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Review Article

Myopia: Not Merely an Inconvenience but a Crisis

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Abstract

Myopia, or nearsightedness, is increasingly prevalent globally, particularly among children and young adults, representing the most common refractive error. While significant eye growth occurs during adolescence, the precise causes of myopia progression remain unclear. The COVID-19 pandemic has exacerbated existing challenges, highlighting the urgent need for comprehensive understanding and intervention. Myopia is associated with various ocular disorders, leading to potential permanent vision impairment if left untreated, emphasizing the importance of timely screening and early treatment initiation.

This article examines factors contributing to myopia progression and explores methods for halting its advancement. It aims to explore the potential causal mechanisms underlying myopia onset, highlighting emerging research paradigms and novel insights into ocular physiology. By clarifying the underlying pathophysiological pathways, this article seeks to inform targeted interventions aimed at arresting myopia progression and preserving visual acuity.

The article surveys therapeutic modalities aimed at halting myopia progression, ranging from traditional optical corrections to behavioural interventions. In summary, this article provides a comprehensive exploration of myopia, covering its etiology, progression, and management strategies. By synthesising current research findings and perspectives, it aims to deepen understanding of this growing public health challenge and inform targeted interventions to alleviate its global burden.

Key words: myopia; nearsightedness; myopia progression; myopia causes; myopia treatment; myopia management

Introduction

Myopia is a refractive condition where objects up close appear sharp, while those at a distance appear blurry (Turbert, 2023). Recognized as one of the five immediate priorities for the World Health Organization's (WHO) 'Vision 2020' initiative, myopia represents a significant cause of reduced vision worldwide (Pararajasegaram, 1999, p. 359). Myopia is the prevailing eye condition on a global scale, affecting an estimated 22.9% of the world's population, equating to an estimated 1.406 billion individuals (Holden et al., 2016, p. 1036). The myopia surge has become increasingly evident. In 2010, 28% of the global populace experienced this condition, with projections indicating a potential escalation to 50% by 2050. The impact is particularly pronounced in East Asia, with prevalence rates soaring as high as 90%, according to insights from Michael X. Repka, MD, affiliated with Johns Hopkins University in Baltimore (World Health Organization & Brien Holden Vision Institute, 2016).

Individuals with myopia face increased risks of significant ocular morbidity, encompassing conditions such as retinal detachment, glaucoma, myopic macular degeneration, and cataracts (Smith & Walline, 2015). Epidemiological studies have identified age, gender, parental myopia history, parental education, and the amount of close/near work performed by children as potential factors influencing the development of myopia. However, the precise interplay between genetic and environmental factors in contributing to this condition remains a subject of ongoing exploration (Lam et al., 2008).

The escalating prevalence and potential complications of myopia have led to its recognition as a global health concern. Myopia progression is a significant cause of global visual impairment (Holden et al., 2016). While long regarded as merely an inconvenience, the mounting evidence of its complications - ranging from retinal detachment and glaucoma to potential blindness – has brought myopia to the forefront of attention among medical professionals (Smith & Walline, 2015). This shift in perspective underscores the urgent need for comprehensive research, early intervention strategies, and effective management protocols to address this growing public health challenge.

Etiology and Mechanisms of Refractive Errors:

The human eye functions like a convex lens, converging light onto a focal point known as the retina. Light entering the eye first encounters the cornea, then passes through the pupil and lens, ultimately converging at the retina. From there, signals are transmitted via the optic nerve to the brain's visual cortex, where images are formed (National Eye Institute, 2022). While both the lens and cornea contribute to light bending, the cornea primarily performs this task, accounting for approximately 66% of the bending, with the lens providing fine-tuning adjustments (Meek et al., 2003). Consequently, any irregularities in vision often stem from alterations in the cornea's shape or the eye's axial length.

Individuals with myopia exhibit elongated eyes, causing the focal point to converge in front of the retina, leading to blurred distance vision (Carr & Stell, 2017). In contrast, hyperopia, or hypermetropia, results from eyes with a shorter axial length, causing objects nearby to appear blurry as light rays converge behind the retina (Majumdar & Tripathy, 2023).

Notably, all newborns initially have eyes with a shorter axial length similar to those with hyperopia, rendering them unable to focus on nearby objects until approximately 1-2 years of age, when their eyes gradually assume the correct size. This developmental process typically completes by age 2, enabling children to see objects normally (Semeraro et al., 2020).

Etiological Theories of Myopia

One point of inquiry revolves around the factors influencing the elongation of certain individuals' eyes while others remain unaffected. This puzzle has spurred the exploration of three distinct theories aimed at unraveling the underlying mechanisms - Near-Work Theory, DNA Theory and Outside Theory.

DNA Theory

The DNA Theory attributed myopia development primarily to genetic factors, suggesting that the condition was predetermined by one's DNA and passed down through hereditary lines. In essence, individuals were believed to inherit their likelihood of developing myopia from their familial lineage (Morgan & Rose, 2019). However, this theory began to lose credibility largely due to a groundbreaking study conducted in 1969 among Alaskan tribes. This study yielded fascinating findings: while the middle-aged and elderly individuals of these tribes had never been exposed to myopia, children and teenagers exhibited myopia rates exceeding 50%. Such a drastic shift within a single generation cast doubt on the notion that genetics alone determined myopia prevalence.

Particularly striking was the observation that the younger generation had adopted a more Westernized lifestyle, characterized by increased engagement in activities requiring near work, such as reading and using electronic devices. This pivotal discovery prompted a paradigm shift in understanding myopia etiology, laying the groundwork for the emergence of the Near Work Theory (The Economist, 2022).

Near-Work Theory

The Near-Work Theory posits that extended periods engaged in close-up tasks exert increased strain on the eyes. According to this theory, the repetitive and sustained effort required for activities such as reading, using electronic devices, or performing intricate tasks at close range may contribute to the elongation of the eyeball (Huang et al., 2015). The extent to which our ciliary muscles are engaged correlates with the elongation of our eyeballs, resulting in a rounder and more squeezed state. This prolonged compression can make it increasingly challenging for the eyeballs to relax.

Therefore, the theory suggests that the more time spent engaging in activities such as reading books or staring at screens on electronic devices like phones or laptops, the greater the strain placed on the eyes is. Consequently, the cumulative effect of prolonged near work may exacerbate the strain on the eyes, potentially leading to elongation of the eyeballs over time (Carr & Stell, 2017).

The Near-Work Theory traces its origins to Johannes Kepler, the renowned German astronomer, who first proposed the idea in 1604. Kepler's personal experience with glasses led him to hypothesize that prolonged engagement in close-up tasks might cause visual impairment. However, it wasn't until the 1970s that this theory gained significant traction among scientists, becoming the prevailing explanation for rising myopia rates and shaping research in ophthalmology and vision science (Kadri-Langford, 2022).

Historical observations by British physicians revealed a correlation between educational attainment and spectacle prevalence. They noted a stark contrast in myopia rates between Oxford University students and military recruits, with the former showing a considerably higher prevalence. This contrast underscored the potential influence of environmental factors, particularly prolonged near- work activities, on myopia development (The Atlantic, 2022).

In the digital age, the Near-Work theory has found renewed relevance, encompassing the pervasive use of smartphones, tablets, and computer. This contemporary adaptation highlights the potential impact of prolonged screen time and close-range digital activities on visual health.

Nonetheless, the Near-Work theory continues to serve as a compelling framework for understanding the mechanisms underlying myopia progression. Its application to contemporary digital habits underscores the importance of adopting healthy visual practices in an increasingly screen-centric society. Thus, while the theory's empirical validation may pose challenges, its conceptual utility in informing preventive strategies and promoting visual well-being remains undeniable.

A 2008 Australian study suggested that the intensity of near-work sessions, rather than just duration, could significantly influence visual health outcomes. Factors such as visual focus degree, screen or text proximity, and break frequency during prolonged near-work sessions emerged as potential myopia risk determinants (Ip et al., 2008). A comprehensive meta-analysis in 2015 revealed a striking correlation: for every additional hour spent on near-work activities per week, myopia risk increased by an estimated 2% (Gajjar & Ostrin, 2022). This finding highlights the cumulative impact of daily habits like reading, smartphone use, or computer work on visual health.

The Outside Theory.

As inconsistencies in the Near-Work theory emerged, researchers explored alternative explanations, leading to the "Outside Theory." This theory posits that reduced time spent outdoors, rather than near-work activities, is the primary cause of increasing myopia prevalence among children. In 2007, a large-scale study was conducted on children living in California. It found that when children spend time outdoors, the risk of Myopia is greatly reduced (Gupta et al., 2021).

Another study was conducted in Sydney on more than 4,000 children. In this study, children were observed for 3 years. Variables were identified as to how much time they spend outside versus inside, how many near-work activities they undertake, and they reached the same conclusion. (Rose, 2008). According to Foster and Jiang (2014) the outside theory also offers an explanation for why myopia is often called a "disease of affluence," being more prevalent in economically developed countries where children typically spend more time studying indoors and less time outdoors.

Animal studies have provided insights into the underlying mechanisms. Exposure to bright light, particularly sunlight, increases dopamine production in the retina (Norton, 2016). Dopamine regulates eye growth, preventing excessive elongation. Conversely, dopamine deficiency can lead to eye elongation (Park, 2012).

Human trials have further substantiated this theory. A notable study published in 2020 observed thousands of primary school children in Taiwan between 2001 and 2015. In 2010, the Taiwanese government implemented the "Tian-Tian Outdoor 120" program, mandating at least 2 hours of outdoor time for students daily. This intervention led to a significant decrease in myopia rates, from 49.4% in 2012 to 46.1% in 2015 (Wu et al., 2020). These findings underscore the importance of outdoor exposure in myopia prevention and have significant implications for public health strategies and lifestyle recommendations.

The Link Between High-Grade Myopia and Increased Risk of Blindness

A study published in Investigative Ophthalmology and Visual Science in November 2020 predicted that by 2050, 10% of the world's population will have high-grade myopia. High-grade myopia occurs when a person's glasses prescription is -6 diopters or higher; the more severe the prescription, the more elongated the eyes become. This condition significantly increases the risk of future blindness (Luong et al., 2020). The retina of the eye contains a finite amount of tissue. As the eye continues to grow and elongate, the retina must stretch to cover the increased surface area, similar to spreading a fixed amount of butter over an ever-expanding slice of bread. This thinning of the retina can lead to serious complications. In extreme cases, the retina may become so thin that it tears (retinal tear) or detaches completely (retinal detachment), potentially resulting in blindness.

A 2019 study demonstrated that for each diopter increase in myopic prescription, the risk of myopic maculopathy rises by 67%. Myopic maculopathy is an untreatable condition that can lead to blindness. Additionally, myopic eyes have an increased susceptibility to other eye diseases, such as glaucoma (Bullimore & Brennan, 2019).

Recognizing the severity of this issue, the American Academy of Ophthalmology established a task force in 2019 to address myopia as a global health problem (Modjtahedi et al., 2020). However, the outbreak of the COVID-19 pandemic in 2020 and subsequent worldwide lockdowns forced people to remain indoors for extended periods, potentially exacerbating the myopia crisis.

Myopia Prevalence, Economic Impact: A Global Perspective

A study conducted in China compared myopia rates in children before and during the COVID-19 pandemic. Between 2015 and 2019, the myopia rate among 6-year-old children in China was 5.7%. However, after a five-month lockdown period, this rate increased dramatically to 21.5% by June 2020 (Mudditt, 2022). Similarly, in India, myopia prevalence among urban children aged 5-15 years rose from 4.44% in 1999 to 21.15% in 2019, with projections suggesting that by 2050, 48.14% of children in India will have myopia (Priscilla & Verkicharla, 2021). This trend is not limited to Asia. In Europe, a study of over 60,000 participants found that myopia prevalence increased from 17.8% among those born in the 1920s to 23.5% for those born in the 1960s (Williams et al., 2015). In the United States, myopia prevalence increased from 25% in 1971-1972 to 41.6% in 1999-2004 (Vitale et al., 2009). In Australia, cross-sectional studies of 12-year-old children reported a prevalence that increased from 11.5% in 2006 to 18.9% in 2011(French et al., 2013).

Wang et al. (2021) suggest that increased screen time due to remote learning, reduced outdoor activities, and disruptions to routine eye care services during lockdowns may have contributed to accelerated myopia progression among children and adolescents. Changes in lifestyle factors, including sleep patterns, diet, and physical activity levels, could have indirectly impacted myopia development.

The economic impact of myopia is substantial and expected to worsen without intervention. A 2019 study estimated that the global economic burden of uncorrected myopia was US$244 billion in productivity loss annually (Naidoo et al., 2019). In the United States alone, the direct cost of correcting myopia was estimated at $3.9 billion per year (Vitale et al., 2006). As myopia prevalence increases, the demand for optical services will rise, further straining healthcare systems.Efforts to prevent and slow down myopia progression are crucial to mitigate its economic consequences. Investing in these strategies to address the root causes of myopia and providing affordable corrective measures can help alleviate the economic burden associated with this condition.

Addressing the Myopia Epidemic: Prevention Strategies and Treatment Options

When addressing myopia, all three theories—genetic predisposition, outdoor exposure, and near work—should be considered. While genetic factors play a role, the outdoor theory has the most significant impact, followed by near work activities. Since genetics are beyond our control, preventative measures focus on the other two theories.

Key prevention strategies include:

1.Increasing outdoor time in daylight

2.Reducing intense near work activities

3.Engaging in physical activities and sports

In 2018, Xi Jinping declared controlling childhood myopia a national priority for China. By 2021, China had initiated restrictions on the video game industry and private tutoring (The Economist Newspaper, 2022). They also terminated written exams for children up to 6-7 years old (BBC, 2021).

Some schools have installed metal bars on desks to maintain proper reading distances, and physical activities have been promoted (Reuters, 2021).

Similarly, in 2019, Singapore's Ministry of Education eliminated mid-year examinations for 3rd and 5th-grade students to encourage outdoor play (Straits Times, 2019). Pre-school children in Singapore were mandated to have one hour of physical activity daily as part of health promotion measures (Lai, 2017). For those already affected by myopia, while the condition is irreversible, further progression can be prevented by following the aforementioned measures. Although natural correction is not possible, artificial interventions are available:

LASIK: It is an option in patients with low to high myopia, with or without astigmatism. It has been shown that LASIK can improve myopia from -2.00 to -20.00. In this surgery, the shape of the cornea is changed. The surgery takes 15-30 minutes and uses anaesthetic eye drops to minimize discomfort (American Academy of Ophthalmology, 2024).

Orthokeratology (Ortho-K) Lenses: These special contact lenses, worn at night, temporarily thicken the peripheral areas of the cornea. Long-term use can improve daytime vision, though the effects are reversible and require ongoing use for sustained results (AAO, 2023).

These interventions have shown promising results in managing myopia progression. While these interventions can help manage myopia, prevention remains crucial. By implementing strategies that address both outdoor exposure and near work activities, we can work towards mitigating the global myopia epidemic. Public health campaigns and school-based interventions that encourage outdoor time and limit excessive near work have shown success in reducing myopia incidence and progression in several countries (Morgan et al., 2018).

Conclusion

The escalating prevalence of myopia worldwide, particularly among children and young adults, has evolved into a pressing global health concern. This review examines the multifaceted factors contributing to myopia progression, encompassing genetic predispositions, environmental influences, and lifestyle behaviours.

Findings highlight the pivotal role of the "outside theory," which underscores the protective effects of natural light exposure and time spent outdoors. Simultaneously, the near-work theory remains relevant, with prolonged digital device usage and close-range activities exacerbating myopia risk. Genetic factors also contribute, though their precise mechanisms and environmental interactions require further investigation.

This review carries profound implications for public health policies and intervention strategies. By elucidating the underlying pathways contributing to myopia development, targeted interventions promoting outdoor activities, regulating screen time, and incorporating preventive measures into educational curricula could potentially mitigate the global myopia burden.

While this review sheds light on the current understanding, several avenues for future research remain unexplored. Longitudinal studies examining gene-environment interactions could yield deeper insights into individual susceptibility and personalized prevention strategies. Investigations into the molecular mechanisms underlying the protective effects of light exposure and the role of dopamine in ocular growth could pave the way for novel therapeutic interventions.

Ultimately, this review underscores the urgency of addressing the myopia epidemic and its potential consequences for visual health and quality of life. By synthesizing current knowledge and highlighting areas for future exploration, it contributes to ongoing efforts to combat myopia and promote global visual well-being.

Reference

1. American Academy of Ophthalmology. (2023, May 2). What is orthokeratology?
2. American Academy of Ophthalmology. (2024, May 25). LASIK - Laser eye surgery.
3. BBC. (2021, August 30). China bans exams for six-year-old school children. BBC News.
4. Bullimore, M. A., & Brennan, N. A. (2019). Myopia control: Why each diopter matters. Optometry and Vision Science, 96(6), 463–465.
5. Carr, B. J., & Stell, W. K. (2017). The science behind myopia. In H. Kolb, E. Fernandez, & R. Nelson (Eds.), Webvision: The organization of the retina and visual system (pp. 1-19). University of Utah Health Sciences Center.
6. Foster, P., & Jiang, Y. (2014). Epidemiology of myopia. Eye, 28(2), 202-208.
7. French, A. N., Morgan, I. G., Burlutsky, G., Mitchell, P., & Rose, K. A. (2013). Prevalence and 5- to 6-year incidence and progression of myopia and hyperopia in Australian schoolchildren. Ophthalmology, 120(7), 1482–1491.
8. Gajjar, S., & Ostrin, L. A. (2022). A systematic review of near work and myopia: Measurement, relationships, mechanisms and clinical corollaries. Acta Ophthalmologica, 100(4), 376-387.
9. Gupta, S., Joshi, A., Saxena, H., & Chatterjee, A. (2021). Outdoor activity and myopia progression in children: A follow-up study using mixed-effects model. Indian Journal of Ophthalmology, 69(12), 3446-3450.
10. Holden, B. A., Fricke, T. R., Wilson, D. A., Jong, M., Naidoo, K. S., et al., (2016). Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology, 123(5), 1036–1042.
11. Huang, H. M., Chang, D. S., & Wu, P. C. (2015). The association between near work activities and myopia in children - A systematic review and meta-analysis. PLoS ONE, 10(10), e0140419.
12. Ip, J. M., Saw, S.-M., Rose, K. A., Morgan, I. G., Kifley, A., et al., (2008). Role of near work in myopia: Findings in a sample of Australian school children. Investigative Ophthalmology & Visual Science, 49(7), 2903-2910.
13. Kadri-Langford, R. (2022, April 11). Who first understood and discovered how eyes work? Occuity.
14. Lai, L. (2017, April 26). Pre-school children to get one hour of physical activity a day as part of measures to promote healthy living. The Straits Times.
15. Lam, D. S. C., Lee, W. S., Leung, Y. F., Kwok, A. K. H., Wang, J. K., et al., (2008). The effect of parental history of myopia on children's eye size and growth: Results of a longitudinal study. Investigative Ophthalmology & Visual Science, 49(3), 873–876.
16. Luong, T. Q., Shu, Y. H., Modjtahedi, B. S., Fong, D. S., Choudry, N., et al., (2020). Racial and ethnic differences in myopia progression in a large, diverse cohort of pediatric patients. Investigative Ophthalmology & Visual Science, 61(13), 20.
17. Majumdar, S., & Tripathy, K. (2023). Hyperopia. In Stat Pearls. Stat Pearls Publishing.
18. Meek, K. M., Dennis, S., & Khan, S. (2003). Changes in the refractive index of the stroma and its extrafibrillar matrix when the cornea swells. Biophysical journal, 85(4), 2205–2212.
19. Modjtahedi, B. S., Abbott, R. L., Fong, D. S., Lum, F., & Tan, D. (2020). Reducing the global burden of myopia by delaying the onset of myopia and reducing myopic progression in children. Ophthalmology. Advance online publication.
20. Morgan, I. G., & Rose, K. A. (2019). Myopia: is the nature-nurture debate finally over? Clinical and Experimental Optometry, 102(1), 3–17.
21. Mudditt, J. (2022, October 5). Why short-sightedness is on the rise. BBC News.
22. Naidoo, K. S., Fricke, T. R., Frick, K. D., Jong, M., Naduvilath, T. J., et al., (2019). Potential Lost Productivity Resulting from the Global Burden of Myopia: Systematic Review, Meta-analysis, and Modeling. Ophthalmology, 126(3), 338–346.
23. National Eye Institute. (n.d.). How the eyes work.
24. Norton, T. T. (2016). What do animal studies tell us about the mechanism of myopia-protection by light? Optometry and Vision Science, 93(9), 1049-1051.
25. Pararajasegaram, R. (1999). VISION 2020-the right to sight: From strategies to action. American Journal of Ophthalmology, 128(3), 359-360.
26. Park, A. (2012, May 7). Why up to 90% of Asian schoolchildren are nearsighted. Time.
27. Priscilla, J. J., & Verkicharla, P. K. (2021). Time trends on the prevalence of myopia in India – A prediction model for 2050. Ophthalmic and Physiological Optics, 41(4), 466–474.
28. Reuters. (2021, September 1). Explainer: Why and how China is drastically limiting online gaming for under 18s.
29. Rose, K. (2008). Time spent outdoors can prevent the development of myopia. Acta Ophthalmologica, 86, 0-0.
30. Semeraro, F., Forbice, E., Nascimbeni, G., Cillino, S., Bonfiglio, V. M. E., et al., (2020). Ocular refraction at birth and its development during the first year of life in a large cohort of babies in a single center in Northern Italy. Frontiers in Pediatrics, 7.
31. Smith, M. J., & Walline, J. J. (2015). Controlling myopia progression in children and adolescents. Adolescent Health, Medicine and Therapeutics, 6, 133–140.
32. Straits Times. (2019, May 28). Many primary and secondary schools scrap mid-year exams in 2020, a year ahead of schedule. Retrieved June 20, 2024.
33. The Atlantic. (2022, October). The myopia generation. Retrieved June 20, 2024.
34. The Economist. (2022, June 9). Short-sightedness was rare. In Asia, it is becoming ubiquitous.
35. Turbert, D. (2023, December 18). Myopia (Nearsightedness). American Academy of Ophthalmology.
36. Vitale, S., Sperduto, R. D., & Ferris, F. L., 3rd (2009). Increased prevalence of myopia in the United States between 1971-1972 and 1999-2004. Archives of ophthalmology (Chicago, Ill.: 1960), 127(12), 1632–1639.
37. Wang, J., Li, Y., Musch, D. C., Wei, N., Qi, X., et al., (2021). Progression of myopia in school-aged children after COVID-19 home confinement. JAMA Ophthalmology, 139(3), 293-300.
38. Williams, K. M., Bertelsen, G., Cumberland, P., Wolfram, C., Verhoeven, V. J., et al., European Eye Epidemiology (E (3)) Consortium (2015). Increasing Prevalence of Myopia in Europe and the Impact of Education. Ophthalmology, 122(7), 1489–1497.
39. World Health Organization, & Brien Holden Vision Institute. (2016). The impact of myopia and high myopia: Report of the Joint World Health Organization – Brien Holden Vision Institute Global
40. Scientific Meeting on Myopia, University of New South Wales, Sydney, Australia, 16–18 March 2015. World Health Organization.
41. Wu, P. C., Chen, C. T., Chang, L. C., Niu, Y. Z., Chen, M. L., et al., (2020). Increased time outdoors is followed by reversal of the long-term trend to reduced visual acuity in Taiwan primary school students. Ophthalmology, 127(11), 1462–1469.

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