DOI: 10.53469/jcmp.2026.08(01).11

Protecting the Hyperopia Reserve in Children and Adolescents: A Research Progress Review

Mengen Gao[1,2], Zhen Chen[1], Junguo Duan[1,3,*]

[1]Chengdu University of TCM, Chengdu 610075, Sichuan, China
[2]Eye School of Chengdu University of TCM, Chengdu 610075, Sichuan, China
[3]Eye Health with Traditional Chinese Medicine Key Laboratory of Sichuan Province, Chengdu 610075, Sichuan, China
**Correspondence Author*

Abstract: ***In recent years, the trend of myopia affecting younger children and its increasing incidence has become increasingly severe. Against this backdrop, hyperopia reserve, as an indicator reflecting children's refractive development status, is regarded as a key early warning signal before the onset of myopia. Strengthening the protection of hyperopia reserve in children and adolescents and promoting their visual health have become a "Bright Project" of widespread societal concern. Based on the latest research data and findings, this article systematically reviews and reflects on prevention and control strategies for insufficient hyperopia reserve from various aspects, including daily management, behavioral interventions, optical correction, pharmaceutical prevention, and appropriate traditional Chinese medicine techniques. The aim is to provide reference insights for enhancing the protection of children's hyperopia reserve and preventing the trend of myopia at younger ages.***

Keywords: Hyperopic Reserve, Outdoor Activity, Low-intensity Red Light, Appropriate Techniques Of TCM**.**

1. Introduction

Hyperopia reserve is derived from the understanding of the dynamic process of refractive development in children and adolescents. The magnitude of hyperopic diopters present during the eye's emmetropization process can be defined as hyperopia reserve value [1]. Insufficient hyperopia reserve refers to a condition where an individual has normal uncorrected visual acuity, and their refractive status after cycloplegia does not meet the diagnostic criteria for myopia, but the hyperopic diopters are lower than the physiological range corresponding to their age group.

The problem of insufficient hyperopic reserve among children and adolescents in China has become increasingly severe. Epidemiological surveys [2-4] have shown that its detection rate remains persistently high, with a distinct trend of earlier onset. Recently, the Notice on the Scientific Protection of Children's Hyperopic Reserve, jointly issued by multiple national departments, emphasized the core role of hyperopic reserve in myopia prevention, aiming to advance the visual health management of children and adolescents. Studies [5-7] have indicated that hyperopic reserve serves as a highly accurate indicator for predicting the onset of myopia in children. This paper aims to collate and summarize safe and effective methods for protecting hyperopic reserve, providing a reference for the preservation of children's hyperopic reserve.

2. Daily Management and Behavioral Interventions

Studies have shown that both environmental and genetic factors are important causes of insufficient hyperopia reserve. The eyeballs of children and adolescents are in a critical developmental stage. If adverse effects of environmental factors on visual development can be reduced through daily management and behavioral interventions, the depletion of hyperopia reserve can be slowed down.

2.1 Outdoor Activities

Multiple studies have confirmed that outdoor activities are important protective factors for preserving hyperopic reserve in children and delaying the onset and progression of myopia [8-9]. The underlying protective mechanism can be explained by the light-dopamine hypothesis: this hypothesis points out that dopamine, as a key neurotransmitter in the retina, not only participates in the transmission of visual signals and the normal development of the retina, but also plays an important regulatory role in the process of refractive development [10]. In addition, the protective effect of outdoor activities on hyperopic reserve is also partially achieved through the vitamin D metabolic pathway. Studies have shown that outdoor exposure helps increase serum vitamin D levels, which may indirectly inhibit the excessive activity of scleral fibroblasts in the posterior pole of the eye, thereby slowing down the abnormal elongation of the axial length [11].

A study indicated that increasing daily outdoor activity time by 76 minutes can reduce the risk of myopia by 50% [12]. It is worth noting that the effectiveness of outdoor activities in myopia prevention and control depends not only on the cumulative duration, but also closely on the light intensity. A study conducted by He's team demonstrated that under the condition of 5, 000 lux/min light intensity, a daily outdoor time of 170 minutes or a cumulative light intensity of 850, 000 lux/day can reduce the incidence of myopia by 30%.An intervention study in China found that increasing classroom lighting intensity from 100 lx to 500 lx can also slow down the onset of myopia and axial length elongation in students to a certain extent [13]. This provides a feasible alternative strategy for regions and seasons where outdoor activities are limited by factors such as climate and academic workload.

Ensuring a cumulative daily daytime outdoor activity duration of no less than 2 hours is a daily health behavior that can effectively slow down the depletion of hyperopic reserve and prevent myopia in children and adolescents. Schools and families should jointly supervise the implementation of this

measure to ensure that children have sufficient time to stay in outdoor environments, laying a solid foundation for their visual health.

2.2 Eye-Using Habits

Multiple studies [7, 14-15] have shown that children with poor eye-using postures have a higher risk of insufficient hyperopia reserve. A study by Wei et al. [16] found that through popularizing children's eye health knowledge via the "integration of medical care and education" model and actively guiding children to improve their own eye-using behaviors and habits, the incidence of insufficient physiological hyperopia reserve in the intervention group was significantly lower than that in the non-intervention group after one year. In addition, the younger age of onset and high popularity of mobile device use have become emerging risk factors affecting hyperopia reserve. Prolonged use of electronic screens can directly lead to decreased visual acuity; therefore, controlling screen time is one of the important behavioral intervention measures to delay the depletion of hyperopia reserve.

Cultivating good eye-using habits is the cornerstone of protecting hyperopia reserve. It is recommended to combine family supervision with school guidance and encourage the implementation of the "20-20-20" rule during eye rest intervals (every 20 minutes of screen use, look at an object 20 feet away for 20 seconds) to alleviate regulatory fatigue and maintain the stability of the refractive development environment.

2.3 Dietary Structure

With the improvement of living standards, the per capita sugar intake has gradually increased, and the adverse health impacts of a high-sugar diet have become increasingly prominent. Multiple studies [17-19] have indicated that a high-sugar diet is associated with myopia to a certain extent. The underlying mechanism may involve elevated blood glucose and insulin levels, which in turn participate in and promote the onset and progression of myopia through multiple pathways, including the polyol pathway, glucagon signaling pathway, insulin signaling pathway and inflammatory mediators.

In addition, fried foods also have a potential impact on the development of myopia. A study by Guo et al. [20] found that the intake of saturated fat and cholesterol was positively correlated with axial length. Sun et al. [21] revealed that children in the obese BMI (Body Mass Index) group had a lower detection rate of hyperopia reserve, confirming a correlation between BMI and hyperopia reserve.

Although current research on the relationship between hyperopia reserve and diet remains insufficient, the impact of dietary structure on myopia has been supported by conclusive evidence. Based on the above analysis and considerations, advocating a balanced and healthy dietary structure is of positive significance for the early prevention and control of insufficient hyperopia reserve.

3. Pharmacological Prevention

In the myopia prevention and control system for children and adolescents, pharmacological intervention is one of the important strategies for delaying the depletion of hyperopia reserve and controlling the onset of myopia. At present, the drugs commonly used for protecting hyperopia reserve include low-concentration atropine eye drops, low-concentration raceanisodamine eye drops, and lutein.

3.1 Raceanisodamine Eye Drops

Low-concentration raceanisodamine eye drops have been proven to be an effective intervention for delaying the onset and progression of myopia. Its core mechanism of action lies in the non-selective blocking of muscarinic receptors in the ciliary muscle, which can effectively alleviate the excessive spasm and rigidity of the ciliary muscle during sustained near work. Thus, it partially eliminates the pathological stimulation of axial elongation, achieving the goal of delaying the premature and excessive depletion of hyperopia reserve.

A study by Wang [22] showed that the effective rate of 0.5% raceanisodamine eye drops in the treatment of pseudomyopia in adolescents could reach 94.6%. Zhang et al. treated pseudomyopia in children with 0.05% raceanisodamine eye drops, with an overall effective rate of 81.40%, and this result was consistent with the findings of Sun et al. [23]. In addition to raceanisodamine, atropine eye drops are commonly used for myopia prevention and control at present, and both their efficacy and adverse reactions are concentration-dependent [24]. However, at present, atropine is mostly used clinically in children and adolescents who have already developed myopia, and research on its application in populations with insufficient hyperopia reserve remains inadequate. In contrast, raceanisodamine eye drops have superior safety and tolerability profiles, demonstrating broader clinical application prospects in the protection of hyperopia reserve.

4. Optical Intervention

With the continuous advancement of myopia prevention and control strategies, optical intervention has emerged as a cutting-edge approach to slow down the depletion of hyperopic reserve and inhibit the onset of myopia.

4.1 Low-intensity Red Light

In recent years, basic research has demonstrated that low-intensity red light therapy can delay axial length elongation by improving the scleral remodeling process, thereby suppressing the occurrence and progression of myopia [25]. At present, this therapy is mainly applied to children who have already developed myopia, while research on its efficacy in hyperopic reserve preservation remains insufficient. This may be attributed to the fact that hyperopic reserve has only garnered widespread attention as a key focus of myopia prevention and control in recent years.

A randomized controlled trial conducted by He's team [26] enrolled children with a spherical equivalent (SE) ranging from -0.50 D to +0.50 D. After one year of red light intervention, the results showed that repeated low-energy red light exposure could reduce the incidence of myopia in pre-myopic children by 54.1% relative to the control group.

Additionally, at the 6-month mark of intervention, the mean spherical equivalent of the red light group shifted toward hyperopia by +0.18 D.

Similar conclusions were drawn in a study by Zhang's team [27]. This study targeted children with a spherical equivalent between 0.00 D and +0.50 D. Following 6 months of repeated irradiation with 650 nm low-intensity red light, children aged 6–10 years with insufficient hyperopic reserve exhibited increased hyperopic reserve volume and shortened axial length. At the 6-month follow-up, the mean spherical equivalent of the red light group shifted toward hyperopia by +0.53 D.

Another study [28] involving adolescents aged 7–16 years further revealed that after one year of intervention with 605 nm low-intensity red light, children without hyperopic reserve showed statistically significant improvements in axial length, spherical equivalent, and choroidal thickness.

Low-intensity red light intervention exhibits promising potential in slowing the depletion of hyperopic reserve. However, whether refractive rebound occurs after discontinuation of the therapy, as well as the long-term changes in axial length and choroidal thickness, still await further research and verification.

4.2 Defocus Spectacles

Optical intervention based on the peripheral defocus theory has become a crucial research direction for slowing myopia progression. A study conducted by Wang 's team indicated that for children with a rapid depletion of hyperopic reserve, wearing plano defocus spectacles can effectively slow down axial length elongation. As a core biological indicator for evaluating myopia progression, the effective control of axial length is directly associated with delaying the onset and development of myopia.

Although this study suggests the potential of plano defocus spectacles in the intervention of insufficient hyperopic reserve, relevant research targeting this specific population remains relatively limited. Its applicability in non-myopic children, optimal timing for initiating intervention, design of optical parameters, and long-term preventive and therapeutic efficacy still await validation through more high-quality clinical studies.

In the future, with the continuous advancement of functional optical design technology, defocus spectacles are expected to become a promising non-invasive intervention option for the stage of insufficient hyperopic reserve.

5. Appropriate Traditional Chinese Medicine (TCM) Techniques

The onset and progression of myopia are closely related to the sufficiency of visceral qi and blood, as well as the smooth flow of qi and blood through meridians and collaterals. Against this backdrop, appropriate TCM techniques, with their unique advantage of treating diseases before they occur and the concept of holistic regulation, provide an effective approach to preserving the hyperopic reserve of children and adolescents.

5.1 Auricular Plaster Therapy

Expert guidelines recommend that auricular plaster therapy can be selected based on clinical conditions for the prevention and control of mild myopia in children and adolescents. Zhou Yilang et al. found that auricular plaster therapy as an adjunct to behavioral intervention in the treatment of adolescent myopia complicated with ciliary muscle spasm can significantly improve visual acuity, optimize axial length, and enhance the overall therapeutic effect. Liu Jing et al. in a study targeting children aged 4–6 years with insufficient hyperopic reserve, revealed that the combined intervention of auricular plaster therapy and eye movement exercises yielded an overall effective rate of up to 95%, with the status of hyperopic reserve significantly improved. Zhang Yunxia et al. also pointed out that auricular plaster therapy combined with traditional Chinese medicine (TCM) atomization eye fumigation is safe and effective in preventing and controlling insufficient hyperopic reserve in children, which helps improve uncorrected distant visual acuity. As a non-invasive, easy-to-operate, cost-effective appropriate TCM technique with good compliance among children, auricular plaster therapy has high promotion value and is suitable for the early protection of visual health in children and adolescents.

In addition to auricular plaster therapy, other appropriate TCM techniques such as conventional acupuncture, intradermal needling, and TCM fumigation have also demonstrated unique value in myopia prevention and control [29-30]. However, most current studies have focused on populations with established myopia, and high-quality clinical studies targeting children at the stage of insufficient hyperopic reserve remain scarce. Future research needs to further explore the applicability, mechanism of action, and efficacy evaluation system of these techniques in early intervention, so as to enrich the repertoire of appropriate TCM techniques for insufficient hyperopic reserve management and provide more personalized prevention and control strategies for children with different constitutions and needs.

6. Conclusions and Prospects

The visual health situation of children and adolescents is becoming increasingly severe. A growing body of evidence indicates that comprehensive interventions combining behavioral interventions and various medical approaches have shown positive effects in slowing down the insufficiency of hyperopic reserve. However, systematic research on protective measures for hyperopic reserve remains relatively weak at present, and the standardization and promotion mechanisms for these measures are not yet sound, which urgently requires the joint attention of the whole society, especially medical workers, educators and parents. Only through the organic combination of scientific assessment, precise intervention and whole-society collaboration can we effectively protect the hyperopic reserve of children and adolescents, delay the premature depletion of hyperopic reserve, and fundamentally curb the development trends of early onset and high myopia.

References

[1] He X G, Zhang X, Xu X. Orderly promoting myopia screening, refractive archives establishment, and the closed-loop management of myopia prevention and control for children and adolescents [J]. Zhonghua yu Fang yi xue za zhi [Chinese Journal of Preventive Medicine], 2021, 55(4): 551-555.
[2] Li Ning, Wang Yan, Yang Lei et al. Study on the correlation between hyperopia reserve and ocular biometric parameters after ciliary muscle paralysis in 4-14 year-old students from Hotan County, Xinjiang [J]. International Eye Science, 2025, 25(8): 1371-1376.
[3] ZHAO Y, GUO N, GAO Y X. Myopia and hyperopia reserve of Uyghur children aged 6~ 12 years in Yecheng county of Xinjiang [J]. International Eye Science, 2023: 986-990.
[4] Xuezhen LIU, Aiping FAN, Shuangpan Y, et al. Advances in epidemiological research on insufficient hyperopia reserve in children [J]. Chinese Journal of School Doctor, 2024, 38(2): 152-155.
[5] Karla Zadnik, Loraine T. Sinnott, et al. Prediction of Juvenile-Onset Myopia [J]. JAMA Ophthalmology, 2015, 133(6):683-689.
[6] Li S M, Kang M T, Li L, et al. Cohort study on the association between hyperopia reserve and myopia incidence in primary school students: The Anyang Childhood Eye Study [J]. Chinese Journal of Ophthalmology, 2022, 58(10): 754-759.
[7] Yi SUN, Rong LIN, Li-hua X, et al. Status and influencing factors of insufficient hyperopia reserve among children without myopia in Guangzhou in 2021 [J]. Chinese Journal of Disease Control and Prevention, 2023, 27(3): 368-372.
[8] Xiaodan WEI. Analysis of visual acuity development of preschool children in a kindergarten from 2017 to 2021 [J]. Chinese Journal of School Doctor, 2023, 37(4): 252-254.
[9] JIN J X, WU X Y, et al. Protective effect of increasing time spent outdoors on vision change among elementary and secondary school students [J]. Chinese Journal of School Health, 2014, 35(12): 1776-1779.
[10] SUN W F, YANG J L et al. Advances in research on the role of dopamine in myopia [J]. Chinese Journal Of Optometry Ophthalmology And Visual Science, 2015, 17(6): 377-380.
[11] Mutti Donald O, Marks Amanda R. Blood levels of vitamin D in teens and young adults with myopia [J]. Optometry and vision science: official publication of the American Academy of Optometry, 2011, 88(3): 377-382.
[12] Xiong, Shuyu, Sankaridurg, Padmaja, Naduvilath, Thomas, et al. Time spent in outdoor activities in relation to myopia prevention and control: a meta-analysis and systematic review [J]. Acta ophthalmologica, 2017, 95(6): 551-566.
[13] HUA W, JIN J, WU X, et al. Elevated light levels in schools have a protective effect on myopia [J]. Ophthalmic Physiol Opt, 2015, 35(3): 252-262.
[14] Wang Q. Prevalence and influencing factors of myopia in adolescents and children in Gaoping, Shanxi Province [J]. International Eye Science, 2020: 1054-1058.
[15] SHI Hao-nan, LIU Xiao-jing, MA Shao-wei et al. The impact of eye use patterns and genetic factors on myopia in Uygur middle school students in Urumqi: a cross-sectional survey [J]. Chinese Preventive Medicine, 2021, 22(3): 161-165.
[16] Ning W E I, Mei-Ling T, Jing W, et al. Influence of eye healthcare information teaching for the visual development of children under “combination of medicine and education” [J]. International Eye Science, 2016: 1531-1533.
[17] Mehmet M. Uzel, , Ufuk Elgin, et al. Comparison of Anterior Segment Parameters in Juvenile Diabetes Mellitus and Healthy Eyes [J]. European Journal of Opthalmology, 2016, 26(6):618-622.
[18] Xiao Z G. Correlation analysis between plasma insulin level and refractive development [J]. International Eye Science, 2020: 1641-1644.
[19] LIU Zhenrong, ZHANG Ming. Current status of low vision in a population with opportunistic diabetes based on a physical examination center [J]. West China Medical Journal, 2022;37(5): 738-742.
[20] Guo P, An N, Wu S, et al. Relationship between myopia and frequency of high energy food intake among adolescents in Nantong [J]. Chinese Journal of School Health, 2022, 43(4): 598-602.
[21] SUN Jing, ZHANG Mei, XU Xiaodong et al. Associations between sleep patterns and hyperopic refraction in children aged 6-7 years [J]. Chinese Journal of School Doctor, 2025, 39(08): 569-575.
[22] Wang H J. Efficacy of atropine and anisodamine eye drops for adolescent pseudomyopia [J]. International Eye Science, 2017: 519-521.
[23] SUN Xuefeng. A clinical study on the treatment of children’s myopia with chineseherbal hot compress eye mask combined with racemic anisodamineeye drops [J]. China Modern Doctor, 2023, 61(06): 70-72.
[24] Song-Yu Li, Ying-Xin Yang, Chao Yang et al. Meta-analysis of different concentrations of atropine eye drops in controlling myopia progression in children and adolescents [J]. International Eye Science, 2023, 23(01): 96-102.
[25] Gawne TJ, Ward AH, Norton TT. Long-wavelength (red) light produces hyperopia in juvenile and adolescent tree shrews [J]. Vision Res, 2017, 140(11): 55-65.
[26] HE X, WANG J, ZHU Z, et al. Effect of repeated low-level red light on myopia prevention among children in china with premyopia: a randomized clinical trial [J/OL]. JAMA Netw Open, 2023, 6(4): e239612.
[27] Cong Zhang, Lingli Zhang, et al. Clinical Efficacy of Repeated Low-Level Red-Light at 650 nm Therapy for Children with Insufficient Hyperopia Reserve [J]. Chinese Journal Of Optometry Ophthalmology And Visual Science, 2025, 27(6): 425-431.
[28] Fan Dawei, Zhang Weiliang, et al. Comparative study on application effect of 650-nm low-intensity single-wavelength red light irradiation on myopia prevention and control in adolescents with different myopia degrees [J]. Journal of Qiqihar Medical University, 2025, 46(7): 640-645.
[29] SHANG Xiao-juan, TAN Yi, ZHANG Peng, et al. Therapeutic Effect of Myopic Acupuncture Combined with Pointer Therapy in Preventing and Controlling Low to Moderate Myopia in Children [J]. World Journal of Integrated Traditional and Western Medicine, 2024, 19(2): 374-378.

[30] Fu zhen, BAI Yang, CHEN Xuesi, et al. Research progress on intervention of pseudo-myopia in children and adolescents using press needling [J]. Shanghai Journal of Traditional Chinese Medicine, 2025, 59(6): 9-12.