Prevalence and Related Factors for Myopia in School-Aged Children in India

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Background

Due to high prevalence myopia has gained importance in epidemiological studies. Children with early onset are at particular risk of complications associated with myopia, as progression over time might result in high myopia and myopic macular degeneration. Both genetic and environmental factors play a role in the increasing prevalence of myopia. The aim of this study is to review the current literature on epidemiology and risk factors for myopia in school children (aged 6–19 years) around the world.

Myopia (short-sightedness, near-sightedness) causes distance blur and is a refractive error where the eye is typically too long in relation to the refractive power of the anterior segment of the eye. The prevalence of myopia is increasing worldwide and it is discussed to be the most common cause of vision impairment without optical correction in developed countries.

Myopia in school children is a critical public health problem, especially in Asian countries . After years of scientific research, the precise etiology of myopia remains elusive. Furthermore, there are no general and well-accepted guidelines followed by eye care practitioners for interventions that may decrease myopia development in children.

India is the second most populated country in the world with 41% of the population (492 million) under 18 years of age. While numerous studies have shown an increasing prevalence of myopia worldwide, there continues to be uncertainty about the magnitude of myopia in Indian school going population.

Main body

PubMed, Medline, BMJ Journal and Research Gate were searched for the following keywords: prevalence, incidence, myopia, refractive error, risk factors, children and visual impairment. English language articles published between Jan 2013 and Mar 2019 were included in the study. Studies were critically reviewed for study methodology and robustness of data. Eighty studies were included in this literature review.

Myopia prevalence remains higher in Asia (60%) compared with Europe (40%) using cycloplegic refraction examinations. Studies reporting on non-cycloplegic measurements show exceptionally high myopia prevalence rates in school children in East Asia (73%), and high rates in North America (42%). Low prevalence under 10% was described in African and South American children. In recent studies, risk factors for myopia in schoolchildren included low outdoor time and near work, dim light exposure, the use of LED lamps for homework, low sleeping hours, reading distance less than 25 cm and living in an urban environment.

Conclusion

Low levels of outdoor activity and near work are well-established risk factors for myopia; this review provides evidence on additional environmental risk factors. New epidemiological studies should be carried out on implementation of public health strategies to tackle and avoid myopia. As the myopia prevalence rates in non-cycloplegic studies are overestimated, we recommend considering only cycloplegic measurements.

Introduction

Myopia has become a major global public health problem, particularly in East Asia . The direct cost of providing eyeglasses to people who need refractive correction are also enormous. In the United States, the National Health and Nutrition Examination Survey (NHANES) reported the annual direct cost of correcting distance vision impairment due to refractive errors to be between US$3.9 and US$7.2 billion. The prevalence of myopia is generally highest in populations of East Asian, particularly in urban locations such as Guangzhou, Hong Kong, and Korea. Affected by many factors, such as visual function, psychology, aesthetics, and economy, the quality of life in patients of myopia was seriously impaired.

India is the second most populated country in the world, with around 41% of its population (492 million) being less than 18-year age group. This young population is an important asset for development of the country and their challenges must be addressed in time. However, due to the large regional differences in culture, habits, socioeconomic status, educational levels and urbanization, there continues to be an uncertainty about the exact magnitude of myopia burden in Indian school going children and its trend over time. The study was undertaken to fill up this lacuna which can help in understanding the prevalence of myopia, regional variations and prediction of trend, using all the published literature of the last four decades from India.

While rising myopia is a cause of concern in most of the countries, it is not given due importance in India due to lack of adequate nationwide prevalence data and prospective studies comparing the trend of myopia over decades. Due to this, the representation of India is poor in studies predicting global trends of myopia. Previous studies by the authors have reported a prevalence of myopia of only 13.1% among school going children in north India with an annual incidence of 3.4%.

Background

The modern rise in myopia mirrors a trend with children in many countries spending considerable amounts of time engaged in reading, studying or using computer and smartphones. The evidence suggests that not only genetic, but also environmental factors such as time spent outdoors, play a major role in this rise, and probably explain the epidemic of myopia that has appeared in East Asia. In other parts of the world, the prevalence of myopia also seems to be increasing. Therefore, myopia has gained particular importance in epidemiological studies. It is estimated that 1.4 billion people were myopic in 2000, and it is predicted that by 2050 the number will reach 4.8 billion.

Socioeconomically, refractive errors, particularly if uncorrected, can affect school performance, limit employability and impair quality of life. Myopia is known to be associated with several ocular complications such as retinal detachment, glaucoma, cataract, optic disk changes and maculopathy. High prevalence rates pose a major public health challenge due to visual impairment. The global potential productivity loss associated with the burden of visual impairment in 2015 was estimated at US$244 billion from uncorrected myopia, and US$6 billion from myopic macular degeneration. Children with early onset myopia are the group at major risk, as they will have higher duration of the disease, higher myopia progression and will be at risk of developing high myopia plus myopic macular degeneration. Age of myopia onset or duration of myopia progression is the most significant prognosticator of high myopia in later childhood.

Methodology

Literature search

PubMed and Medline were searched to identify the prevalence of myopia among children, as reported in articles between January 2013 and March 2019. The following keywords were used in various combinations: *prevalence, incidence, myopia, refractive error, and visual impairment* (("prevalence" All Fields] OR "incidence" [All Fields]) AND ("refractive error"[All Fields] OR "myopia"[All Fields] OR "visual impairment"[All Fields])). All publications in English and abstracts from non-English publications were reviewed. The reference lists of relevant publications were also considered as a potential source of information. If other studies (e.g., older than 5 years) were essential to draw conclusions, they were included in the discussion section. Studies were critically reviewed for study methodology and robustness of data, particularly the myopia definition and measurements under cycloplegia. No attempts to discover unpublished data were made.

Study selection

Full-text articles included in the prevalence analysis were required to meet the following criteria: 1) a cross-sectional or cohort design 2) refractive error measurements taken with a refractometer 3) clear definition of myopia and information on cycloplegic or non-cycloplegic measurements 4) prevalence assessed in children aged 6–19 years 5) studies with a minimum sample of 100 children. If more than one definition of myopia was used in a study, the prevalence for the more commonly used one was selected in order to enable comparison. Results for up to two age-groups were presented, and if data for more than two cohorts were reported, the average for the study or the most common age-group was selected. Studies were excluded from the prevalence analysis if they presented self-reported near-sightedness, reported the prevalence of visual impairment (but not myopia) or included animals.

Result

The search identified 627 unique articles. Twenty-eight articles fulfilled the criteria for being included in the main analysis (myopia prevalence). One study was excluded, as it presented data from primary care optometry clinics. Additionally, 25 articles were included in the analysis of risk factors.

Prevalence of myopia in school children

Myopia prevalence remains higher in Asia (60%) compared with Europe (40%) using cycloplegic refraction examinations. Studies reporting on non-cycloplegic measurements show exceptionally high myopia prevalence rates in school children in East Asia (73%), and high rates in North America (42%). Low prevalence under 10% was described in African and South American children. In recent studies, risk factors for myopia in schoolchildren included low outdoor time and near work, dim light exposure, the use of LED lamps for homework, low sleeping hours, reading distance less than 25 cm and living in an urban environment.

Change over time

In several countries the prevalence of myopia has increased in the last years. In a study from the Haidian District in Beijing, China, the prevalence of myopia in a cohort of 15-year-old schoolchildren increased from 55.95% in 2005 to 65.48% in 2015. In Fenghua city, eastern China, the prevalence of myopia in high school students increased from 79.5% in 2001 to 87.7% in 2015, and high myopia (SER greater than − 6.0 D) was a major contributor to this increase. In Western China not only myopia prevalence increased, but also a higher rate of annual myopia progression was recently noted. The Waterloo Eye Study showed a long-term increase in myopia prevalence also in the United States. The prevalence rate reached 42.4% in 10 to 15-year-old children, and 53.9% in 15 to 20-year-old; this was significantly higher than the 21% peak value (in those aged 20–30 years) reported in a comparable study done in 1892.

Risk factors

There are some risks factors that can contribute for the prevalence increase such as parental myopia, ethnic differences, less time outdoors, increased near work, population density and socioeconomic status.

Parental myopia

In a study conducted by Lim et al. children (aged 6–18 years) with two myopic parents had a mean refractive error of − 2.33 D and the odds ratio of having myopia in childhood with two myopic parents was 2.83, compared with no parental myopia. Although genetic factors have some impact on eye growth, the development of myopia appears to be mainly influenced by environmental factors such as education.

Outdoor time

Outdoor time has been proven to be the strongest environmental factor that can delay myopia onset.

Myopia progression was not strongly associated either with near work or outdoor/sports activity in siblings with common environmental exposures. In a randomized clinical trial by He et al., a 40-min class of outdoor activities on

each school day for 3 years resulted in a reduced incidence of myopia from 39.5 to 30.4%. A recent RCT showed that outdoor activities can inhibit progression in myopic children aged 6 to 7 years old by 30% in 1 year. These results might indicate that high-risk patients require a sum of treatments for the control of the condition, including changes in lifestyle (increase in outdoor time) and treatment with atropine eye drops, progressive contact lenses or orthokeratology.

Near work

The SAVES study revealed that near work was a risk factor for myopia but only for the 6-year-old children, and not in 12-year-old cohort. This result might indicate that near work can be a factor for inducing the earlier onset of myopia in smaller children. There might be a difference in the mechanism of setting myopia development between early onset and later onset myopes.

Because the effect of near distance activities on myopia onset and progression was shown to be higher in younger children, it seems to be reasonable to limit unnecessary time spent on near distance activities (including electronic devices) by pre-school children, and these activities should be under strict parental control.

LED lamps and hours of sleep

The mechanism underlying the sleeping time-myopia relationship is not well understood yet and future research is needed; presumably inactivity of the ciliary muscle during the sleep could prevent or alleviate the myopic progression. However, other new variables may be involved such as the effect of dim light. New findings suggest that in addition to bright light exposure, rod pathways stimulated by dim light exposure could be important to human myopia development. One study with Australian children aged 10 to 15 years old demonstrated that myopic children spent less time in both scotopic and outdoor photopic light conditions compared with non-myopic children. Myopes may also have reduced sensitivity to low spatial frequency S-cone stimuli with consequences in their failure to emmetropize normally.

Socioeconomic status (SES)

In the North India Myopia Study, the prevalence of myopia was 13.1%. Myopia was more common among children with higher SES and among private school students, compared to governmental school pupils. Presumably children in private schools spend more hours at school compared to children in public schools; they spend more time reading and writing at home, with significantly more pressure and a greater likelihood of extra classes. Studying and reading for over 5 hours daily, watching television for over 2 hours daily, and playing video/mobile games were also significantly associated with myopia.

Contradictory findings were reported by a Dutch study of a multi-ethnic cohort of 6-year-old children, revealing a significant influence of socioeconomic factors on the prevalence of myopia. In particular, children of non-European descent, with children from low maternal education, low family income, were more likely to be myopic.

Discussion

Cycloplegic refraction is established as the gold standard for epidemiological studies on refractive errors. Nevertheless, within our review nine studies used non-cycloplegic measures, while 19 studies presented cycloplegic refraction. Studies reporting non-cycloplegic measurements of prevalence cannot be considered as reliable; application of non-cycloplegic measurements leads to substantial errors, both in prevalence rates and associations with risk factors.

The results show that there is an increasing trend of myopia in India over the last four decades. Other meta-analyses from different parts of the world have also shown similar trends. The prevalence of myopia is much less in Indian school going children as compared to other Asian countries where it could be as high as 70–80%. While the prevalence may not be as high as that of East Asian countries, the actual numbers of myopes will be large considering our huge population and that 29% of the population consists of children less than 15 years of age (National Health Profile 2015, published by Government of India). This epidemiological variation also holds great importance as it pertains to world's second most populated country which has more than 40% of young population who are at risk of developing myopia. Holden et al has estimated the prevalence of myopia in South Asia region (which includes India) to be around 20% in 2010, 38% in 2030 and 53% in 2050. We have found a lower prevalence of myopia in school going children in India over the last four decades as compared to other Asian countries where myopia is far more prevalent. Rudnicka et al has also found that increment in myopia prevalence in South Asian

countries is less as compared to East Asian countries. Thus, various meta-analyses which predicts global myopia trends fail to bring out this regional variation due to under representation of Indian studies.

Interestingly, in some migrant groups, primarily of East Asian origin, the children were significantly more myopic than those of European origin, presumably because of the intensive education that the children are receiving. Children of East Asian ethnicity spend less time outdoors and more time in near work activities compared to European Caucasian children at all school ages.

Myopia was also common in a diverse Southern Californian pediatric cohort and children of Asian ancestry had the highest prevalence. Particular lifestyle habits in different populations may partially explain dissimilarities in myopia prevalence. It has been suggested that a probable causative role in the development of myopia is the competitive and stressful education systems in some East Asian countries.

This study confirms the findings of existing literature that urban adolescents (11–15-year age group) constitute an important 'at risk' subset of the general population requiring immediate attention and intervention where the prevalence of myopia increased to more than double in the last decade. Rural adolescents are also achieving the similar growth rate. Similar trend was obtained in other countries as well because myopia tends to develop after the natural curve of emmetropization is over

New risk factors, apart from outdoor time, such as the use of LED lamps for homework, dim light, low sleeping hours, reading distance less than 25 cm and living in an urban environment were described in recent studies. Additional epidemiological studies should be carried out to further expand the knowledge of outdoors on myopia progression. Interventional studies might be also needed to better understand the effectiveness of preventive methods in different settings and age groups. Although light intensity patterns in humans have been implicated in myopia protection, research needs to be further expanded to understand how bright needs to be the exposure to avoid myopia. Longitudinal patterns of light exposure in different refractive errors (e.g. myopes, hyperopes and emmetropes) are needed to understand which of light parameters is the most important (e.g. light intensity, duration or regularity). This study did not focus on the prevalence of high myopia, which is an important indicator and should be further developed.

Conclusion

It can be concluded that prevalence rates were shown to increase in Asia, but also in Europe and North America. Particular lifestyle habits in different populations may partially explain dissimilarities in myopia prevalence between geographical regions. Preventive measures such as outdoor programs and changes on near distance activities in preschool children should be implemented.

It has shown for the rapidly rising trend of myopia in rural school going children compared to their urban counterparts. This should result in adoption of urgent preventive and curative measures among various stakeholders to tackle this menace on time. Future prospective studies should be planned among various diverse regions of India to elucidate the trend of myopia and study various local epidemiological risk factors involved.

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