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Impact of environment and genetic factors on myopia in goan children: A behavioral perspective

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ABSTRACT

Background: The interaction between lifestyle and family history of myopia plays a vital role in the development and progression of myopia. Understanding this interaction is essential to developing holistic treatment approaches.
Clinical Relevance: An environment-genetic score is a measure that combines information about a person's genetic predisposition and environmental factors that may contribute to the development of a specific condition. This score can help optometrists and other eye care professionals make more informed and personalised decisions regarding the management and treatment of myopia.
Materials and Methods: A cross-sectional study was conducted in the ophthalmology outpatient department in Goa, India. Children aged between 7 and 15 years were included. Children with less than 0.1 logMAR visual acuity later underwent objective and subjective refraction. A prevalidated questionnaire was used to assess the environmental impact on myopia. Parental myopia was recorded. An Environmental Genetic Index (EGI) can be created to evaluate the risk of myopia in a given population. The difference between the prevalence of myopia in these families is defined as EGI.
Results: 152 children were evaluated, of which 64 (42.10%) were females. This study included 75 myopes (49.34%) and 77 emmetropes (50.66%). The prevalence of myopia in the myopic family was 85.71%; in the one-sided-myopic family, it was 60%; and in the non-myopic family, it was 45%. The environmental genetic index was 0.4071, suggesting that genetic factors may play a 40.71% role in the formation of myopia and environmental factors may play a 59.29% role in myopia development.
Conclusion: Genetic factors may have played a 40.71% role in the formation of myopia in the studied population. 12.98% of Myopes lived in a flat, usually in a smaller house, without access to the garden compared to 1.33% of emmetropes. A statistically significant difference was seen in the distance near work was performed; myopes tend to hold their targets closer than 30 centimetres.

1. Introduction

Myopia, commonly known as nearsightedness, is a refractive error of the eye that has experienced a global surge in prevalence over the past few decades. While genetic factors have long been recognised as essential contributors to myopia, growing evidence suggests that environmental influences play a significant role in its development and progression.[1] Understanding the impact of the environment and genetics on myopia is crucial for developing effective strategies to mitigate its increasing prevalence.

One of the prominent environmental factors associated with myopia is outdoor light exposure, particularly natural daylight. Numerous studies have demonstrated an inverse relationship between outdoor time and myopia prevalence,

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indicating that increased exposure to natural light may have a protective effect against myopia development.[2,3] It is suggested that outdoor light exposure promotes dopamine release in the retina, inhibiting the eyeball's excessive elongation, a key factor contributing to myopia.[4] Animal studies have further supported this association, showing that exposure to bright light can prevent myopia development.[5] Therefore, encouraging individuals, especially children, to spend more time outdoors in well-lit environments may help reduce the risk of myopia.

Prolonged engagement in near-work activities, such as reading, writing, and the use of digital devices, has also been implicated as an environmental risk factor for myopia. Several studies have reported a positive association between the duration of near-work activities and myopia prevalence, particularly among children and adolescents.[6] The exact mechanisms underlying this relationship are not yet fully understood, but it is believed that prolonged near-work tasks may lead to increased accommodative effort and convergence, resulting in axial elongation of the eyeball and the development of myopia.[7] However, it is worth noting that the evidence regarding near work as a risk factor for myopia is not entirely consistent across all studies.[8] Further research is needed to elucidate the precise role of near-work activities in myopia development.

The indoor environment, including lighting conditions, may also contribute to the development and progression of myopia. Studies have shown that insufficient illumination levels indoors, especially in schools and workplaces, are associated with an increased risk of myopia. Inadequate lighting may increase visual strain, influencing myopia development.[9] Furthermore, excessive exposure to artificial light, particularly from electronic devices, has been suggested as a potential risk factor for myopia progression.[10] The blue light emitted by digital screens may disrupt the regulation of eye growth, potentially contributing to myopia development.[11] Therefore, optimising indoor lighting conditions and promoting responsible use of electronic devices may help mitigate the impact of the indoor environment on myopia.

Numerous studies have established a vital genetic component in the development of myopia. It has been observed that myopia tends to run in families, with individuals having a higher risk of developing myopia if one or both parents are myopic.[12,13] Twin studies have further confirmed the heritability of myopia, with higher concordance rates among monozygotic twins compared to dizygotic twins.[14] Genetic variations and polymorphisms associated with eye structure and refractive error have also been identified.[15] However, it is essential to note that while parental myopia increases the likelihood of myopia in children, it is not the sole determinant, indicating the role of additional factors.

Apart from specific behaviours, children may share genetic and environmental exposures with their myopic parents. Genetic factors linked to myopia susceptibility can be inherited by children from their myopic parents, increasing their likelihood of developing myopia.[16] Moreover, children raised in households with myopic parents are likely to have similar lifestyle patterns and exposure to environmental risk factors, such as reduced outdoor time and increased near-work activities.[8] These shared influences contribute to the higher risk of myopia observed in children with myopic parents.

This study aims to understand the relationship between genetic predisposition and myopia. It also seeks to understand how lifestyle and behavioural factors influence the incidence of myopia.

2. Materials and Methods

The institutional review boards approved the project, and it adhered to the tenets of the Declaration of Helsinki. A cross-sectional study was conducted in the ophthalmology outpatient department in Goa, India. Parents who approved enrollment in the study were included. An informed written consent form was signed by either a parent or legal guardian of each subject. Children aged between 7 and 15 years were included. Children with a prior history of any other ocular manifestations, systemic disorders, or myopia due to secondary reasons were excluded from the study. Children with visual acuity of less than 0.1 logMAR later underwent objective evaluation using retinoscopy and subjective refraction. Cycloplegic refraction was performed. The spherical equivalent (SE) was calculated as sphere + $\frac{1}{2}$ cylinders, and myopia was defined as SE 0.5 D in at least one eye. Children with logMAR visual acuity of 0.1 in both eyes, no glasses, or an ophthalmic history were classified as emmetropic (SE< 0.50D). Axial length (AL) was measured with a contact A-Scan machine and was recorded in millimetres (mm). A prevalidated questionnaire was used to assess the environmental impact on myopia.[17] This questionnaire consisted of questions about time spent outdoors, reading distance, time spent reading, reading distance, etc. It calculated the mean daily outside exposure required by multiplying the days by the minutes and dividing by seven. Parental myopia was registered as 0, 1, or 2 myopic parents by questionnaire.

2.1. Environmental genetic index (EGI)

An environmental genetic index can be created to evaluate the risk of myopia in a given population. This indicator may be used for early intervention or preventive strategies to identify those more likely to develop myopia. Children were divided into three groups. The group with both parents' myopia was called the myopic family, children with either of the parents' myopia were grouped as a one-sided myopic

family, and children with no myopic family were called the non-myopic family.

Prevalence of disease = Genetic factors (GF) + environmental factors (EF).

Prevalence of myopia in Myopic family (P_M)= GF +EF

Prevalence of myopia in Non-Myopic families (P_N) = 0+ EF = EF

EGI = P_M - P_N

EGI = (GF+EF)-(0+EF)

EGI = GF +EF-0-EF

EGI$_=$GF[18]

The difference in the prevalence of myopia in these families is defined as EGI, which ranges from 0 to 1. An increased EGI indicates a more substantial genetic influence and a diminished environmental influence.[18] To derive the effect of genetic influence, EGI is multiplied by 100. To derive the environmental impact, EGI is subtracted from 1.

Multiple regression analysis was performed to understand the impact of different independent variables on the refractive error. All the data were analysed using the statistical tools in Statistical Package of Social Science (SPSS version 14).

3. Results

A total of 152 children residents of Goa were evaluated, of which 64 (42.10%) were females. The average age of the participants was 9.663 ± 24405 years. This study included 75 myopes (M) (49.34%) and 77 emmetropes (E)(50.66%). Demographic data is represented in Table 1. The prevalence of myopia in the myopic family was 85.71%; in the one-sided-myopic family, it was 60%; and in the non-myopic family, it was 45%. (Table 2) The environmental genetic index was 0.4071. EGI overall reflects the effects of both genetic factors and environmental factors. The EGI is 0.4071, suggesting that genetic factors may play a 40.71% role in the formation of myopia and environmental factors may play a 59.29% role in myopia development.

Table 3 shows near-work behaviour between emmetrope and myope. Closer working distance showed a statistically significant difference. ($p<0.05$), 41.33% of Myopes had a working distance of less than 30cm compared to 22.97% of emmetropes.

Table 4 shows outdoor activity and duration.

Multiple regression was performed to understand these variables' effect on myopia incidence. The total impact of the variables on the incidence was 3.5% (Adjusted R square 0.035).

4. Discussion

The environmental and genetic index (EGI), which precisely represents both the effects of genetic and environmental factors, was developed to distinguish between the effects of genetic and environmental factors (myopia prevalence in kids with two myopic parents) and ecological factors (myopia prevalence in kids with two non-myopic parents). In our study, EGI was calculated as 0.4071; we saw a drastic difference in the prevalence of myopia in the myopic family (85.71% vs 45%). Similar results were seen in the previous study, where EGI was calculated as EGI = 0.385. A different result was seen in a study conducted in China, where a computed EGI of 0.125 indicates that environmental influences may contribute 87.5% and genetic factors 12.5% to myopia development, respectively.[19]

Over the past years, numerous studies on schoolchildren and students have documented a strong correlation between the development of myopia and education. A critical analysis of the data reveals that near work (accommodation) is not solely to blame for the development of myopia but only when combined with a learning process, including retention or memorising.[19] Similar results were seen in our study. Studying at home showed a difference between emmetropes and myopes, whereas reading in spare time, including leisure reading, did not differ.

Myopia, promoted by sustained accommodation, has been linked in certain studies to reading continuously, reading over a longer time, and reading at closer ranges.[20,21] It has been hypothesised that the hyperopic defocus produced on the retina by accommodative lag during close work increases eye growth since imposed hyperopic defocus is a potent stimulant for eye growth in animal models.[22] The Sydney Myopia Study (SMS) involved 2353, 12 and 13-year-old children. The study found that reduced reading distance (<30 cm) and prolonged reading (>30 min) increased the incidence of myopia by 2.5- and 1.5-fold, respectively.[23] Our study also demonstrated that myopes had a closer working distance than emmetropes.

In our study, none of the kids owned their device but had access to their parent's device. On average, 41.33%

Table 1: Demographic data

		Emmetrope	Myope	p-Value
n		77	75	N.A
Age (years)		9.740 ± 2.190	9.586 ± 2.691	N.A
Gender	Male	32	32	N.A
	Female	45	43	
Spherical Equivalent (D)	Right Eye	0±0	-2.71±2.386	0.00
	Left Eye	0±0.25	-2.664±2.377	0.00
Axial Length (mm)	Right Eye	23.021±0.813	24.018±0.996	0.392
	Left Eye	23.075±0.792	24.026±0.959	0.472

Table 2: Prevalence of myopia based on family history and environment genetic index

	Non Myopic Family	One- Sided Myopic Family	Myopic Family	
Emmetrope	66	10	1	77 (50.657%)
Myopia	54	15	6	75 (49.34%)
	120 (78.94%)	25(16.447%)	7 (4.605%)	152
	Prevalence of myopia in myopic family	0.85714		
	Prevalence of myopia in non-myopic family	0.4500		
	EGI	0.4071		

Table 3: Near work activities between myopes and emmetropes

Near Work		Emmetrope	Myope	p-value
	n	77	75	
	Never	9 (11.68%)	17 (22.66%)	
	< 5 h/w	55 (71.42%)	36 (48%)	
Read in Spare time	5 -10 h/w	12 (15.58%)	18 (24%)	0.372
	11 to 15 h/w	0 (0%)	1 (1.33%)	
	> 15 h/w	1 (1.29%)	3 (4%)	
	Never	30 (38.96%)	29 (38.66%)	
	< 5 h/w	25 (32.46%)	19 (25.33%)	
Hand-held computer games	5 -10 h/w	19 (24.67%)	18 (24%)	0.372
	11 to 15 h/w	2 (2.59%)	7 (9.33%)	
	> 15 h/w	1 (1.29%)	2 (2.66%)	
	Never	5 (6.49%)	4 (5.33%)	
	≤ 15 h/w	12 (15.58%)	19 (25.33%)	
Close-up activities?	16 - 30 h/w	29 (37.66%)	10 (13.33%)	0.265
	31- 45 h/w	24 (31.16%)	27 (36%)	
	> 45 h/w	7 (9.09%)	15 (20%)	
Near Work distance	< 30 cm	17 (22.07%)	31 (41.33%)	0.01
	> 30 cm	60 (77.92%)	44 (58.66%)	
	< 30 minutes	9 (11.68%)	8 (10.66%)	
	30 min - 2 hours	29 (37.66%)	25 (33.33%)	
Smartphone or tablet	2 - 4 hours	30 (38.96%)	31 (41.33%)	0.754
	4 - 6 hours	9 (11.68%)	11 (14.66%)	
	>6 hours	0 (0%)	0 (0%)	
	I don't study at home	2 (2.59%)	1 (1.33%)	
	- 30-60 minutes	32 (41.55%)	25 (33.33%)	
Studying at home	- 1-2 hours	31 (40.25%)	33 (44%)	0.426
	- 2-3 hours	11 (14.28%)	13 (17.33%)	
	- More than 3 hours	1 (1.29%)	3 (4%)	

Table 4: Outdoor activities in between myopes and emmetropes

Outdoor			Emmetrope	Myope	p-value
		n	77	75	
Play Outside	Week days	Never	4 (5.19%)	8 (10.66%)	0.559
		1 day/week	1 (1.29%)	8 (10.66%)	
		2 days/week	12 (15.58%)	13 (17.33%)	
		3 days/week	25 (32.46%)	18 (24%)	
		4 days/week	19 (24.67%)	9 (12%)	
		Every weekday	16 (20.77%)	19 (25.33%)	
	Weekend	Never	12 (15.58%)	12 (16%)	0.843
		1 day/week	26 (33.76%)	30 (40%)	
		2 days/week	37 (48.05%)	33 (44%))	
Number of sports activities		No	18 (23.37)	32 (42.66%)	0.621
		1	48 (62.33%)	36 (48%)	
		2	12 (15.58%)	4 (5.3%)	
		≥ 3	1 (0.012%)	3 (4%)	
Duration		Hours/Day	0.374 ± 0.20	0.311 ± 0.206	0.745

of myopes spent 2-4 hours using smartphones compared to 38.96% of emmetropes. There was no statistically significant difference between the two groups. According to the meta-analysis's findings, using smart devices for extended periods—alone and in conjunction with computer screens—may raise the chance of developing myopia. Objective measurements such as face-to-screen distance, surrounding light, posture, viewing angle, and applications may help clarify how digital devices affect myopia. Our study showed that, on average, both myopes and emmetropes spend 1-2 hours studying at home. This also included any form of extra tutoring they received post-school. 20% of Myopes read one or more books unrelated to their coursework per week compared to 11.68% of emmetropes. Previous studies have shown that spending more time in education is one of the causative risk factors for myopia.[24] A lack of outdoor time is one possible mediator in the causal relationship between spending more time in school and developing myopia.

77.922% of Emmteropes spend three or more weekdays outdoors compared to 61.33% of myopes. 10.66% of Myopes did not play outdoors during weekdays. No statistically significant difference was seen in the time spent outdoors between myopes and emmetropes. In a previous hospital-based observational study, compared to the last visit, the change in SE was negatively impacted by 0.06 D for every hourly increase in outdoor activity per day.[25] According to specific theories, intense light causes the retina to release dopamine, and this more significant release of dopamine prevents the eyeball from elongating axially.[26]

Current living conditions impacted the refractive error status. Upon asking where they currently lived, 12.98% of myopes lived in a flat or apartment without a garden, compared to 1.33% of emmetropes. 98.66% of emmetropes lived in a house with access to the garden. The difference was statistically significant.

In a study that evaluated the effects of greenness on myopia risk and school-level myopia, myopia prevalence in schools and teenagers' personal myopia risk were inversely correlated with greenness around schools.[27] In a study conducted in mainland China, the housing style of a flat room in a lower dwelling level and more time spent outside were considered protective factors against myopia.[28] A study conducted in Hong Kong to understand the effect of the size of living space on myopia progression demonstrated that kids with axial myopia typically had more hyperopic defocus and lived in smaller households.[28]

The study was questionnaire-based and depended on subjective responses. In further studies, an objective assessment of kids' outdoor activity, living conditions, and near work needs to be assessed.

5. Conclusion

In the studied population, genetic factors may play a 40.71% role in the formation of myopia. 12.98% of Myopes lived in a flat, usually in a smaller house, without access to the garden compared to 1.33% of emmetropes. A statistically significant difference was seen in the distance near work was performed; myopes tend to hold their targets closer than 30 centimetres.

A higher number of myopes tend to study for longer hours at home (M: 20.33% vs E: 15.57%) and read for more than 5 hours in their spare time (M: 29.33% vs E: 16.87%). The percentage of emmetropes playing more than one sport was higher than myopes (E: 15.592% vs M: 9.3%).

6. Source of Funding

None.

7. Conflict of Interest

None.

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