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Current Concepts of Myopia, Etiology, and Recent Treatments in Saudi Arabia

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Abstract

Myopia is vision focusing error that makes distant objects blurred and poses alarming signs for further ocular complications such as retinal changes, corneal macular degeneration, and some other ocular defects. The eyeball's size and axial length may increase as myopia progresses, reducing retinal and scleral thickness. This study has focused on the etiology and risk factors related to myopia and the recent treatment strategies to overcome myopia in SA. The prevalence of myopia in Saudi Arabia (SA) is increasing day by day in children. In addition, the parents are not aware of the complications and knowledge about myopia. Myopia is classified into syndromic and non-syndromic, malignant and alternative, axial and refractive, and congenital and adult myopia based on genetics, pathology, anatomical features, and age respectively. Various factors are responsible for the prevalence of myopia, such as race, age, gender, heredity, and environmental factors. However, indoor activities such as reading books, studying under LED lamps, utilizing dim lights, display of TV, LCD, using computers, mobile phones, and video gaming are the significant factors responsible for myopia development. Early detection and screening methods in schools and hospitals helped diagnose vision problems and detect eye diseases. Various studies were conducted in different regions of SA that were helpful in the early diagnosis of ocular defects such as hyperopia, myopia, and other optic complications. Some standard methods for treating myopia in SA are using spectacles with single-vision lenses, multi-focal soft lenses, and progressive lenses. In contrast, pharmaceutical interventions such as atropine drops are frequently used to prevent myopia. Surgical interventions such as laser vision corrected (LVC) surgery, laser in situ keratomileusis, and photo-refractive keratectomy (PRK) surgeries are safe and effective treatment methods for curing myopia. Early screening programs, parents' training, awareness day, advertisement on social media, and outdoor activities are necessary for the prevention of myopia and its related ocular defects. This study also indicated that there is little knowledge of myopia among the general people in SA. Therefore, to reach a larger audience, more effort is required. Parental knowledge of eye conditions and RE could be increased with the use of more public information campaigns, media advertisements, and awareness days.

Keywords: Myopia; Refractive error; etiology; prevalence; risk factors; Saudi Arabia.

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1. Introduction

The leading cause of blindness worldwide is an uncorrected refractive error, including myopia, hyperopia, and astigmatism. Untreated refractive error is a significant factor in the permanent loss of vision. Many kids from all around the globe suffer from visual impairments. According to an estimate, there are approximately 285 million blind persons worldwide, of which 19 million are youngsters under age 14 (Darraj et al., 2016). In 2000, 1.4 billion persons had myopia; in 2050, that figure is predicted to rise to 4.8 billion (Holden et al., 2016). Individuals must undergo appropriate eye condition diagnosis and treatment to prevent long-term vision loss. In order to avoid vision-related issues and eye pathologies, strategies to enhance regular eye screening and educate people on the value of early follow-up for vision care are crucial. The most frequent eye diseases are amblyopia, strabismus, and myopia, which are found in school-aged children in Saudi Arabia (SA) (Al-Tamimi et al., 2015).

Myopia is one of the refractive error types and is significantly known as near-sightedness. It occurs when light rays from a distance are focused in front of the retina instead of focusing on the retina. In this condition, the near objects can be seen clearly, however, the objects that are far seem blurred. Myopia occurs when the retina or cornea is curved or the eyeball is very large in some cases. About 30% of the world's population is affected by myopia (Jensen and Goldschmidt, 1986).

Various studies have been conducted to know the progression and etiology of myopia worldwide. Genetic and non-genetic factors, as environmental factors, played a vital role in the progression and development of myopia. It is reported by The Northern Ireland Childhood Errors of Refraction (NICER) study that the chances of re-development of myopia were 2.91 times high in children with one parent myopic. In contrast, the chances of myopia were 7.79 times high in children that have two myopic parents (Donoghue et al., 2015).

Numerous research has revealed that the environment significantly contributes to the emergence of non-syndromic myopia that connects with time spent outdoors, LED lighting for homework, population density, social and economic status, and video gaming (Russo et al., 2022). Indoor exercises, spending more time with books, and utilizing dim lights are responsible for myopia development, while outdoor activities have a positive effect.

The refractive error prevalence in SA was 18.5% among both genders (Algorinees et al., 2017). Poor quality of life, social status, psychological and financial factors are the main risk factors for myopia in SA (Teh et al., 2021). Myopia is corrected by using contact lenses, spectacle lenses, progressive lenses, multi-focal lenses, pharmaceutical interventions, and surgical interventions such as laser vision correction surgery, photorefractive keratectomy, and laser in situ keratomileuses. Myopia progression in SA is gradually increasing (Zhu et al., 2019).

There is a great need to develop new treatment methods in the SA because parents are unaware of the importance of screening their children at an early age and are unaware of different treatment methods. Moreover, they have a low understanding of refractive errors. There is a need to diagnose refractive error at an early stage of childhood. The aim of this study is to discuss the etiology of myopia and recent treatment strategies for the prevention of myopia in SA.

1.1 Prevalence of Myopia in Saudi Arabia

The purpose of screening the students and children was to detect the chances of optic ailments, amblyopia, refractive errors, strabismus, and other eye disorders. This early detection can reduce the number of children with poor eyesight. The percentage of myopia is increasing in children due to poor quality of life, social and economic status, poor diet, and indoor activities such as higher study pressure. In SA, fewer studies are conducted regarding the prevalence of refractive errors. Mostly their research was hospital-based or only school-based, examining children of different ages.

It is reported that the prevalence of refractive errors in students (8-12 years) of primary school in SA was 13.7% (Mantyjarvi, 1983). In different areas of Al-Hasa, in SA, the prevalence of refractive errors was assessed in children (6-14 years). The students with weak sight were selected and further examined by subjective and objective refraction with a refractometer and streak retinoscopy. Out of total refractive error, myopia was detected in 65.7% students. The refractive error prevalence was 4.5% in total school-age students in a research conducted in Abdulaziz medical city in Riyadh, SA (Almudhaiyan, 2020). In Qassim Province of SA, the prevalence of correctable visual impairment was detected by examining the students by the cover test, cycloplegic, visual acuity, ocular motility, auto refraction, and anterior segment examination with ophthalmoscopy. The study revealed that myopia, anisometropia, and astigmatism were linked with age. From these, about 16.3% of students with refractive errors benefited from using spectacles (Nahhas and Al- Rohaily, 2017). The research was done on the prevalence of refractive errors in the young generation in Riyadh city of SA. According to the study, 25.7% of adults were with hyperopia, 66.3% were with astigmatism, and 71.7% experienced myopia.

1.2 Computer Vision Syndrome Prevalence in Saudi Arabia

Ophthalmologists have some severe concerns about visual issues brought on by excessive usage of computers as well as other video display equipment. This syndrome affects internet users who operate these devices for excessively extended periods and includes visual and non-visual symptoms. Due to a paradigm shift toward internet-based learning, various indicators are regularly observed among students at universities and colleges. A study was conducted at Qassim University of SA showed the association of computer-based vision symptoms with myopia. According to the following study a higher prevalence of different ocular complaints in myopic patients who had their vision corrected with contact lenses as opposed to people who used glasses (Al Rashidi and Alhumaidan, 2017).

2. Pathophysiology of Myopia

The pathophysiology of myopia is still under investigation. Myopia is developed from deprivation when the lens cannot focus the images on retina. It leads to the development of refractive errors and abnormal eye growth (Coviltir et al., 2019). The eyeball length or axial length increases in myopia than the focus of the image at the lens or cornea. The progressive elongation in axial length leads to various ocular defects, such as macular degeneration and retinal detachment. The greatest proof for the visual control of ocular development is gathered from studying animal models, which demonstrate that eyes may effectively adjust for intentionally inserted myopia and hyperopia by adapting the axial length to the changed reference spot (Smith and Hung, 1999). By creating artificial hypermetropia using minus lenses, hyperopic defocusing causes the retina to rotate counterclockwise and the axial length to rise, which causes myopia to develop to restore the ideal refractive state (Coviltir et al., 2019). Near the posterior pole, scleral and choroidal thinning is more pronounced. However, it is less pronounced at the center. Axial length in the retro-equatorial region is associated with the thickness of the retina and cell density of retinal pigment, but both are independent in the macular region. Axial enlargement is also associated with a foveal optic disc (Wei et al., 2013).

2.1 Retinal thickness in myopia

Researchers reported that retinal thickness is also linked with myopia. The foveal thickness at the retina is measured by Optical Coherence tomography (OCT). The thickness of the fovea increases, but the thickness of the retina at the prefoveal and parafoveal region decreases when the ratio of myopia increases. The foveal thickness can be a factor in the diagnosis of refractive errors. According to histopathology studies, the retina at the posterior pole becomes thin and degenerate. These changes may cause an alteration in the retina's thickness, measured by OCT (Zereid and Osuagwu, 2020).

3. Risk factors and etiology of Myopia

Various factors are responsible for the etiology and progression of myopia such as gender, age, social status, diet, environmental factors, and genetic factors. All the factors are summarized in Table 1.

3.1. Gender

Various studies were conducted concerning refractive errors in children and adults at schools and medical colleges. These studies demonstrated that the chances of myopia in females were higher as compared to males depending on an individual's age and maturity level. Albirk and Hirsch revealed that the onset of myopia in males was lower than in females (Hirsh, 1952; Alsbirk, 1979; Almudhaiyanet al., 2020).

Table (1) Risk Factors of Myopia

Factors	Occurrence
Gender	More in females
Age	Less in babies and lower in early age
Genetic factors	X-linked autosomal dominant
Environmental factors	Indoor activities increase the chances

3.2. Age

Myopia progression also depends on age. The chances of myopia are lower at an early age. The prevalence of myopia is less in babies but chances in children of 6 to 8 years of age increase due to an increase in axial length (Atkinson and Braddick, 2013).

3.3. Genetic factors

The refractive errors, including myopia are autosomal recessive, X-linked, and autosomal dominant (Vagge et al., 2018). If one parent is affected with myopia, the child is more likely to be juvenile myopic. If both parents are myopic, the chances of juvenile myopia increase six times. There are more chances of myopia progression and its development in children with myopic parents. Scholars presented that the myopia onset is higher in monozygotic twins than in dizygotic twins (Pacella et al., 1999). The Correction of myopia evaluation trial revealed that myopia development is associated with parental myopia (Kurtz et al., 2007).

3.4.Environmental factors

The non-genetic environmental factors have an association with myopia progression. Indoor activities, schooling, reading, extensive studies, and video gaming are responsible for increasing axial length and aiding in myopia progression. Indoor activities affect the growth of the eyes (Morgan and Rose, 2019). Social economic status, poor quality of life, poor diet, and intelligence are factors for the occurrence of myopia. Outdoor activities and exercises help in reducing the progression rate (McBrien and Barnes, 1984).

A study was conducted in SA by comparing ocular comorbidities and refractive error among students of India and SA living in SA. Refractive error was detected more in Indians. These results were due to genetic counseling and altering the acquired factors responsible for causing optic problems. The degree of progression of myopia was high in Indians. Yasir and his colleagues (2020) reported that the prevalence of myopia was 38% in India. In SA, outdoor activities have proved to be protective factors for treating myopia. In contrast, the educational pressure of studies and international exams burden is more on Indians, which engages the students in indoor work and enhances the chances of myopia (Yasir et al., 2020).

Further investigation, refractive services, and vision screening methods are needed for secondary and preparatory students. A family with positive refractive error is a predictable factor among school students. There is a great need to determine the risk factors and treatment strategies for controlling myopia development and its progression

4. Classification of Myopia

Myopia can be classified based on five factors summarized in Table 2.

4.1. Classification of myopia based on genetic factors

Myopia is classified into two main classes based on genetic factors. The first is syndromic myopia and the second one is non-syndromic myopia. Non-syndromic myopia is not directly linked with gene mutation. The phenomenon of polymorphism in various genes lies under the heading of non-syndromic myopia. On the other hand, syndromic myopia is known as Marfan syndrome, which is directly linked with genetic mutations. According to a Genome-wide study, also called The Consortium for Refractive Error and Myopia (CREAM) study, 24 loci are discovered that are engaged in developing myopia and enhancing myopia risk (Russo et al., 2022).

4.2. Classification of myopia based on rate of progression

Myopia is classified on the basis of the rate of progression into temporary, permanent, progressive, and stationary myopia by Donders. Stationary myopia is slowly growing and stops rapidly. Permanent myopia progressed rapidly at the start and ascends until the 1920s to 1930s while, temporary myopia progressed at the end of the 1920s, and the progression rate becomes zero. These varieties are linked with vision ocular threatening conditions (Donders, 1984).

Table (2) Classification of Myopia

Factors for Classification	Types of Myopia
Genetic factors	Syndromic myopia
	Non-syndromic myopia
Rate of progression	Temporary myopia
	Permanent myopia
	Progressive myopia
	Stationary myopia
Anatomical features	Axial myopia
	Refractive myopia
Age	Congenital myopia
	Youth myopia
	Adult myopia
	Late adult myopia
Pathology	Malignant myopia
	Alternative myopia

4.3. Classification of myopia based on anatomical features

Myopia is classified into axial myopia and refractive myopia on the basis of anatomical features by Borish (Borish, 1954). In Axial myopia, axial length is longer for refractive components while, on the other hand, those components are stronger in refractive myopia (Duke-Elder, 1970a).

4.4. Classification of myopia based on age

Myopia is classified by Grosvenor on the basis of age into congenital myopia which starts at birth, youth myopia which starts at the age of 6 to 15 years, early adult myopia which remains at the age of 20 to years and late adult myopia occurs late in life even starts from age of 40 years and up to life (Banks, 1980).

4.5. Classification of myopia based on pathology

Myopia is classified into malignant and alternative myopia on the basis of pathological conditions (Duke-Elder, 1970 b) that is detected by the optical system of eye biologically. Pathological myopia leads to degeneration of macula, retina at peripheral site, and optic nerve. In pathological myopia, there are huge chances of myopic macular degeneration, glaucoma, cataract, choroidal neovascularization, and foveoschisis (Kaiti et al., 2021).

5. Treatment strategies for controlling Myopia in SA

5.1. Orthokeratology for controlling myopia

Orthokeratology is the overnight wear of reshaping of the cornea to provide the positive power of corrected vision in the daytime. Many studies have conducted research to compare the change in axial length by using single-vision lenses and orthokeratology lenses. The result indicated that orthokeratology lenses more effectively controlled myopia (Gammoh, 2019). Orthokeratology is also the development of contact lenses that are permeable to gas. This treatment temporarily restructures the cornea to lessen optic defects like hyperopia, myopia, and astigmatism. Though FDA has approved it, there is a need for further findings about its long-term usage. A study was conducted for the knowledge evaluation of optometrists in 2018 in Jeddah city of Saudi Arabia. This study found that optometrists generally lacked a thorough understanding of orthokeratology, which prevented them from prescribing it to patients. This is because, in the literature, there have not been nearly enough studies done on it to determine whether it is a better long-term option to cure ocular defects like myopia (Basheikh et al., 2018).

5.2. Under-correction of myopia

A problem of defocusing occurs in myopia and the under-correction of myopia controls the further progression of this error. Many clinicians recommend under-correction of myopia for controlling myopia in different countries such as the USA, Spain, Portugal, and South Africa (Wolfsohn et al., 2016). The research was conducted to examine the attitude and beliefs of youngsters toward using contact lenses in Riyadh, SA. This study sought to assess the attitudes of non-compliant teenagers, who made up a significant section of the study population, regarding using contact lenses in place of spectacles to rectify refractive error. It appeared that contact lenses could be a useful tool in handling such situations. These findings suggest that optometrists prescribe contact lenses to patients to promote compliance with refractive error correction, but with a stronger focus on patient education and follow-ups (Alsaqr et al., 2021). Both parents and kids generally disagree with the way people wear glasses. As contact lenses are linked to improved self-esteem, using them may be a better alternative for those who disagree with glasses. Additionally, it has been hypothesized that those who use contact lenses have a positive self-perception of their physical attractiveness, athletic prowess, and public acceptance (Terry et al., 1997; Miller, 2020).

5.3 Progressive addition lenses for controlling myopia

It has been reported that the progressive addition lenses slowed down the progression of myopia in students of many countries. These lenses reduce the progression by approximately half a diopter and accommodative lag when lenses of +1.5D and +2D were used. It was a successful method of controlling myopia in many countries (Edwards et al., 2002). According to a survey conducted at the Qassim University of SA, one hundred and thirty-eight students were with progressive addition lenses. It was the highly prescribed form of optical compensation, such as myopia in different regions of SA. After this survey, they concluded that the wearers were with satisfactory vision, but there were some complaints after using progressive addition lenses. The risk factor was not race, gender, or age, but it was time since they wore these lenses (Alaziz, 2022). There is a need for further investigation on finding the treatments for refractive errors, especially myopia.

5.4 Multi-focal soft contact lenses for controlling myopia

Multi-focal soft contact lenses were used to treat presbyopia and can be used for other refractive errors, such as myopia. These multi-focal lenses are designed to reduce optic error and also distance correction. These are successfully used to treat presbyopia, but further research is needed to investigate the use of lenses to treat myopia (Walline, 2013). According to research conducted at King Abdulaziz university and hospital, SA, the use of multi-focal soft contact lenses slowed myopia development and axial elongation (Raffia et al., 2021). It is suggested that increasing the power of multi-focal contact lenses can improve the refractive error.

5.5 Pharmaceutical techniques for controlling myopia

Atropine drops are used for the treatment of mydriasis, cycloplegia, and amblyopia. Atropine sulfate acts on cholinergic receptors and inhibits muscular action. In a phase-I study of myopia, atropine drops (1% concentration) were used in children of Singapore (Tong et al., 2009). Another agent 7-methylxanthine is tested on animals and also successfully entered clinical trials (Kaiti et al., 2021). When compared with atropine drops, no adverse effects were observed. Pirenzepine gel is known as an anti-myopia agent and now it is under examination for retarding the progression of myopia (Trier et al., 2018).

5.6 Surgical interventions for controlling myopia

Surgical interventions include Collamer lens implantation, intraocular implantation, and laser corneal surgery for the treatment of myopia. Dopamine injections and mesenchymal stem cell injections have a positive effect in reducing myopia progression. Posterior scleral reinforcement is the surgical method used for decreasing axial length (Xue et al., 2014).

5.7 Laser Vision Correction Surgery (LVC) in SA

The most popular kind of myopia treatment is LVC surgery, which has great results despite a small but significant failure rate due to post-operative myopia that both patients and surgeons find less satisfying. The corneal center and curve are reshaped by the surgeon during the LVC operation, which rectifies the eye's refractive defect. Well-designed satisfaction surveys and studies can give healthcare professionals some essential information about the caliber of their communication and care because unhappy patients may decide to move to another service supplier (Said and Tabbara, 2011). Previous research revealed that the comparatively low pain level and quick visual recovery of LVC surgery make it popular. On the other hand, patients with thin corneas and extreme myopia typically undergo laser-assisted sub-epithelial keratectomy (LASEK). Due to the potential for corneal ectasia and other ocular issues, a thin cornea is a risk factor for prescribing LVC surgery (Lim et al., 2016).

Research reported by Artini and his colleagues (2018) was that 96.1% of high myopic patients and 69.9% of very high myopic patients showed satisfactory results to LVC in SA (Artini et al., 2018). The common side effect after LVC surgery was dry eye people faced in SA (Alamri et al., 2021).

5.8 Laser in situ keratomileusis (LASIK) and Photo-refractive keratectomy (PRK) Surgery in SA

The procedures for corneal treatments are photorefractive keratectomy, radial keratotomy, laser sub-epithelial keratomileusis, and laser in-situ keratomileusis. The refractive error is corrected by an excimer argon fluoride laser of 193nm which removes the anterior stroma in the cornea and then creates the curvature in radius. In PRK surgery, an ophthalmologist removes the corneal surface cells to treat refractive errors. On the other hand, LASIK surgery creates a small flap in the cornea that gives access to tissues (Wang and Yang, 1997). PRK surgery in SA is considered safe and effective. The reason behind it is that LASIK surgery leaves a small flap in the cornea which may be alarming and cause complications when the eye is injured. However, PRK and LASIK surgery is not recommended for children under the age of 18 years (Cavuoto et al., 2022).

5.9 Small Incision lenticule extraction (SMILE) in SA

The methods of refractive surgery are very effective and safe, however, the development of dryness in the eyes is problematic. SMILE is a novel surgical treatment method that leads to less nerve density and corneal sensitivity change than LVC and LASIK. In this method, a femtosecond laser is applied to produce the lenticule extracted from the incision. Previous studies have reported the safety, efficacy, and predictability of using SMILE performed in the cornea (Miranda et al., 2022; Siedlecki et al., 2020). It gave better results than underlying treatments, and no adverse effects have been observed in the literature.

5.10 Light dopamine theory

Various studies suggested that a decrease in the prevalence of myopia might be associated with spending much time outside (Alemam et al., 2018). While the detailed mechanism behind this connection is unclear, some concepts have been put forth, such as light dopamine theory, which postulates that exposure to sunlight during outdoor recreation triggers the retina to release dopamine neurotransmitters which are capable of preventing the increase in axial length of the eye (Cohen et al., 2012). According to researchers, animals like monkeys and chicks can delay myopia development when exposed to high light intensities. The amount of sunlight is directly linked with ocular vision. According to research, exposure to light of 10,000 lux was substantially correlated with an increase in the level of ocular dopamine and a decrease in the onset of myopia in chicks (Guggenheim et al., 2014). However, the sunlight outside would cause the pupils to constrict, increasing the focus depth and reducing visual blur.

5.11 Parental Awareness

A policy is required to increase the knowledge and perception of parents and teachers. Such a development may assist in formulating a strategy to alter misguided beliefs and misconceptions about the approaches to treating childhood refractive error (RE). In SA, parents have a low understanding of pediatric RE and have negative attitudes toward using glasses as a management tool for RE. It is necessary to address misperceptions and misconceptions about the techniques of treating childhood RE, as well as to enhance community awareness of RE and the significance of early identification and treatment (Alghamdi and Alrasheed, 2021).

6. Conclusion

This study represented a detailed overview of the etiology of myopia and recent treatment strategies to overcome myopia in Saudi Arabia. The prevalence of myopia is increasing day by day. The overall lifestyle has undoubtedly changed significantly due to computers and other electronic display equipment. However, there is an alarmingly high prevalence of severe vision issues linked to the extended use of such technology. This issue needs to receive considerable attention on a worldwide scale.

This study also indicated that there is little knowledge of myopia among the general people in SA. Therefore, to reach a larger audience, more effort is required. Parental knowledge of eye conditions and RE could be increased with the use of more public information campaigns, media advertisements, and awareness days. Eye care professionals should be more engaged, and more household actions should be performed to improve the children's adherence to treatment. The entire society must be aware of the advantages of atropine drops and patches. Early diagnosis and intervention could be provided by implementing screening tests for kindergarten children.

7. Future Perspectives

Since parents are frequently the first people, children learn from and develop healthy behaviors. Therefore, parents have a significant impact on them. Thus, promoting health resources needs to consider parents' knowledge of childhood eye problems, their mentality toward taking medication, and their management of illnesses in accordance with medical advice. More parent-friendly communication methods for such patient information should be used in the research area to increase their efficacy. There is a great need for further investigation to find the appropriate treatments and enhance the screening methods for early detection and diagnosis.

8. Declarations

8.1 Conflict of Interest Statement

The authors have no conflict of interests to declare.

8.2 Funding Disclosure

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