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Methods of preventing and retarding the progression of myopia

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Abstract:

Myopia is an increasing problem worldwide. Its prevalence is predicted to over 4 billion of people in 2050, what would be almost 50% of the population. Therefore, authors have analyzed available literature in terms of treatment that may be able to prevent or slow the progression of myopia. There are risk factors such as genetic factors which nowadays could not be modified. However, there are other risk factor such as near work or protective factor such as time spent outdoor which could be modified. Moreover, therapeutic interventions seem to play more significant role. Among available methods it is mentioned: pharmacology including drops of atropine and pirenzepine, undercorrection, contact lenses, orthokeratology, bifocal or multifocal spectacles and soft multifocal contact lenses. Methods are described with their mechanism of action and efficacy.

Key words: myopia; prevention; therapy; progression

Introduction and purpose

Uncorrected refractive errors are the major cause of visual impairment and are found in as many as 42% of the global population [1]. They are also responsible for 3% of cases of blindness in the world [1]. Data on East Asia indicate a significant increase in the incidence of myopia. Sixty years ago, around 10-20% of the Chinese population was short-sighted. Currently, as many as 90% of adolescents and young adults in China suffer from myopia. In other parts of the world, there is also a significant increase in the incidence of this disease. In Europe and the US, myopia affects about half of young adults. Frequency of its occurrence doubled the in relation to what occurred half a century ago. Some researchers indicate that the occurrence of myopia reaches epidemic proportions [2]. Another publication assessing the prevalence of myopia has indicated the current occurrence of myopia at 22.9% of the world population and high myopia at 2.7%. It has been predicted that in the year 2050 there will be 4758 million people with myopia in the world, which will constitute 49.8% of the population, and 938 million with high myopia (9.8% of the population) [3]. Due to the significant increase in the presence of myopia, including high myopia with its complications, it was decided to review the literature regarding methods of prevention or slowing down the progression of myopia.

Description of the state of knowledge

Risk factors

Genetic factors

Genetic factors play important role in myopia. A child whose parents are both short-sighted has a much greater risk of developing myopia than a child whose one or both parents are not short-sighted [4]. In 2013, Consortium for Refractive Error and Myopia (CREAM) was set up. It brought together scientists from different countries who identified as many as 24 genes that could be involved in the initiation of myopia. These genes are involved in the nerve cells functioning, metabolism and the development of the eyeball. Individual genes have little effect on the occurrence of myopia, however, it was estimated that if there are several of them, the risk of myopia may increase up to tenfold [5].

Near work

Near work, such as reading, writing or computer skills is probably responsible for a noticeable increase in myopia. Huang et al. carried out the meta-analysis which described the correlation between close-up work and myopia. Their results indicated a 2% increase in the risk of myopia for each additional hour of time spent on the near work per week. It was estimated that people who do more near work have an 80% greater risk of myopia. In addition, it was noted that children with myopia spend more time reading, and not learning, using a computer or watching TV than their colleagues without refractive error. The above observation indicates that the impact of near work on myopia comes mainly from reading [6].

Protective factors

Time spent outdoor

It is believed that the time spent outdoor reduces the risk of myopia. In Sherwin's analysis, the summed odds ratio indicates a reduction in the risk of short-sightedness by 2% for each additional hour in the week spent outside, after matching for other variables. The authors believe that increasing the amount of time spent outside can be a simple method that can reduce the risk of myopia development and progression in children and adolescents [7]. They point to the existence of many possible mechanisms in which time spent outdoor can protect against the occurrence and progression of myopia. Increased secretion of dopamine by the retina in response to sunlight has been described, which results in the blocking of eyeball elongation in experimental myopia. Another mechanism may be increased intensity of light occurring outside, which leads to a narrowing of the pupil, increasing depth of focus and thus a reduction in image blurring and slow down eyeball growth. Another less likely explanation is that increasing amount of time spending outdoor will reduce the amount of time spending at near work, which results in a substitution effect.

Interventions to retard myopia progression

Pharmacology

Numerous studies indicate that muscarinic antagonists, atropine and pyreneazepine, slow the progression of myopia [8-11]. Despite many years of research, the mechanism of their action is still unclear. Atropine is a nonspecific muscarinic receptor antagonist, whereas pyrezepine is a selective antagonist for M1 receptors, which are distributed in a large amount in the retina, and in a small number in the ciliary body and iris, what reduces its cycloplegic and mydriatic effects. The efficacy of pirenzepine in slowing the progression of myopia has been estimated at 51% -77% with minor side effects in the form of papillary conjunctivitis and isolated cases of photophobia and image blurring during reading [12].

The well tested and most frequently used antimuscarinic drug is atropine. Currently, the theories of its action to inhibit the progression of myopia are based on the local effect on retina or biochemical changes caused by the binding of muscarinic receptors, as well as increased exposure to ultraviolet by dilating the pupil which may limit the increase of the axial length of the eyeball or reduce the chronic inflammation in the eye. The most effective is the 1% solution of atropine, however, due to intolerable side effects and a high resignation rate is very rarely used. Application of atropine may reduce the progression of myopia up to 1 diopter per year. Different solutions of atropine slow the progression of myopia, however stronger solutions seem to have a stronger effect, but the rebound effect after discontinuation of the drug is also greater. Weaker solutions have less pronounced adverse effects of therapy, such as hypersensitivity to light or accommodation loss. According to the report of the American Academy of Ophthalmology from 2017, it seems that 0.01% solution of atropine is the most sensible approach to the treatment of myopia in children due to the lasting effect of therapy and low risk of adverse effects [10]. However, a study published last year which compared the use of low concentrations of atropine (0.05% / 0.025% / 0.01%) on progression of myopia showed that the inhibition of progression is concentration-dependent. All concentrations were well tolerated, with no significant adverse effects. However, the highest efficacy in inhibiting the progression of the refractive error and stopping the prolongation of the axial length of the eyeball during the 1-year observation was proved to be a solution of 0.05% [11]

Undercorrection

Traditionally, it was thought that the undercorrection of myopia causes myopic defocus, which is described in the animal model, to slow down myopia progression. According to the latest research conducted in China by Sun et al., the full correction of myopia results in a slightly faster progression of myopia in children who are already myopic than no correction (by 0.27D in 2 years). However, it should be noted that children not using correction will suffer from aquired distance esotropia and blurred distance image. The mechanism that can explain this observation is that children without correction experienced myopic defocus at distance and at near, while those with full correction were stimulated by continuous hyperopic defocus at near[13]. However, there are previous research in which undercorrection produced more rapid myopia progression and axial elongation [14]. Due to studies discrepancies and indications that a slight correction of myopia at 0.5 D-0.75 D does not slow down its progression, this method is not recommended [12].

Conctact lenses

Numerous clinical studies indicate that soft contact lenses and rigid gas-permable lenses are not effective in preventing progression of myopia. The first research on the rigid gas-permeable contact lenses indicated a slow-down in the progression of myopia compared to people with spectacle correction, but subsequent studies did not indicate any difference between the groups. The difference was probably due to their flattening effect, which was only temporary. Similarly, studies carried out on children did not indicate differences in the rate of progression of myopia between people who wear soft contact lenses and glasses [15].

Orthokeratology

Orthokeratology is a method in which reverse geometry gas permeable lenses are used. Basic of this technique is to temporarily reshape the cornea of a myopic eye. Lenses are designed for overnight wear and they are effective at treating myopia of up to 6.00 D and astigmatism of up to 1.75 D. Ortokeratology is an effective option to slow the progression of myopia by moving the image to the central and mid-peripheral retina, which stimulates emmetropization and slows down the elongation of the eyeball. According to available studies, orthokeratology may reduce the eyeball elongation by 32-57% within 2 years in relation to people wearing glasses [16].

Bifocal or multifocal spectacles

It was postulated that two or multifocal eyeglasses could provide sharp vision for many distances, as well as reduce retinal defocus and slow the progression of myopia. Analysis of the Cochrane database published in 2014 showed that the use of progressive addition lenses (PALs) compared to single vision lenses (SVLs) causes a statistically significant slowdown in the progression of myopia, but this value has no clinical significance. Data for the benefits of using bifocal lenses compared with SVLs is limited and inconsistent across heterogeneous trials [17].

Soft multifocal contact lenses

The design of the multifocal soft contact lens used to inhibit the progression of myopia presupposes a peripheral positive power relative to the center with alternating concentric-ring designs. These lenses are assumed to operate on the principle of peripheral myopic defocus, which slows the elongation of the eyeball. A review of the literature indicates that the use of this type of lenses induces the slowdown of myopic progression from 25% to 72%, which corresponds to the reduction of refractive error increase from 0.2D to 0.57D relative to the control group. Moreover, the limitation of eyeball lengthening varies between 27% and 80%. Until now, there are no soft contact lenses approved by the FDA for inhibiting the progression of myopia. There are doubts about the safety of using contact lenses in children. The incidence of keratitis associated with the use of lenses is unknown, and there are doubts about the use of proper hygiene and lens care [18].

Summary

A significant increase in the frequency of myopia resulted in increased interest of scientists in this subject and a large number of publications describing the possibilities of preventing and inhibiting the progression of myopia. The modification of the amount of time spent outdoor seems to be the simplest and the most accessible method that can reduce the risk of developing and progression of myopia. Among the therapeutic methods, the use of low-dose atropine, multifocal contact lenses and orthokeratology was the best assessed. However, none of these methods is registered for the indication of inhibition of myopic progression, so it can be used by doctors only off- label. All described methods of therapy may have adverse effects and the influence of their long-term use is unknown. In addition, it is not known if there is an additive effect of combination therapies.

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