongoing near work may lead to refractive changes in adolescence (Table 2).

Table 2. Association Between Reading Duration and Myopia

Variable	χ^2	P value
Daily reading duration	22.20	<0.001

Outdoor activity duration demonstrated a significant association with refractive status. Adolescents reporting lower outdoor exposure exhibited a higher prevalence of myopia compared with those spending longer periods outdoors.

Analysis of weekday outdoor activity revealed that participants spending less than one hour outdoors per day were more likely to report myopia than those engaging in greater outdoor exposure. The overall association between outdoor activity duration and myopia was statistically significant (χ^2 = 16.81, P < 0.001).

Table 3. Association Between Outdoor Activity and Myopia

Variable	χ^2	P value
Outdoor activity duration	16.81	<0.001

Screen-Use Behavior and Association with Myopia

The myopia status was significantly associated with screen-use behavior. Participants who did not take regular breaks when using digital devices were more likely to have myopia than those with healthier visual habits.

The relationship between screen-break behavior and myopia was statistically significant ($\chi2$ = 9.04, P = 0.0026).

Table 4. Association Between Screen-Break Behavior and Myopia

Variable	χ^2	P value
Regular screen breaks	9.04	0.0026

Odds Ratio Analysis

Odds ratio analysis showed a strong association between refractive status and screen-use habits. Those who did not take regular breaks while using screens for long periods had significantly higher odds of being myopic compared to those who followed recommended visual rest practices (OR = 3.89).

These findings suggest that visual behaviour during digital device use may be an important modifiable risk factor for myopia in adolescents.

Table 5. Odds Ratio for Selected Visual Behaviors

Variable	Odds Ratio (OR)
Absence of regular screen breaks	3.89

Multivariable Analysis

Variables that were found to be significant in the univariate analyses such as reading duration, outdoor activity duration and screen-break behavior were included in a multivariable logistic regression model. Reduced outdoor exposure and prolonged near-work activities were still important predictors of myopia after adjusting for demographic factors.

Of the variables analyzed, long reading time was most strongly associated with the prevalence of myopia, followed by low outdoor activity and inadequate visual breaks during screen use.

5. Discussion

The present cross-sectional study was conducted to study the association of indoor and outdoor activity patterns with myopia in school-going adolescents aged 11–18 years. The results showed significant associations of visual lifestyle behaviors with the prevalence of myopia. Myopia was more common in those who spent less time outdoors, read more, engaged more in screen-based activities, and did not take sufficient visual breaks during near work. Conversely, greater participation in outdoor activities seemed to have a protective association with myopia. These findings are consistent with a growing body of international evidence which suggests that environmental and behavioural factors are crucial to refractive development in childhood and adolescence. [15,16,19,]

Myopia has become a major public health challenge worldwide, especially in areas of rapid urbanization and increasing educational intensity. The worldwide rise in myopia has been ascribed to an interaction of genetic predisposition with significant alterations in lifestyle and environmental exposures. Modern day youth are involved in academic pursuits, screen-based learning and screen-based leisure, while the opportunities for outdoor play and physical activity have been gradually eroded. The present findings reflect these changing behavioral patterns and provide further evidence in support of the contribution of modifiable environmental factors to the development of myopia. [15, 19,30,31]

One of the important results of the present study was a significant association between duration of outdoor activity and myopia. Those who spent less time outdoors were more likely to be myopic than those who spent longer periods outdoors. This finding is in agreement with a number of epidemiological investigations performed across Asia, Europe, Australia and North America. Several prospective studies have shown that increased outdoor activity reduces the risk of incident myopia in children and adolescents. One of the most effective non-pharmacological strategies for myopia prevention has been identified as time spent outdoors. [16,18,,24]

Several biological mechanisms have been suggested to explain the protective effect of outdoor exposure. Bright natural light causes the release of dopamine from retinal amacrine cells, which is thought to suppress excessive axial elongation of the eye. Axial elongation is the primary structural mechanism of myopia development, and increased retinal dopamine activity may contribute to normal ocular growth. In addition, the outdoor environment promotes viewing at a distance, reducing the accommodative demand and visual stress of sustained near work. Exposure to a wider variety of visual stimuli and to higher light intensities may also help refractive development to be healthier. The significant association observed in the present study further supports the importance of outdoor activity as a potentially modifiable protective factor against myopia. [16, 19, 21, 22]

The present study also found a strong association of the duration of reading with the prevalence of myopia. Adolescents who reported reading for long periods of time were significantly more likely to be myopic than those who read for shorter periods of time. Near-work activities have been implicated in the etiology of myopia for many years although the strength of the association has varied between studies. Close work (reading, writing, studying) requires sustained accommodation and convergence and may lead to retinal defocus and affect ocular growth. Prolonged accommodative stress repeated during critical periods of development may contribute to progressive axial elongation in susceptible individuals. [15,19,28]

In recent years, the concept of near work has been extended to include extensive use of digital devices. The present study found that adolescents were extensively using smartphones, computers and other digital devices. More than three-quarters of respondents reported engagement with screen-based activities, indicating the increasing role of digital technology in the daily lives of children. Specifically, screen-use behavior was significantly associated with myopia, particularly among participants who reported insufficient visual breaks during prolonged device use. The observed association between screen-break behavior and myopia is in line with current recommendations for periodic interruption of near-work activities. [17,18,23]

The connection between digital device screen time and nearsightedness is still being studied. Studies have suggested that prolonged screen time may increase myopia risk through mechanisms similar to those of traditional near work. Digital devices are typically viewed at closer viewing distances than print, increasing accommodative demand. Moreover, the continued use of smartphones and tablets often takes place indoors, which can displace outdoor activities that might have a protective effect. The COVID-19 pandemic and the subsequent acceleration of digital education have heightened concerns about children spending too much time in front of screens. The results from the present study add to the growing evidence that visual habits associated with the use of digital devices should be considered in the design of strategies for myopia prevention. [17,18,19,23]

Another significant finding was the high frequency of indoor recreational activities among the study participants. The most common activities reported were use of a smartphone, online content consumption, television viewing and digital gaming. The results are in accordance with general social trends where the use of technology-based leisure pursuits is replacing traditional outdoor recreation pursuits. However, the potential ocular consequences of prolonged indoor visual behavior warrant careful consideration, even though technological advancement brings educational and social benefits. Therefore, encouraging a healthy lifestyle with enough outdoor activity might be an important target for public health.[29, 31, 34]

The results of this study have practical implications. First, they endorse the use of school-based interventions that promote outdoor activities during and after school hours. Previous intervention studies have indicated that increasing daily outdoor exposure could decrease the incidence of myopia in children. Schools can therefore be an ideal setting for prevention strategies, such as extended outdoor recess times and structured physical activity programs. [18,21,22,24]

Secondly, educational campaigns targeting parents, teachers, and students should focus on good visual habits, such as appropriate viewing distances, proper lighting conditions, and regular breaks during near-work activities. The “20-20-20 rule” is commonly recommended where people look away from their screen and at a distant object every 20 min for at least 20 s and may help reduce accommodative stress during long periods of screen use. [17, 18]

Several limitations should be considered when interpreting the findings. First, the cross-sectional design does not allow establishment of causal relationships between lifestyle factors and myopia. Although significant associations were found, temporal directionality cannot be determined. Longitudinal cohort studies are needed to determine if specific behavioural factors are directly involved in the development and progression of myopia. Second, refractive status and activity patterns were self-reported which can lead to recall bias and misclassification. More accurate assessments would include objective measurements of refractive error, axial length and outdoor light exposure. Third, the study population was limited to a specific school-going adolescent group which may affect the generalizability of the findings to other populations and geographic locations. Finally, the lack of complete information concerning parental myopia, socioeconomic status, educational intensity and genetic predisposition might have impacted the observed associations. [15,16,17]

Despite these limitations, this study provides important insights into modern visual behaviors in adolescents and their associations with myopia. Indoor and outdoor activities were assessed to allow comprehensive evaluation of modifiable environmental factors relevant to refractive development. The findings add to the increasing evidence base supporting lifestyle interventions for myopia prevention and highlight the importance of balancing academic demands with digital engagement and outdoor recreation.

6. Conclusion

To conclude, the present study shows significant associations of myopia with several modifiable lifestyle factors in school-going adolescents. Less outdoor activity, longer reading time, more near-work activity and lack of visual breaks were associated with a higher prevalence of myopia. These findings are in accordance with current recommendations that increased outdoor activity and healthy visual habits are important components of myopia prevention strategies. Further prospective studies with objective ocular measurements and longitudinal follow-up are needed to better understand the association between environmental exposures and refractive development in adolescence.

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