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MYOPIA – EPIDEMIOLOGY AND MANAGEMENT IN THE PEDIATRIC POPULATION

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ABSTRACT

Introduction and Purpose: Myopia is currently the most prevalent refractive error worldwide, with a rapidly increasing incidence, particularly among children and adolescents in urbanized regions. This review outlines the most effective evidence-based strategies for preventing and slowing the progression of myopia, with a focus on both pharmacological and non-pharmacological approaches.
The State of Knowledge: Recent studies have highlighted that increased time spent outdoors significantly reduces the onset of myopia in non-myopic children, though its effect on progression in already myopic individuals appears limited. Light exposure, especially to moderate-intensity natural light, has shown potential in mitigating axial elongation and promoting choroidal thickening. Sleep quality and duration may also influence myopia development, though further research is needed to confirm this relationship. Pharmacological intervention with low-dose atropine (particularly 0.01–0.05%) is currently the most effective and widely accepted treatment, offering substantial benefits with minimal side effects. Optical interventions such as orthokeratology, multifocal spectacle lenses, and dual-focus contact lenses have demonstrated efficacy in controlling axial elongation by modifying peripheral retinal defocus.
Summary: Combining lifestyle modifications (outdoor activity and light exposure) with pharmacological (low-dose atropine) and optical (e.g., orthokeratology and bifocal lenses) interventions provides a comprehensive, multimodal strategy to manage and slow myopia progression. Early implementation of such interventions is essential in addressing the growing public health burden of myopia.

KEYWORDS
Myopia, Refractive Error, Atropine, Orthokeratology

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1. Introduction

Myopia is one of the most common ophthalmic condition that impair visual acuity (VA) [1]. Moreover, it is the most common refractive error [2]. Also called short-sightedness, usually starts in childhood and progresses until reaching the full axial length (AL). The most common cause of myopia is axial short-sightedness, which results in focusing the image in front of the retina [3]. In other cases, myopia can result from increased keratometry of the cornea (e.g., in keratoconus) or the lens, as occurs in nuclear cataracts, among others [1, 2]. Myopia can be divided according to severity (in diopters) or the axial length (AL) [4]. High myopia is defined as an axial length of the eyeball greater than or equal to 27mm and/or a refraction greater than -10 D [5]. It should be noted that definitions of high myopia vary in the literature, e.g., Chen et al. define high myopia as ≥-6D [2, 6].

2. Epidemiology

The prevalence of myopia varies by the study group and location. Myopia affects about 20-40% of the general population, of which about 3% is high myopia [7, 8]. Several studies have shown that myopia is more common in urban areas, where a larger ratio of the population works at near distances using electronics, computers, and books. In recent years, the number of myopic patients has been steadily increasing. The review and meta-analysis by Holden et al. found that in 2000, about 1,406 million people (22.9% of the global population) were myopic, and this number will almost double in 2020 to about 2,620 million (34% of the global population). According to mathematical algorithms, it was estimated that by 2050, the number of myopic people will increase to about 4758 million people (almost 50% of the global population) [9]. In Eastern Europe (including Poland), the prevalence of myopia in 2000, 2020, and 2050 is 18%, 32.2%, and 50.4%, respectively [9].

In addition, myopia increases the risk of many complications, including myopic maculopathy, myopia-associated optic neuropathy [10], pathological retinal changes, e.g., retinal detachment (RD) [1]. Therefore, high myopia should be distinguished from pathological myopia. High myopia refers only to a significant refractive error, while pathological myopia involves the above-mentioned consequences [7, 8].

3. Prevention

3.1. Lifestyle

3.1.1. Increased Time Spent Outdoors

Many original papers or meta-analyses in the literature describe the positive effect of spending more time outdoors on decreasing myopia progression in children [10]. Among others, a prospective study (ALSPAC) conducted by Jeremy et al. compared time spent outdoors and physical activity with the incidence of myopia. Authors found that time spent outdoors decreased myopia progression more than physical activity separately [11]. In addition, Sherwin et al. found that each additional hour spent outside reduced the risk of myopia by 2% ($P<0.001$) [12]. Importantly, Xiong et al. found that increased time outside reduces the incidence of myopia, but does not affect children who are already myopic [13]. Guo et al. found that even 30 minutes of daily outdoor activity reduces myopia progression in children who were not originally myopic. The present study examined refractive error and axial elongation as a measure of myopia progression. It was shown that after one year of follow-up axial elongation was axial elongation (0.25 ± 0.20 vs. 0.30 ± 0.17 mm; $P = 0.008$) and progression in myopic refractive error (-0.05 ± 0.97 vs. -0.33 ± 0.70 diopters; $P = 0.002$). These results were statistically significant relative to the control group [14].

3.1.2. Light exposure

The review by Biswas et al. [15] found that factors such as light intensity, the duration of sensation, or the light pattern affect the axial length (AL). The cited studies found that "exposure to both long-term and short-term (30-120 min) light of moderate levels of illumination (500-1000 lux) induces a significant reduction in axial elongation and an increase in choroidal thickness (CT) in young adults" [16-19].

3.1.3. Sleep

The quality, duration, and frequency of sleep in children and their impact on the occurrence of myopia are not entirely clear and fully understood. In the literature, one can see a correlation between sleep duration and its effect on myopia, among other things. Several studies in the literature conclude that shortened nighttime rest increases the risk of myopia [20, 21].

3.2. Atropine drops

Atropine is currently the most widely used pharmacological agent in inhibiting myopia progression in children [22]. Atropine is a non-specific anti-muscarinic agent. It results in partial immobility of accommodation and pupil dilation. Daily use of one dot of high-dose atropine (0.5-1.0%) was found to slow the progression of myopia by 0.68 D per year, while low-dose atropine (0.1% or 0.01%) slowed the progression to 0.53 D per year [1]. A study by Yam et al. compared different concentrations of atropine 0.05% vs 0.025% vs 0.01% vs placebo. After one year, the change in SE (spherical equivalent) was -0.27±0.61 D, -0.46±0.45 D, -0.59±0.61 D, and -0.81±0.53 D, respectively ($P<0.001$), while the increase in AL. was 0.20±0.25 mm, 0.29±0.20 mm, 0.36±0.29 mm, and 0.41±0.22 mm, respectively ($P < 0.001$). A significant adverse effect is an increase in pupil diameter. There were no adverse effects at all concentrations tested, while all concentrations achieved a statistically significant reduction in myopia progression. The most effective concentration appeared to be atropine 0.05% [23]. The main side effects are associated with higher concentrations of atropinę [24]. Most commonly, patients report photophobia, poor near visual acuity, and increased pupil size [25]. The incidence of photophobia at a concentration of 0.01% is estimated to be about 6%, while at a concentration of 0.5%, it is 43.1% [26, 27].

3.3. Optical interventions

Previous studies have found that optical undercorrection or lack of spectacle correction did not affect or exacerbate myopia progression [10, 28, 29]. Jonas et al. primarily singles out multifocal spectacle lenses, dual-focus and multifocal contact lenses [30], and orthokeratology. Jonas et al. distinguish primarily multifocal spectacle lenses, dual-focus and multifocal contact lenses, and orthokeratology [10]. In the present article, we focus mainly on orthokeratology.

3.3.1. Orthokeratology (ortho-k)

Orthokeratology (ortho-k) lenses are primarily used for patients with low to moderate myopia [26]. These lenses are used overnight, resulting in a temporary reshaping of the cornea—or more precisely, a flattening of the cornea, which results in less braking power. The effect lasts throughout the day, negating the need for spectacle correction or contact lenses. In addition, scientific reports suggest that the use of OK reduces the progression of myopia [10, 31-36].

4. Summary

Myopia is the most common refractive error globally, and its prevalence is rising, especially in urbanized regions. While this trend is concerning, several preventive strategies have shown promise in slowing its progression, particularly in children. Spending more time outdoors significantly reduces the risk of myopia onset, especially in children without prior refractive errors. Moderate-intensity light exposure may also help limit axial elongation. Although evidence regarding sleep remains inconclusive, reduced sleep duration may contribute to increased risk. Low-dose atropine (0.01–0.05%) has demonstrated efficacy in slowing myopic progression with minimal side effects. Optical interventions such as orthokeratology, multifocal spectacle lenses, and dual-focus or multifocal contact lenses have also proven effective in reducing axial elongation and refractive shift by modifying peripheral defocus. Combining lifestyle modifications with pharmacological and optical treatments offers the most comprehensive approach to managing and slowing myopia progression in pediatric populations.

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Conceptualization, SK, AR and NP; methodology, MD, NP and SK; software, MK, AS, MD, NP and WD; check AR; formal analysis, AS,MK, WD; investigation, SK, NP, KT and MD; resources, SK and NP; data curation, MK, KT and WD; writing – rough preparation, SK, MD, AR, NP, MK, AS and WD; writing – review and editing,SK, MD, AR, NP, MK, AS and WD; visualization, WD; supervision, AR, SK, KT and MD; project administration, MK, AS and MD;

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