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Review Article

Causes, prevalence and treatment of myopia: a review

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ABSTRACT

The aim of this work is to investigate the causes, prevention strategies, and prevalence of myopia, a common refractive error increasingly recognized as a global public health concern. A comprehensive literature review was conducted using major academic databases, including PubMed, Google scholar, and Web of Science, with selected keywords to identify relevant studies on myopia's etiology, prevention, and treatment. Evidence indicates that myopia arises from an interplay of genetic predisposition and environmental influences. Individuals with a family history of myopia are at higher risk; however, lifestyle factors, particularly prolonged near work and limited outdoor activity, significantly contribute to onset and progression. The prevalence of myopia varies widely across regions, with rapid increases noted in many parts of the world, especially in urbanized settings. Preventive strategies, such as encouraging outdoor time for children and limiting excessive near work or screen use, have shown promise in reducing risk. For individuals with established myopia, several management options exist, including orthokeratology (ortho-k) lenses, multifocal contact lenses, and other optical interventions, which aim to slow disease progression. Addressing myopia requires both public health initiatives to promote preventive lifestyle changes and early clinical interventions to manage its impact. By understanding its multifactorial causes and employing evidence-based prevention and control strategies, it is possible to mitigate the growing burden of myopia and preserve long-term visual health.

Keywords: Myopia, Nearsightedness, Refractive error

INTRODUCTION

Myopia, often referred to as nearsightedness, is a refractive error that makes images to appear blurry for distant objects while leaving near things in focus Myopia is a common vision condition throughout the world, and many people have it.[1] The word myopia comes from the Greek term muopia, which translates to "to shut the eyes. Myopia, commonly known as nearsightedness, is the most prevalent type of refractive vision error. However, the condition is caused by environmental and genetic factors. A well-researched theory indicates that prolonged near work with inadequate accommodation can produce retinal defocus, resulting in axial elongation of the eye and myopia. We have conducted a large body of research examining its causes, but the exact mechanisms of myopia are still not well understood.[2] When parallel light rays enter the eye of someone who is nearsighted, they go through the lens and come together in front of the retina, rather than hitting it directly.

This misalignment prevents the eye from clearly seeing far away objects and allows the close image to remain clearer. In a typical eye, light rays come in and converge at the fovea centralis, which is the area of the retina that's most sensitive to light. Myopia usually manifests in children over 6 years of age as the eye's axial length grows abnormally longer when measuring the distance from the front surface to back surface of the eyes. The axial length increases rapidly until about age 14, after which it develops more slowly.[3] Myopia has become a significant public health concern due to its rising prevalence and the ongoing progression of the disease. It's estimated that by 2050, around 4.8 billion people-nearly half of the global population-will be affected by myopia, with about 938 million of those cases classified as high myopia.[1] Research indicates that myopia is linked to a higher risk of visual impairment and serious eye conditions that can emerge later in life, such as glaucoma, cataracts, and retinal detachment.[4] Since the 1970s, there has been a strong focus on studying soft contact lenses (SCLs) to help slow down the progression of myopia. Additionally, multifocal SCLs with peripheral addition (ADD) have proven effective in reducing myopia progression in children, both preschoolers and school-aged children.[5-7] This paper provides a systematic literature search to find studies relevant to myopia. Subsequent sections describe the method, the typology, causes, and prevention of myopia in depth. The following section presents the results and discussion.

LITERATURE REVIEW

A literature review was performed to identify studies relevant to myopia. Searches were conducted in the databases using relevant search terms. The databases searched include PubMed, Embase, and Web of Science. Studies published in English, exploring the causes, prevention and prevalence and/or incidence of myopia in defined populations or geographical region, were selected for inclusion. Initially the results of the search were screened based on title and abstract. Each article selected for full-text retrieving was then screened again for review against the inclusion criteria. Data was gathered from each of the studies we included, using a standardized form for data extraction. We pulled out key details such as the study characteristics (like the year it was published, the design of the study, and the country where it took place), information about the participants (including sample size and age), the diagnostic criteria for myopia, and the estimates for prevalence or incidence of myopia. Data were synthesized narratively from the results of the included studies. The findings were organized by geographical region and age group. The overall observed patterns or trends across studies were discusses, and potentially influential factors related to myopia prevalence were noted.

PREVALENCE OF MYOPIA

In recent years, we've seen a noticeable rise in myopia, especially among urban populations and younger individuals. This increase can be attributed to a mix of factors, including genetics, environmental influences like not spending enough time outdoors and too much close-up work, as well as shifts in lifestyle. Understanding myopia prevalence is critical for understanding its impact on public health and constructing management and prevention strategies.[8] Myopia is often seen as a simple refractive error. However, with the recent rise in incidence and prevalence of myopia worldwide, in general and especially in Asia, researchers are thinking differently about myopia.[9-13] Data from Japan, China, and Taiwan suggests that, with irreversible vision loss, high axial myopia is now among the most common causes of vision loss in the world. Often this is simply as a result of the irreversible side effects of high axial myopia-open angle glaucoma, retinal detachment, macular hemorrhage, macular degeneration, choroidal neovascularization, open angle glaucoma.[14,15]

Holden and colleagues took a deep dive into data from 145 studies involving a whopping 2.1 million participants. They found that back in 2000, around 1.4 billion people were living with myopia, which is roughly 22.9% of the global population.[12] Back in 2000, projections indicated that around 163 million people across the globe were living with high myopia, which was about 2.7% of the world's population at that time. Fast forward to 2050, and with the rising rates of myopia alongside global population growth, we’re looking at a significant increase in numbers. It’s estimated that a staggering 4,758 million individuals-nearly 49.8% of the global population-will have myopia, and the count of those with high myopia could hit around 938 million, or 9.8% of the world’s population. These sharp increases point to myopia and high myopia potentially becoming major public health issues worldwide, affecting vision health, healthcare systems, and even socioeconomic factors.[12] Because of these issues, it is important to understand the prevalence of myopia across other cultures and countries/regions, so individuals and populations that may be at high risk can be identified, and proactive steps can be taken to intervene in order to prevent or limit myopia. The variation in prevalence rates across countries has also suggested possible environmental, and genetic factors in the development of myopia, in conjunction with myopia management.

CAUSES OF MYOPIA

Myopia is an intricate eye complication that means distance vision is blurred. Although myopic vision loss can be corrected with spectacles or a contact lens, it is important to understand the source of myopia and the public health burden as rates of myopia increase. A schematic of a myopic eye showing the correction using a concave lens is shown in Figure 1. Myopia develops from a complicated interplay between environmental and genetic factors. Not every individual with genetic predisposition or exposure to environmental risk factors will be myopic, and it is possible that the combination and interaction of these risk factors can differ across individuals. Current research is continuing in order to better elucidate the underlying processes of myopia to allow for improved strategies for prevention and management.

Genetic factors play a significant role in the development of myopia, or nearsightedness. Recent studies have uncovered several genes that are linked to how our eyes grow and develop their refractive abilities. This research sheds light on the intricate genetic framework that influences our susceptibility to refractive errors. People with certain genetic traits, especially those who have a family history of myopia, are more likely to develop this condition. Understanding the genetic factors behind myopia not only deepens our knowledge of how it works biologically but also sets the stage for future studies, the creation of targeted treatments, and the development of personalized strategies for managing myopia. On the flip side, environmental factors are also closely tied to the development of myopia. Spending excessive time on near tasks-like reading, writing, or staring at screens-has been consistently associated with a higher risk of becoming nearsighted. Additionally, not getting enough natural sunlight during childhood and adolescence seems crucial for healthy eye development. Other influences, such as poor indoor lighting and socioeconomic conditions, may also play a role in both the onset and progression of myopia.

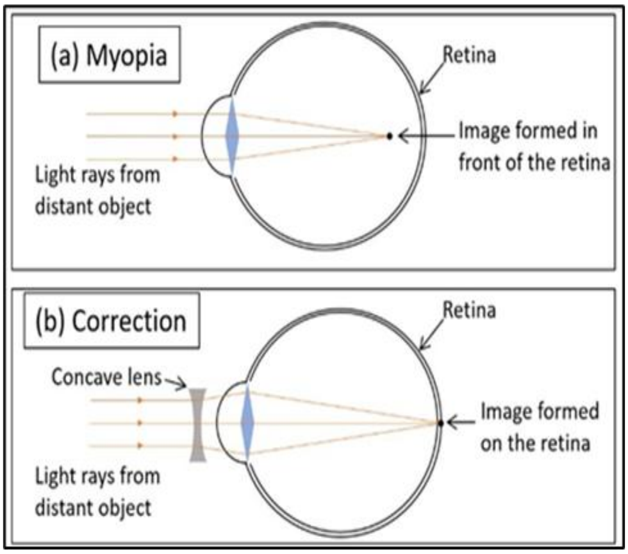

Figure 1: Schematic representation of myopia and corrective interventions.

PREVENTION/TREATMENTS OF MYOPIA

Presently, there are several proposed and researched methods of reducing myopia progression: slowly introducing executive bifocal glasses; outdoor exposure, contact lenses, peripheral defocusing lenses, atropine affected eyedrop outcomes, orthokeratology at night, and multifocal SCLs would all be considered pharmaceutical interventions.[16-23] A systematic review from the Cochrane database in 2011 found that contact lenses, bifocals, and progressive addition lenses aren't effective long-term solutions for managing refractive myopia, just like custom lenses.[24]

Contact lenses

Contact lenses can play a significant role in managing myopia by adjusting how light focuses in the eye. As the eye moves, these lenses help keep a steady area of focus in the outer (peripheral) part of the retina.[25-29] As the eye shifts, studies involving children who wear orthokeratology (or ortho-k) lenses-special lenses that are worn overnight to gently reshape the cornea-indicate that this type of peripheral focus might actually slow down the rate at which the eye grows longer, a major factor in worsening myopia.[30,31] This likely occurs because reshaping the cornea with ortho-k lenses sends a signal to the eye to stop growing. Likewise, soft bifocal contact lenses have also shown potential in slowing down myopia progression in school-aged children.[32,33] These lenses are crafted to offer different focal zones, which could affect how the eye interprets visual information. However, at the time of some studies, there wasn't any solid clinical trial data to confirm whether soft bifocal lenses produce the same type of peripheral myopic defocus as ortho-k lenses.[31,34] Some researchers have raised questions about whether this mechanism is indeed active in soft bifocal lenses. Research from both animal studies and human clinical trials shows that how our retinas process visual information, especially from the edges of our vision, is crucial in the development and progression of myopia. There's a growing amount of evidence suggesting that creating a peripheral myopic defocus-where images on the periphery are focused in front of the retina-could be a promising approach to slow down the elongation of the eyeball and help manage the progression of myopia.[33,35,36]

Research involving both humans and animals indicates that peripheral retinal defocus can play a role in eye growth, even if central (foveal) vision stays clear.[37] Certain optical lenses that either lessen hyperopic defocus or induce myopic defocus in the peripheral retina have shown promise in slowing down the progression of myopia in children of school age.[38] While also a useful, feasible, and potentially attractive method of controlling myopia, necessary use of contact lenses is not always practical. While safety was the primary issue, there have been recognized possible side effects/symptoms in children wearing contact lenses, similar to the possible side effects and symptoms documented in adults.[39-41] Like many overnight wearers, an example of a possible side effect is the microbial keratitis risk. On top of all the above issues, discomfort can make it more challenging to optimally use contact lenses as a treatment for myopia rather than just being a burden. Indeed, it was stated that consistent wear of glasses was very important in the reduction of myopia onset and progression.[42] A few multi-zones, presbyopia contact lenses have been developed that correct for myopia by removing hyperopic defocus37.[36,43] However, whether these multizone contact lenses actually correct hyperopic defocus depends on the visual system's response to the lenses.[32] MFSCLs have a distance and near correction (for the papilla) that gives a continuous experience of the treatment zone, while also correcting for the compliance shortcoming of spectacle options. In addition, there are contacts with ADD in progressive designs with newer soft lenses, where the distance optical correction was adjusted and targeted to the peripheral area.[32,33] MFSCLs are preferable to nighttime orthokeratology and atropine eyedrops because they do not have the chance of developing microbiological keratitis or side effects, respectively.

Laser surgery

When it comes to correcting myopia, there are a few surgical options available alongside contact lenses, but keep in mind that these can be pricier and come with greater risks. These procedures usually involve reshaping the cornea, either with lasers or precise incisions. When it comes to laser eye surgeries, some of the most popular options are PRK (photorefractive keratectomy), LASEK (laser epithelial keratomileusis), and LASIK (laser in situ keratomileusis), with LASIK being the go-to choice for many people. it creates a thin flap on the cornea and reshapes the tissue underneath to enhance focus. PRK, on the other hand, removes the outer layer of the cornea before reshaping it, while LASEK keeps that layer intact. There's also a newer method called SMILE (small incision lenticule extraction), which corrects vision by taking out a small, lens-shaped piece of tissue through a tiny incision, making it a less invasive option for myopia correction.

Pharmaceutical agents

Topical muscarinic antagonists, like the non-selective atropine and the M1-selective pirenzepine, have shown promise in slowing down the axial elongation of the eye. This effect plays a significant role in managing the progression of myopia.[44,45] There are many preclinical research involving various animals such as rats, mice, monkeys, guinea pigs, chickens, Syrian hamsters, and tree shrews-has shown that atropine can effectively inhibit the development of myopia.[46] Moreover, numerous clinical studies in humans have backed up atropine's effectiveness in controlling the progression of myopia. For instance.[47,48] Wu et al looked into the use of cycloplegic agents for managing progressive myopia and found that atropine stands out as the best option for controlling this condition. Clinical trials have revealed that low-dose atropine eye drops, especially at a concentration of 0.01%, can significantly curb the progression of myopia, all while causing far fewer side effects compared to the higher doses that were used in earlier treatments.

Despite the progress we've made in managing myopia, there are still some kids who just don't respond well to the treatments we have. This leaves us scratching our heads about the best ways to help them. One interesting option that researchers are looking into is pirenzepine, an antimuscarinic drug that might help slow down the worsening of myopia in children and teens. It works by targeting specific muscarinic receptors, especially those in the ciliary muscle of the eye. This muscle is crucial for changing the lens shape to help us see things up close, a process called accommodation. By easing the tension in the ciliary muscle, pirenzepine can lessen the effort needed for accommodation, which might help prevent the eyeball from elongating too much-a major contributor to developing myopia. In a randomized, placebo-controlled clinical trial led by Tan and colleagues, the effectiveness of pirenzepine ophthalmic gel was tested on children aged 6 to 12.[49] The results were promising, showing that pirenzepine significantly slowed myopia progression compared to the placebo group, based on both the average change in spherical equivalent refractive error and the number of participants who showed worsening vision. These findings are consistent with earlier animal studies, reinforcing the idea that pirenzepine could be a solid option for treating myopia in children.

OBSERVATIONS IN DIFFERENT COUNTRIES

Myopia, also known as nearsightedness, occurs at varying rates in different countries of the world. In Beijing, China the incidence rate is 65.5%, while Singapore has a much lower rate of 11%.[50-53] The United States has a reported incidence rate of about 28.1%, and the United Kingdom has a rate of 17.8%. Other locations with myopia rates are New Delhi, India (13.1%); Sydney, Australia (18.9%); Northern Ireland (22.8%); and Spain (19.1%).[50-57] These statistics illustrate the variegation of incidence rates for myopia around the world, which matters because myopia is becoming a global health concern. If myopia gets too severe, it results in clinical conditions including retinal detachment, glaucoma, and cataracts, which could ultimately cause visual impairment or blindness. Figure 2 shows how prevalent myopia is in those under age 25 worldwide.

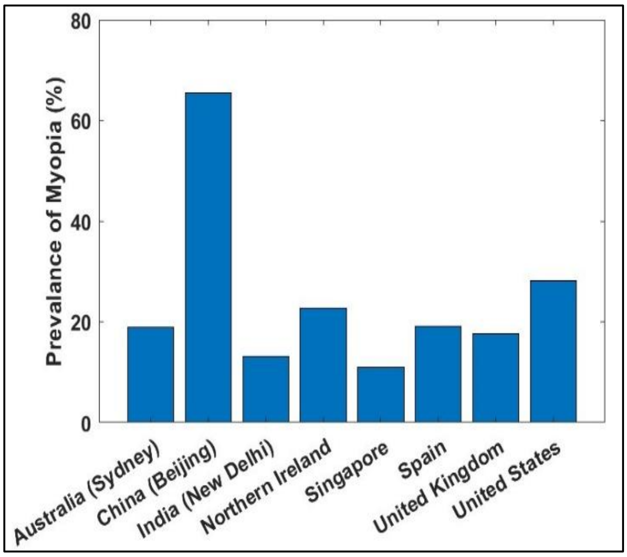

Figure 2: Myopia prevalence among youth across countries.[50-57]

This gives a solid summary of the main influences of various types of myopia. Notable influencers include factors such as genetics, environment, daily lifestyle, and the way we use our vision. However, various factors can contribute to myopia, as many people develop myopia due to a mixture of these factors and potentially others related to their individual circumstances (Table 1).

Table 1: Etiology of myopia.

Types of myopia	Causes of myopia	References
Axial myopia	Genetics significantly influence the development of axial myopia, along with other forms of myopia.	58
Curvature myopia	Curvature myopia is primarily caused by abnormalities in the shape of the cornea, but genetics, eye rubbing and some eye disease may also influence curvature myopia.	59 and 60
Index myopia	Index myopia arises from abnormalities in the power of the lens and is typically connected to aging, or potentially any other outside factor influencing the lens such as diabetes or cataracts.	61

The research identified a number of effective treatment options to manage myopia. Orthokeratology is a fascinating treatment that involves using specially designed contact lenses to reshape the cornea. Research has shown that it can effectively slow down the progression of myopia. In a similar vein, multifocal contact lenses-designed with varying optical strengths across different zones-have also demonstrated potential in helping to reduce the speed at which nearsightedness worsens. The use of atropine eye drops, low doses particularly, was found to be a treatment that was also significantly effective for myopia management. The treatment options show the value of individualized treatment plans and early intervention on the rates of myopia emerging and increasing globally. The review identified a number of laser methods for the treatment of myopia, namely LASIK, PRK and SMILE. This laser treatment was very effective in reducing refractive error and improving visual acuity among those with myopia. MFSCLs are a better treatment choice than nocturnal orthokeratology and drops of atropine to treat myopia. MFSCLs are good because they lower the chances of microbiological keratitis (which can be a serious keratitis infection), and have fewer side effects. Research has shown that multiple factors have an impact on how well multifocal SCLs (MFSCLs) fit and work. These include how long people wear the lenses, the ADD power of the lenses (which changes based on design), and the size of the wearer's pupil. The results point to optical methods using myopic defocus as promising ways to slow down myopia. Scientists don't yet grasp how optical signals affect eye parts like the choroid, retina, and sclera leading to axial elongation. However, studies on animals have shown that eyes can respond to optical defocus. This suggests that this method could be useful to manage myopia.

DISCUSSION

This article discusses the cause, prevalence, and treatment of myopia with the intent of providing a comprehensive overview of this increasingly common refractive error. A review of the current literature identifies some key findings.[1,5-7] Myopia (nearsightedness) occurs from a combination of environmental and genetics factors.[58] Myopia is becoming more widespread globally among children and the urban population.[62,63] We can significantly reduce our chances of developing it by spending more time outdoors and reducing activities that require extended periods of close-up focus. Also, there are several specialized lenses and optical treatments that help decrease the rate of myopia progression.[64] Understanding root causes, promoting prevention behaviors, and identifying treatment options identifies pathways to take concerted action to address the myopia epidemic and supporting sustained eye health.

This article examines the causes, prevalence, and treatment of the multifactorial nature of myopia requires a contextually appropriate method of prevention and management. Understanding the genetic and environmental contributors to myopia will provide potential avenues for intervention, including changes to the ocular environment, promotion of outdoor time, and visual ergonomics. Public health initiatives aimed at education around modifiable risk factors and effective prevention strategies are vital to reversing the trend of increasing prevalence for myopia.

CONCLUSION

This review presents the multifactorial nature of myopia, emphasizing the important interactions between genetic factors and environmental influences, such as near work and time spent outdoors. Through a synthesis of currently available evidence on prevalence, risk factors, and prevention, this paper advances our understanding of myopia in the context of an expanding global public health challenge. We emphasized that lifestyle changes (e.g., more time spent outdoors) and optical shape wearers (e.g., orthokeratology and multifocal contact lenses) have potential to slow the onset and progression of myopia. These perspectives are essential in guiding pathways to the development of more efficacious evidence-based myopia management and prevention strategies, and to positively affect visual health outcomes globally.

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