# Efficacy of Repeated Low-Level Red Light in the Prevention and Control of Myopia among Children and Adolescents

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## ABSTRACT

**Objective:** To evaluate the efficacy of repeated low-intensity red light (RLRL), orthokeratology (ortho-k) lenses, and defocus spectacle lenses in controlling axial length (AL) elongation in children and adolescents with myopia.

**Study Design:** Prospective randomised controlled trial.

**Place and Duration of the Study:** Ophthalmology Centre of Heilongjiang Hospital of Beijing Children's Hospital, Harbin, China, from January 2023 to May 2024.

**Methodology:** A total of 128 myopic children aged 6-18 years were enrolled and randomly assigned to the RLRL group (43 cases), the ortho-k lens group (43 cases), and the defocus spectacle lens group (42 cases). Changes in AL were observed at baseline and at the one-year follow-up.

**Results:** There were no significant differences in age, AL, and refractive error among the three groups at baseline ($p > 0.05$). Follow-up showed that the RLRL group had significantly better AL control efficacy at three months, six months, and one year compared to the ortho-k lens group and the defocus spectacle lens group (***$p < 0.001$). Subgroup analysis revealed no significant impact of gender, age, and myopia severity on the changes of AL ($p > 0.05$), confirming the universal applicability of RLRL treatment in inhibiting AL elongation.

**Conclusion:** RLRL outperforms ortho-k lenses and defocus spectacle lenses in controlling AL elongation in myopic children, demonstrating promising clinical application prospects. In future, large-sample, multicentre, long-term follow-up studies are needed to verify its efficacy.

**Key Words:** *Myopia, Repeated low-intensity red light, Orthokeratology lenses, Defocus spectacle lenses*.

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## INTRODUCTION

In recent years, myopia among children and adolescents has gained global attention, with the widespread use of electronic devices further exacerbating this public health concern.[1,2] In some Asian regions, the incidence of myopia among school-aged children is as high as 80-90%. This high incidence not only affects the quality of life but also increases the risk of severe complications such as macular holes and retinal detachment, which can lead to irreversible vision loss.[3,4] Existing interventions for myopia — including spectacle lenses, orthokeratology lenses (ortho-k), and low-concentration atropine — still have limited efficacy in controlling axial length (AL).[5]

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Excessive AL growth is a key mechanism underlying myopia progression and is theoretically positively correlated with the severity of myopia.[6] Natural light or 650 nm red light can stimulate retinal cells to secrete dopamine, and adequate dopamine can inhibit excessive AL elongation.[7] Currently, small-scale clinical studies have indicated that repeated low-level red light (RLRL) at a wavelength of 650 nm can be effective in suppressing the growth of AL.[6] However, comparative studies on its long-term efficacy, safety, and comparison with traditional interventions are still scarce.[8] Therefore, this study aimed to compare the clinical efficacy of RLRL, ortho-k lenses, and defocus spectacle lenses in myopia prevention among children, providing further evidence for optimising intervention strategies.

## METHODOLOGY

This study enrolled children and adolescents aged 8 to 13 years who were diagnosed with myopia and initiated treatment at the Ophthalmology Centre of Heilongjiang Hospital of Beijing Children's Hospital, Heilongjiang, China, from January 2023 to May 2024. Patients were randomised into three treatment groups: RLRL therapy (wearing single-focus spectacle lenses), ortho-k lens therapy, and defocus spectacle lens therapy. All patients

underwent a comprehensive ophthalmic examination before treatment, including visual acuity testing (VA testing), refractive error measurements, and AL measurement. During the treatment period, follow-up visits were conducted every three months to record changes in visual acuity, refractive error, and AL. The study was approved by the hospital's ethics committee, and all the subjects and their guardians signed informed consent forms.

The study subjects had spherical equivalent refraction (SER) of -1.0D to -5.0D after dilation, astigmatism <2.5D, anisometropia <1.5D, best-corrected visual acuity (BCVA) ≥0.0 logMAR (1.0 or 20/20 Snellen), and were willing to participate and accept randomisation. Children with ocular abnormalities, systemic diseases, or a history of myopia control treatment were excluded.

The RLRL group received treatment using a photobiomodulation device, with each session lasting 3 minutes, administered twice daily at intervals of ≥4 hours. The ortho-k lens group wore lenses overnight. The defocus spectacle lens group wore lenses throughout the day, ensuring at least 10 hours of wear per day. During the treatment process, visual acuity, refractive error, and AL changes were regularly checked at follow-up times of three months, six months, and one year. The efficacy of the three groups was compared. The appearance of the photobiomodulation device, ortho-k lenses, and spectacle lenses is shown in Figure 1.

AL was measured using a non-contact A-scan ultrasound scanner, employing optical high-precision measurement to avoid potential damage to the cornea from the contact instruments. During the measurement, the subjects maintained a stable head position, and three measurements were taken and averaged. A standardised visual acuity chart was used for unaided and corrected VA testing, and an automated computerised refractometer was used for refractive error measurement. All the data were averaged from three measurements. This study employed a double-blind design, and data recording was completed by professionally trained personnel to ensure the objectivity of the experimental results. Equipment calibration and quality control were maintained throughout the process.

Statistical analysis was performed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation, and normality was confirmed by the Shapiro-Wilk test. The t-test was used for comparisons between two groups, and one-way analysis of variance (ANOVA) was used for comparisons among three groups, with a significance level of $p < 0.05$. Categorical variables (such as gender) were analysed for differences between the groups using the chi-square test. GraphPad 8.0 software was used for chart drawing.

## RESULTS

At baseline, there were no significant differences in mean age, AL, and refractive power among the subjects in all groups ($p > 0.05$). The mean ages of subjects in the RLRL therapy group, ortho-k lens therapy group, and defocus spectacle lens therapy group were 9.6 ± 2.15 years, 9.1 ± 1.17 years, and 9.5 ± 1.55 years, respectively (with male proportions of 51.0, 55.0%, and 35.2%). Prior to treatment, there were no statistically significant differences in mean AL and refractive power values for both right and left eyes among the three groups (Figure 2A).

Follow-up results demonstrated that the RLRL therapy group exhibited significantly superior changes in AL compared to the ortho-k lens group and defocus spectacle lens group at three months, six months, and one year post-treatment (Figure 2 B-D, $p < 0.001$). Specific data are presented in Table I. RLRL therapy showed superior efficacy in controlling AL elongation compared to ortho-k lenses and defocus spectacle lenses, with its advantages becoming more pronounced over long-term follow-up.

**Table I: Comparison of AL changes during follow-up among different treatment groups (mean ± SD, mm).**

| Follow-up time | Group I | Group II | Group III | p-value (Inter-group comparison) |
|---|---|---|---|---|
| 3 Months | -0.07 ± 0.11 | 0.03 ± 0.07 | -0.02 ± 0.01 | Group I *vs.* Group II: 0.001<br>Group I *vs.* Group III: 0.003 |
| 6 Months | -0.09 ± 0.12 | 0.15 ± 0.12 | 0.09 ± 0.07 | Group I *vs.* Group II: <0.001<br>Group I *vs.* Group III: <0.001 |
| 12 Months | -0.05 ± 0.16 | 0.27 ± 0.17 | 0.17 ± 0.07 | Group I *vs.* Group II: <0.001<br>Group I *vs.* Group III: <0.001 |

*Group I: RLRL Treatment group, Group II: Ortho-k lens treatment group, Group III: Defocus spectacle lenses treatment group. p-values were calculated using independent sample t-tests, with statistically significant differences indicated by p<0.05,*

**Table II: Comparison of AL changes among subgroups based on gender, age, and myopia severity in the RLRL treatment group (mean ± SD, mm).**

| Subgroups | Male (n = 22) | Female (n = 21) | 5-10 years (n = 31) | 11-15 years (n = 12) | Low myopia (n = 28) | Moderate myopia (n = 13) | High myopia (n = 2) | p-values |
|---|---|---|---|---|---|---|---|---|
| AL Change (mm) | -0.09 ± 0.15 | -0.01 ± 0.15 | -0.06 ± 0.17 | -0.05 ± 0.15 | -0.04 ± 0.16 | -0.08 ± 0.16 | 0.04 ± 0.04 | Gender: 0.099<br>Age: 0.761<br>Myopia Severity: 0.517 |

*p-values were calculated using independent sample t-tests for gender and age subgroups, and one-way ANOVA for the myopia severity subgroup, with a significance level set at p <0.05.*

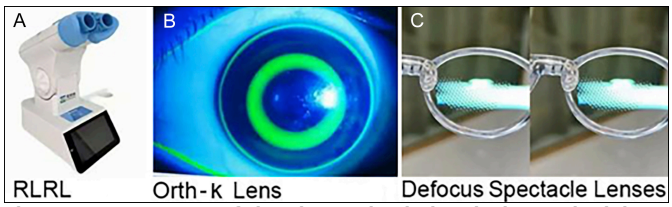


**Figure 1: Appearance of the photo-stimulating device, ortho-k lens, and spectacle lenses.**

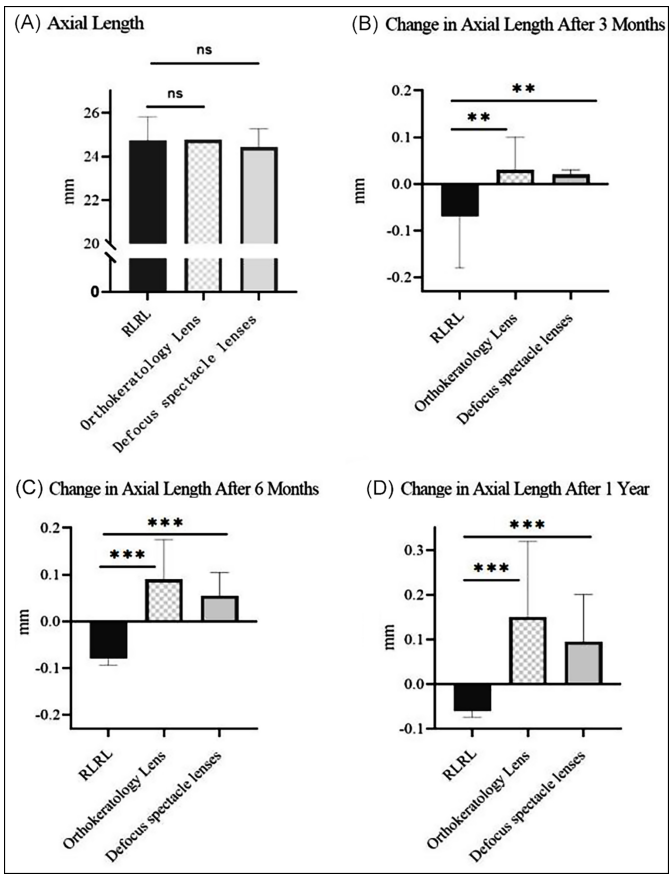


**Figure 2: Changes in mean AL in three groups before and after treatment across the three groups. (A) Mean AL in the three groups before treatment. (B) Mean AL in the three groups after three months of treatment. (C) Mean AL in the three groups after six months of treatment. (D) Mean AL in the three groups after one year of treatment. p<0.05, **p<0.01, and ***p<0.001.**

Subgroup analysis revealed no statistically significant differences in AL changes among patients of different gender, age, and myopia severity within the RLRL therapy group (p >0.05, Table II). This outcome indicates that the efficacy of RLRL is relatively consistent across the subgroups.

## DISCUSSION

In recent years, the incidence of myopia among children and adolescents has continued to rise, with a worsening severity. This trend is attributed to prolonged close reading, frequent use of electronic devices, poor visual habits, combined with genetic factors.[9] Studies have shown that interventions such as wearing ortho-k lenses, defocus spectacle lenses, and using low-concentration atropine can significantly delay the progression of myopia.[10] Additionally, single-vision spectacle lenses combined with RLRL therapy have demonstrated significant effects in delaying myopia progression among adolescents, with no notable adverse effects on ocular surface structure and function, indicating high safety.[11]

The results of this study indicate that RLRL therapy effectively controls AL growth in adolescents with myopia, with no significant differences in efficacy across subgroups based on gender, age, and myopia severity, suggesting its potential for broad clinical applicability in inhibiting axial elongation. Despite showing higher significant efficacy compared to ortho-k lenses and defocus spectacle lenses, the current results are insufficient to fully ascertain its superiority due to limitations such as a smaller sample size and shorter follow-up duration. This conclusion requires further validation through larger-scale, multicentre, and long-term follow-up studies.

Regarding the mechanism of action of RLRL therapy, current research proposes many possible explanations. One proposed mechanism is the promotion of choroidal thickening: red light stimulation of the retina may increase choroidal blood flow and thickness, thereby improving posterior ocular blood supply and indirectly inhibiting rapid axial elongation.[12] Low-intensity red light can promote the secretion of retinal dopamine, a key signalling molecule, which delays axial growth by inhibiting scleral remodelling.[7] By reducing the retinal sensitivity to near focus, the increase in refractive power is slowed.[13] RLRL may enhance scleral oxygenation and restore scleral collagen levels by increasing ocular fundus ocular fundus blood flow and metabolism.[14] Although these hypotheses provide potential explanations for the therapeutic mechanism, further fundamental research and experimental validation are required.

Multiple studies have demonstrated that RLRL has significant efficacy in controlling myopia-related axial elongation, and no severe adverse reactions have been observed.[15] However, safety remains a primary clinical concern. For example, Zhao Peiquan's team reported a case of macular degeneration following RLRL therapy, potentially related to unstable light power or individual patient sensitivity to phototoxicity.[16] Additionally, studies have indicated that cessation of RLRL therapy may trigger short-term rebound phenomena such as decreased choroidal thickness, increased spherical equivalent (SE), and AL growth.[12] These findings suggest that the power and frequency of red light therapy should be strictly controlled in clinical use, with enhanced long-term monitoring to mitigate potential risks.

This study also has certain limitations. First, the sample size is relatively small, particularly in subgroup analyses, where the limited number of highly myopic patients limits the generalisability of the results. Second, the follow-up duration is relatively short, preventing assessment of the long-term efficacy of RLRL and its applicability in patients with high myopia. Furthermore, the absolute range of changes in AL observed in this study is small, and its clinical significance requires further investigation to determine whether these changes translate into practical clinical benefits. Finally, although existing studies indicate that RLRL is a safe and effective intervention, its combined effects with other interventions — such as pharmacological treatment or optical correction — and its specific therapeutic mechanisms

still require further research. Future studies should integrate basic scientific research and validate the efficacy and safety of RLRL through large-sample and long-term rando-mised controlled trials.

## CONCLUSION

RLRL therapy demonstrates good efficacy in adolescents and children of different age groups. Compared to ortho-k lenses and defocus spectacle lenses, RLRL has significant effects and good applicability in controlling axial elongation in myopia. However, this study has certain limitations such as a smaller sample size and shorter follow-up duration. Larger-scale, multi-centre, and long-term studies are needed in the future to validate the efficacy and safety of RLRL and explore its potential as an intervention for myopia prevention and control.

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**ETHICAL APPROVAL:**
Ethical approval was obtained from the Institutional Ethics Committee of Harbin Children's Hospital (No. 2021-IEC-02).

**PATIENTS' CONSENT:**
Informed consent was obtained from all the adolescents, children, and their guardians included in the study.

**COMPETING INTEREST:**
The authors declared no conflict of interest.

**AUTHORS' CONTRIBUTION:**
XZ: Acquisition and drafting of the work.
ZL: Critical revision.
DZ: Data collection and critical revision.
ZX: Approval of the final version to be published.
All authors approved the final version of the manuscript to be published.

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