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Research Article

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Efficiency analysis of repeated low-level red-light as an alternative treatment therapy for children myopia control

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【Abstract】 Objective To discuss the efficacy of repeated low-level red-light (RLRL) as an alternative treatment therapy for children myopia control. **Methods** Using the retrospective cohort study method, a group of 35 myopic children and adolescents myopia patients were selected as the experiment group who used the RLRL for 3 years and followed up as required. Both of their eyes were treated with RLRL while only the right eye was selected for the study. Another 35 children and adolescent myopia patients were selected as the control group who only wore single-focal glasses for 3 years and followed up. The baseline characteristics of the two groups matched. The uncorrected visual acuity (UCVA), spherical equivalent(SE), axial length(AL), fundus of both groups were reexamined every 3 months during treatment. **Results** The AL growth of RLRL group was lower than the control group obviously after 3 years (the F value of inter group was 5.195, $P=0.026$), and the AL of the RLRL group reached the lowest points in the 3 and 6 month, and then rised slowly. The SE of RLRL group showed a decreasing trend in the first 6 months and then rised slowly compared with the control group (the F value of inter group was 632.561, $P<0.01$). And the UCVA of group RLRL showed less significant reduction compared with control group after 3 years, the total effective rate was up to 80%. No ocular complication was observed in RLRL group, including conjunctival congestion, corneal edema, corneal ulcer and cataract. There was one sample who got macular ellipsoid zone fracture in the second year after treatment, and recovered by itself after stopping treatment. **Conclusion** To a certain degree RLRL can delay the progression of children and adolescent myopia without obvious adverse omplications in short period.

【Key words】 repeated low-level red-light, myopia, uncorrected visual acuity (UCVA), spherical equivalent(SE), axial length(AL), retrospective cohort study method

Myopia is the most common refractive error at present, and China has one of the

highest myopia prevalence rates among adolescents in the world ^[1]. According to the survey of the World Health Organization, myopia has become one of the main causes of visual impairment worldwide ^[2]. The annual expenses associated with optical interventions or costly surgical procedures for myopia correction have imposed a significant financial burden on society. With the prevalence of myopia, there has been a significant increase in the incidence of high myopia worldwide, which has become the second leading cause of low vision and blindness in our population due to its associated complications ^[3-4].

Current treatments for myopia include drugs, orthokeratology, progressive/bifocal lenses, surgery, and environmental intervention. Among them, the effect of low-concentration atropine eye drops is more accurate and has entered phase III clinical studies, but there is still a lack of strong clinical data on its potential side effects ^[5]. Orthokeratology can effectively manage 35-60% of myopia progression, while environmental interventions, such as increased outdoor time, have demonstrated a reduction in myopia incidence but are generally considered ineffective for controlling the progression of existing myopia in children ^[6]. The current treatment methods exhibit limitations and corresponding adverse effects. Therefore, the future research direction lies in developing novel prevention and treatment approaches that possess reduced side effects and enhanced precision in curative outcomes.

Choroid is a vascular structure between retina and sclera mainly, which has multiple functions. By changing its thickness, choroid regulates the position of retina and the synthesis of scleral extracellular matrix molecules, thus steady-state control of ocular axis growth, and plays an important role in the etiology of myopia ^[7-9]. Studies have shown that improving the choroidal metabolic rate and circulation can prevent or slow down the progression of myopia ^[10-11].

The mechanism of RLRL does not rely on the thermal activity of traditional light drugs, but uses the photochemical conversion potential of low-intensity red light, which can cause photochemical reactions in the retina. It includes improving the activity of cytochrome C oxidase ^[12-13], changing gene expression to regulate the mitochondrial respiratory chain ^[14], and increasing the biological activity of nitric oxide ^[15]. Current

studies have shown that eye irradiation with RLRL can increase choroidal blood flow [16], thereby increasing choroidal thickness, blood circulation and blood supply, helping to improve the problem of insufficient oxygen supply in the ground of myopia [17-19], inhibiting the rapid growth of the ocular axis in myopia, and thus controlling the development of myopia.

1 Data and methods

1.1 General Information

A retrospective cohort study was used to analyze the clinical data of 35 children and adolescents with myopia who were treated with RLRL in Tongji Hospital Affiliated to Shanghai Tongji University and Nanxiang Hospital of Jiading District from June 2019 to June 2022. They were re-examined every 3 months for 3 years as required (both eyes were included in the study process, and only the right eye was selected for analysis). 35 cases of myopic children who only wore single-focus frame glasses without any intervention treatment in two hospitals during the same period were selected as the control group, including 17 cases of male 17 eyes and 16 cases of female 16 eyes. The SE of the experimental group was -1.0 -- 7.75D, and the mean SE was (-4.514 ± 1.885) D. The diffusivity of all subjects was ≤ -1.50 D, and the mean age was (10.11 ± 1.875) years. The mean corneal curvature was (43.579 ± 1.335) D. The average axial length was (25.644 ± 0.460) mm. In the control group, SE was -0.50 -- 7.50D, the average SE was (-4.236 ± 1.516) D, and the dispersions were all ≤ -1.50 D. There were 17 eyes in 17 males and 16 eyes in 16 females. The mean age was (10.03 ± 1.992) years; The mean corneal curvature was (43.430 ± 0.800) D. The average axial length was (25.634 ± 0.585) mm. There were no significant differences in age, sex ratio, SE, mean corneal curvature, baseline axial length and UCVA between the two groups ($P > 0.1$). The best corrected visual acuity (BCVA)(Log MAR visual acuity) of all patients was ≤ 1.0 , and the IOP was 10-21 mmHg(1 mmHg=0.133 kPa), Ocular and other systemic diseases affecting visual acuity and myopia progression were excluding. As shown in table1.

Table 1 Comparison of baseline data between RLRL group and control group

Group	Eyes (n)	Age (years)	Male/Female (n)	SE (D)	Axial length (mm)	UCVA (logMAR)	Mean keratometry (D)
RLRL group	35	10.2 ± 2.1	18/17	-4.5 ± 1.3	25.6 ± 0.9	0.23 ± 0.15	43.5 ± 1.4
Control group	35	10.4 ± 2.0	17/18	-4.3 ± 1.2	25.7 ± 0.8	0.25 ± 0.16	43.6 ± 1.3
P value	—	0.854	0.811	0.527	0.93	0.527	0.649

1.2 Methods

1.2.1 Related examination of ocular

Gender, age, eye and body health of the patients were analyzed in detail, and children with tic syndrome, photoallergy, organic eye lesions, and psoriasis were excluded. The subject's eye examination included objective refraction (semiannually) following ciliary paralysis with compound tropicamide eye drops. UCVA, BCVA and diopter are checked every three months with a comprehensive optometer (Nidek, Japan). Every three months, slit-lamp microscope (Nidek, Japan) was used to check and rule out anterior lobe disease, intraocular pressure was measured by non-contact tachymeter (Nidek, Japan), fundus photography (Nidek, Japan) and optical coherence tomography (Zeiss, Germany) were used to check and rule out fundus disease. IOL Master(German Zeiss company) measures the length of the axis of the eye, Log MAR eye chart checks vision, etc.

1.2.2 The usage method of RLRL instrument and follow-up index

The RLRL instrument utilized in this study (Eyerising, Suzhou Xuanxia Optoelectronic Technology Co., LTD.) is a desktop semiconductor low-intensity single-wavelength red amblyopia treatment device. The targeted anatomical structure treated by this instrument is the fundus of the subjects, which has been certified by the National Optoelectronic Products Radiation Safety Quality Supervision and Inspection Center. In accordance with the national safety standard for laser products (GB7247.1-2012), it can be safely employed in ocular applications. The product has obtained a Class II medical device registration certificate, the manufacturer has a medical device production license, and the therapeutic instrument has been listed and widely used in

major hospitals. Subjects were irradiated with RLRL under natural pupils twice a day, their heads were placed on the instrument bracket for three minutes each time, their eyes were kept open, and they continued to focus on the light spot. Intervention was performed twice a day for 3 minutes each time, the interval was greater than 4 hours, and no more than five times a week. It is required to be supervised by parents and to wear single-focus glasses at all times except for the intervention. Treatment should be terminated if the duration of afterimage is greater than 6 minutes, severe short-term visual acuity decline, continuous anterior halo, dark spots, any retinal structural damage, color vision abnormalities, etc. There are currently no special requirements for room lighting. UCVA, SE, ocular axis, intraocular pressure, fundus and macular OCT were reviewed every 3 months after treatment.

1.3 Statistical method

The statistical analysis was conducted using SPSS 22.0 software. A Shapiro-Wilk test confirmed that the measurement data followed a normal distribution, and they were expressed as $\bar{x} \pm s$. A sphericity test revealed that the SE and ocular axis values measured at different time points did not meet the assumption of sphericity (approximate $X^2 = 317.539$, 2464.972 ; All $P < 0.01$). Therefore, the Greenhouse-Geisser method was employed to adjust for degrees of freedom, with a significance level set at $P < 0.05$. Repeated measures one-way ANOVA and independent samples t-test were used for analysis. Non-parametric tests and Chi-square tests were utilized for variables that did not follow a normal distribution.

2 Results

2.1 AL changes before and after treatment in two groups

At three years of follow-up, there was a statistically significant difference in the overall change of AL between the RLRL group and the control group (between group $F = 5.195$, between group $P = 0.026$; $F_{\text{time}} = 341.334$, $P_{\text{time}} < 0.001$; Intergroup $F \times \text{time} = 115.707$, intergroup $P \times \text{time} < 0.001$). In the RLRL group, AL showed an obvious shortening trend in the first half year of treatment, and then increased slowly. The mean difference in March and June were 0.057 ± 0.005 and 0.075 ± 0.005 , respectively, with $P < 0.001$. After six months, AL in the red light group kept a low increase, and the

increase rate was much lower than that in the control group. From 18 to 21 months, the axis of the eyes in the RLRL group gradually approached the initial stage of intervention, and the mean difference was 0.011 and -0.006, respectively. $P=0.166$, 0.516 . The interaction between the two groups showed significant differences from the 15th month. At the third year of intervention, the mean difference between the RLRL group and the control group was 0.490mm ($t=31.799$, $P < 0.001$), which was significantly better than the control group. As shown in tables 2, 3 and 4.

Table 2 Changes of ocular axis between RLRL group and control group

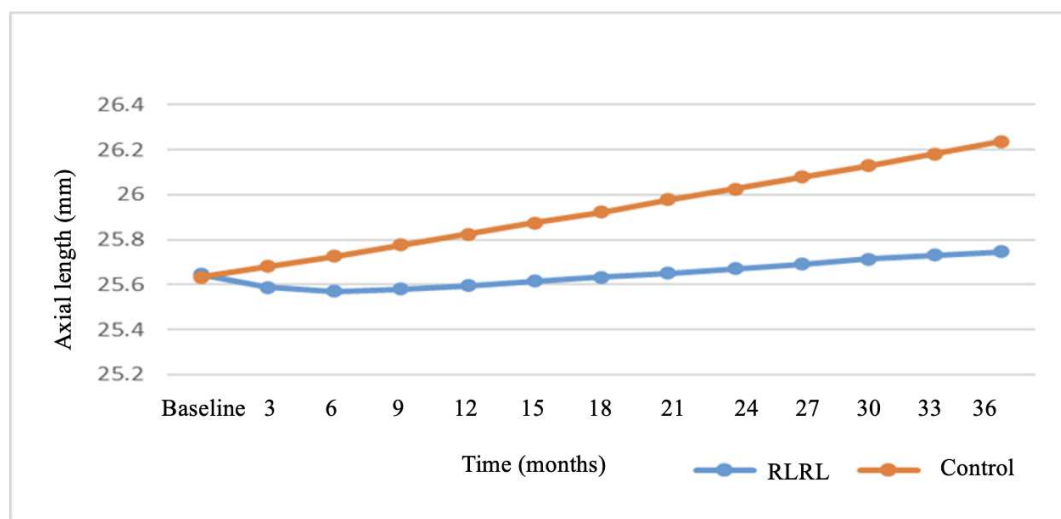


Table 3 Comparison of mean AL between RLRL group and control group

Comparison of axial length between the RLRL and control groups								
Group	n	Baseline	3 months	6 months	9 months	12 months	15 months	18 months
RLRL group	35	25.645±0.4						
		60	25.588±0.446	25.570±0.440	25.580±0.439	25.595±0.435	25.616±0.437	25.634±0.437
Control group	35	25.634±0.5						
		85	25.681±0.583	25.726±0.583	25.776±0.581	25.824±0.580	25.874±0.578	25.923±0.576
T value			14.951	19.363	22.198	25.108	26.604	26.773
P value			< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Group	n	Baseline	21 months	24 months	27 months	30 months	33 months	36 months
RLRL group	35	25.645±0.4						
		60	25.651±0.432	25.671±0.433	25.691±0.433	25.713±0.435	25.732±0.435	25.747±0.431
Control group	35	25.634±0.5						
		85	25.977±0.576	26.025±0.577	26.077±0.578	26.128±0.577	26.180±0.577	26.237±0.573
T value			26.315	28.277	30.365	31.629	33.13	31.799
P value			< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Independent sample t test

Table 4 Comparison of RLRL group mean difference in pairs

Time		Mean difference (I - J)	Std. error	P value	95% confidence interval	
					L Lower	L Upper
	2	.057*	.005	.000	.047	.067
	3	.075*	.006	.000	.062	.087
	4	.065*	.007	.000	.052	.079
	5	.050*	.007	.000	.036	.064
	6	.029*	.007	.000	.014	.044
1	7	.011	.008	.166	-.005	.028
	8	-.006	.009	.516	-.024	.012
	9	-.026*	.009	.006	-.044	-.008
	10	-.047*	.009	.000	-.065	-.028
	11	-.067*	.010	.000	-.087	-.048
	12	-.087*	.010	.000	-.107	-.068
	13	-.102*	.011	.000	-.124	-.080

2.2 Changes of SE before and after treatment in the two groups

The SE data of three years were analyzed, and the inter-group $F=3.557$, $P=0.064$. The differences in different follow-up time and interaction between follow-up time and different intervention methods were statistically significant ($F_{\text{time}}=202.815$, $P_{\text{time}} < 0.001$; * time between groups $F=103.196$; $P_{\text{group} \times \text{time}} < 0.001$). In the RLRL group, SE value fluctuated in the first 18 months of treatment, first decreased and then slowly increased, and the mean difference between SE value and baseline value was -0.207, -0.136, -0.079, $P=0.00$, 0.00 , 0.027 , respectively. In the second year, SE value returned to the initial stage of treatment, and the mean difference was 0.029, $P=0.410$. The SE of the single-focus frame glasses group showed an increasing trend with the extension of time, and the interaction effect between the two groups showed a significant difference from the 18th month, $P < 0.001$ for both groups, as shown in tables 5-6.

Table 5 SE trends in RLRL group and control group

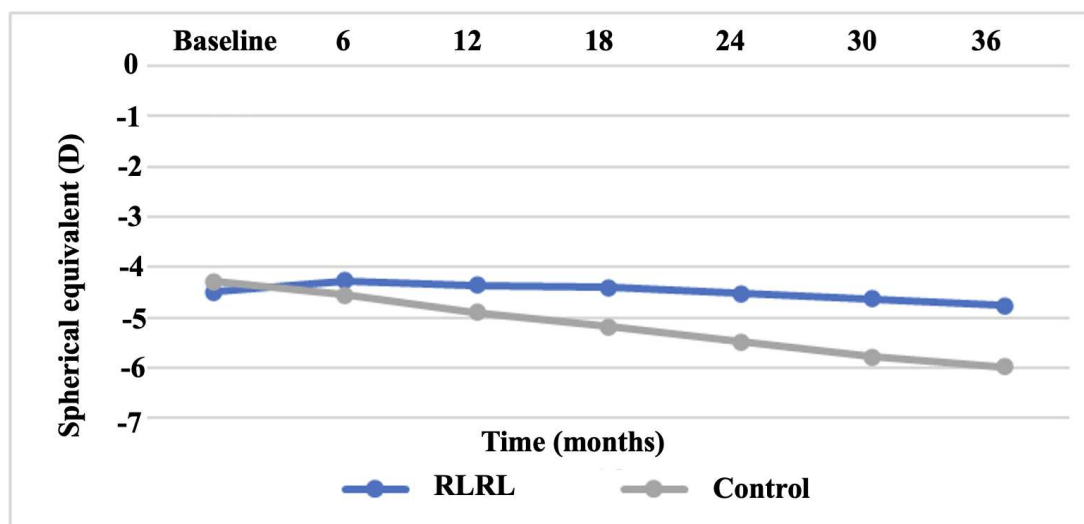


Table 6 Comparison of SE mean values between RLRL group and control group

Group	Eyes (n)	Baseline	6 months	12 months	18 months	24 months	30 months	36 months
RLRL	35	-4.486±1.653	-4.264±1.575	-4.350±1.608	-4.407±1.616	-4.514±1.640	-4.621±1.646	-4.757±1.690
Control	35	-4.278±1.423	-4.557±1.427	-4.893±1.418	-5.186±1.433	-5.479±1.438	-5.786±1.405	-5.979±1.419
<i>t</i> value			12.219	14.49	20.326	24.058	23.406	25.373
<i>P</i> value			< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

2.3 Comparison of UCVA data between RLRL group and control group

The UCVA data of RLRL group was (0.229± 0.1650; 0.239± 0.163; 0.215± 0.167), control group (0.250± 0.107; 0.206± 0.098; 0.136±0.069), comparing the UCVA data of 1, 2 and 3 years of treatment, the difference means between the two groups does not satisfy the normal distribution. The non-parametric independent sample test was conducted, and the difference was statistically significant ($P < 0.01$ for all). Chi-square test was used to analyze the effectiveness of the data in the third year, and the treatment effectiveness was much higher than that of the control group, as shown in tables 7-8.

Table 7 Comparison of UCVA between RLRL group and control group

Group		1 year	2 years	3 years
RLRL	Percentile	0 (0.00-0.03)	0 (0.00-0.00)	0 (-0.03-0.00)
Control		-0.05 (-0.05-0.03)	-0.1 (-0.03 -0.00)	-0.1 (-0.15 -0.07)
	<i>Z</i>	-6.351	-7.011	-6.979
	<i>P</i> value	< 0.001	< 0.001	< 0.001

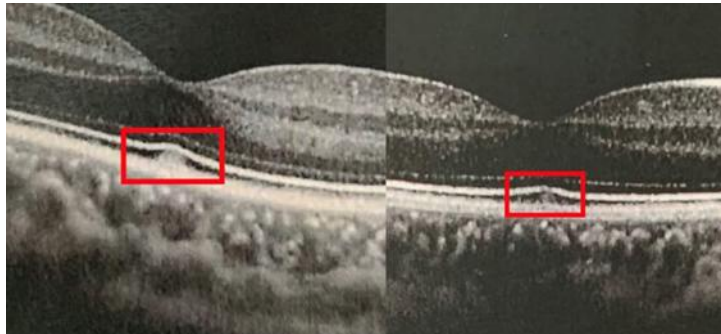
Nonparametric independent sample test

Table 8 Comparison of UCVA changes between RLRL group and control group

Changes in UCVA at 3 years				
UCVA change	RLRL	Control	99% CI	P
Improved by 2 lines	5.7 (2/35)	0 (0/35)	0.106, 0.408	0.001
Improved by 1 line	20 (7/35)	0 (0/35)		
Unchanged	54.3 (19/35)	2.9 (1/35)	0.621, 0.921	< 0.001
Decreased by 1 line	20 (7/35)	28.6 (10/35)		
Decreased by 2–3 lines	0 (0 / 35)	68.6(24/35)		
BCVA<0.8	0 (0 / 35)	0 (0 / 35)		

Chi-square test

During the 3-year period of this study, it was found that 1 patient developed ellipsoidal band rupture about 2 years after treatment, recovered spontaneously after stopping treatment for 1 month, and no similar situation occurred again after continuing treatment. There were no significant complaints of discomfort, loss of function (BCVA), or anatomical changes (OCT scan).



Left, the broken of ellipsoid zone in the macular region;

Right, the macular OCT after stopping treatment for 2 weeks

3 Discussion

Myopia is closely related to the change of choroid thickness. With the increase of patients' diopter number and the growth of ocular axis, choroid thickness presents a gradual thinning trend ^[20-22]. Li et al^[23] believe that the thickness of choroid decreases by 58um when the ocular axis increases by 1mm. At present, a large amount of empirical evidence suggests that oxidative stress and inflammation may explain the altered regulatory pathways in myopia, and that oxidative damage associated with

hypoxic myopia can alter the neuroregulation of nitric oxide and dopamine during eye growth.

Recent evidence has confirmed that ocular axis shortening may not be entirely derived from choroidal thickening. Scleral hypoxia is a contributing factor to scleral remodeling and myopia development ^[24], and RLRL treatment may increase fundus blood flow and metabolism, thereby improving scleral hypoxia and restoring scleral collagen levels. At present, this treatment has been widely applied to neurotrauma, stroke, etc ^[25-26] and also applied to age-related macular degeneration, amblyopia, diabetic retinopathy and other retinal diseases that seriously affect vision.

Studies have shown that low-intensity red light therapy for myopia is based on the following three principles: (1) reducing inflammation and edema, improving tissue microcirculation without piercing the skin or entering the body cavity, (2) promoting nerve damage repair, and (3) treating neurological diseases ^[27]. Animal studies ^[28] and clinical studies ^[29-31] have shown that low-intensity red light has the greatest impact on the nitric oxide system and reduces the severity of oxidative stress. It can reduce the levels of inflammatory cytokines such as interinflammatory cytokine (IL-1) and tumor necrosis factor- α by inhibiting them, so as to protect patients from the effects of oxidative stress. Reduce the inflammation associated with myopia ^[32-33]. Clinical studies conducted in recent years have proved that RLRL can inhibit the rapid growth of ocular axis ^[34-35].

Of the 35 patients enrolled in this study, 2 (5.7%) were still slightly below baseline after 3 years of treatment; The increase of 14 patients (39.9%) was less than 0.1mm; The increasment was between 0.1-0.2mm of 17 patients (48.6%) 5.7% (2 patients) was higher than 0.2mm; The therapeutic effect was better than that of the control group. The latest randomized controlled study of He Xiangui ^[36] in 2023 confirmed that RLRL can effectively reduce the incidence of myopia and significantly reduce the development speed of the ocular axis, and our study is consistent with that.

This retrospective study is slightly different with the results published by He Mingguang and Yi Jinglin ^[37-38] in 2021, whose study found that patients reached the lowest ocular axis value at 1 and 3 months of treatment, respectively, while our study

found that patients shortened to the lowest ocular axis value at 6 months of treatment. The possible causes: The patients' basal ocular axis were a bit longer and were older in this retrospective study, which may be more sensitive to 650nm red light irradiation.

At 6 months of treatment, 2 patients abandoned (excluded) due to concerns about unknown side effects, and subsequent follow-up showed a slight tendency to rebound and the ocular axis returned to the initiation stage before treatment.

4 Results

This study confirms that RLRL therapy is an effective new alternative therapy for myopia control, which has the advantages of simple use and significant effect. The relative shortcomings of this study are: insufficient sample size, no randomized controlled double-blind, no choroidal thickness measurement data, lack of self-control before and after treatment, etc. Further double-blind controlled studies on rebound effect, optimal treatment strategy (wavelength, power, duration and frequency of treatment) and potential underlying mechanisms are needed to Increase persuasiveness and guidance.

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (World Medical Association, revised 2013) and in compliance with the Ethical Review Measures for Life Science and Medical Research Involving Humans issued by the National Health Commission of the People's Republic of China (2023). The study protocol was reviewed and approved by the Medical Ethics Committee of Shanghai Jiading District Nanxiang Hospital (approval No. 2023-1116-02; date of approval: 22 November 2023). Due to the retrospective nature of this study and the use of only de identified clinical data, the ethics committee approved the exemption of the legal guardians of the subjects from signing informed consent forms.

Author Contributions

Jingjing Li: Data curation, Formal analysis, Methodology, Resources, Validation, Writing-original draft, Writing-review&editing. **Yiyi Chen** Conceptualization, Writing-review&editing, Project administration, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Reference

[1] He M, Zeng J, Liu Y, Xu J, Pokharel GP, Ellwein LB. Refractive error and visual impairment in urban children in Southern China. *Invest Ophthalmol Vis Sci*. 2004;45(3):793-799.

[2] Liang Y B, Lin Z. Attach importance to the epidemiological study of myopia in children and adolescents in China [J]. *Chinese Journal of Optometry and Vision Science*, 2014, 16(3) :129-131.

[3] Wong YL, Saw SM. Epidemiology of pathologic myopia in Asia and worldwide [J]. *Asia Pac J Ophthalmol (Phila)*, 2016,5(6) : 394-402.

[4] Morgan IG, French AN, Ashby RS, et al. The epidemics of myopia: Aetiology and prevention [J]. *Prog Retin Eye Res*, 2018;62: 134-149.

[5] Robboy MW, Hilmantel G, Tarver ME, et al. Assessment of clinical trials for devices intended to control myopia progression in children [J]. *Eye Contact Lens*, 2018;44(4) :212-219.

[6] He M, Xiang F, Zeng Y, et al. Effect of Time Spent Outdoors at School on the Development of Myopia Among Children in China: A Randomized Clinical Trial. *JAMA: the journal of the American Medical Association*. 2015;314(11):1142-1148.

[7] Ivandic BT, Ivandic T. Low-level laser therapy improves visual acuity in adolescent and adult patients with amblyopia. *Photomedicine and laser surgery*. 2012;30(3):167-171.

[8] Nickla DL, Wallman J. The multifunctional choroid. *Prog Retin Eye Res* 2010;29(2):144-68.

[9] Summers JA. The choroid as a sclera growth regulator. *Exp Eye Res* 2013;114:120-7.

[10] Shurygina IP, Khadzhieva MR. Effect of infrared low-intensity light therapy on orbital blood circulation in children with progressive short sightedness. *Vopr*

Kurortol Fizioter Lech Fiz Kult 2009(5):37-49.

[11] Gawne TJ, Ward AH, Norton TT. Long-wavelength (red) light produces hyperopia in juvenile and adolescent tree shrews. *Vision Res* 2017;140:55-65.

[12] Karu TI, Pyatibrat LV, Kolyakov SF, Afanasyeva NI. Absorption measurements of a cell monolayer relevant to phototherapy: reduction of cytochrome c oxidase under near IR radiation. *Journal of photochemistry and photobiology B, Biology*. 2005;81(2):98-106.

[13] Karu TI, Pyatibrat LV, Afanasyeva NI. A novel mitochondrial signaling pathway activated by visible-to-near infrared radiation. *Photochemistry and photobiology*. 2004;80(2):366-372.

[14] Zhang Y, Song S, Fong CC, Tsang CH, Yang Z, Yang M. cDNA microarray analysis of gene expression profiles in human fibroblast cells irradiated with red light. *The Journal of investigative dermatology*. 2003;120(5):849-857.

[15] Lohr N L , Keszler A , Pratt P , et al. Enhancement of Nitric Oxide Release from Nitrosyl Hemoglobin and Nitrosyl Myoglobin by Red/Near Infrared Radiation: Potential Role in Cardioprotection[J]. *Journal of Molecular & Cellular Cardiology*, 2009, 47(2):256-263.

[16] Zhou L , Xing C , Qiang W , et al. Low-intensity, Long-wavelength Red Light Slows the Progression of Myopia in Children: an Eastern China-based Cohort[J]. 2021. *Ophthalmic Physiol Opt*,2022,42(2):335-344.

[17] Smith E L , Li-Fang H , Baskar A , et al. Effects of Long-Wavelength Lighting on Refractive Development in Infant Rhesus Monkeys[J]. *Investigative Ophthalmology & Visual Science*, 2015, 56(11):6490-6500.

[18] Gawne, TJ, Ward, et al. Long-wavelength (red) light produces hyperopia in juvenile and adolescent tree shrews[J]. *Vision Res*, 2017.07.011.

[19] Li-Fang H , Baskar A , Zhihui S , et al. Narrow-band, long-wavelength lighting promotes hyperopia and retards vision-induced myopia in infant rhesus monkeys.[J]. *Experimental Eye Research*, 2018, 176:147-160,DOI:10.1016/j.exer.2018.07.004

[20] Hamzah F,Shinojima A,Mori R, et al. Choroidal thickness measurement by

enhanced depth imaging and swept-source optical coherence tomography in central serous chorio retionpahy [J]. BMC Ophthalmol,2014,14(1):145.

[21] Flores-Moreno I, Ruiz-Medrano J, Duker JS, et al. The relationshiop between retina and choroidal thickness and visual acuity in highly myopic eyes [J]. Br J Ophthalmol 2013;97 (8):1010-1013.1

[22] Flures-Morena I, Arias-Barquet L,Rubia-Caso MJ et al. Structure versus function :correlation between outer retional and choroidal thickness measured by swept-source OCT with multifocal electroretinography and visual acuity[J]. Int J Retina Vitreous, 2017,3(1):29.

[23] LiXQ, Jeppesen P,Larsen M, et al. Subfoveal choroidal thickness in 1323 children aged 11 to 12 years and association with puberty :the Copenhagen Child Cohort 2000 Eye Study [J].Invest Ophthalmol Vis Sci,2014,55(1):550-555.

[24] Garcia MB; Jha AK; Healy KE; Wildsoet CF .A Bioengineering approach to myopia control tested in a guinea pig model [J] . Invest Ophthalmol Vis Sci, 2017,58(3):1875-1886.

[25] Peplow PV, Chung TY, Baxter GD. light photobiomodulation of wound healing: a review of experimental studies in mouse and rat animal models. Photomed light Surg 2010;28(3):291-325.

[26] Posten W, Wrone DA, Dover JS, et al. Low-level light therapy for wound healing: mechanism and efficacy. Dermatol Surg 2005;31(3):334-340.

[27] E. A. Stroev, V. A. Larionov, L. P. Grigor'eva et al, The treatment of diabetic angiopathies by endovascular low-intensity laser irradiation, Problemy Endokrinologii, vol. 36, no. 6, pp. 23–25, 1990.

[28] R. Ojaghi, H. Sohanaki, T. Ghasemi, F. Keshavarz, M. Youse fifard, and H. Sadeghipour, Role of low-intensity laser therapy on naloxone-precipitated morphine withdrawal Lasers in Medical Science, vol. 29, no. 5, pp. 1655–1659, 2014.

[29] N. M. Burduli and A. S. Krifaridi, Effect of low-intensity laser radiation on the function of vascular endothelium in patients with chronic viral hepatitis, Klinicheskai Meditsina, vol. 87, no. 1, pp. 49–52, 2009.

[30] N. M. Burduli and A. S. Krifaridi, The influence of lowintensity laser radiation on the vascular endothelium function and the cytokine system in patients with chronic viral hepatitis, *Voprosy Kurortologii, Fizioterapii, i Lechebnoĭ Fizicheskoi Kultury*, vol. 2, pp. 30–34, 2011.

[31] L. M. Rubis, Chiropractic management of Bell palsy with low level laser and manipulation: a case report, *Journal of Chiropractic Medicine*, vol. 12, no. 4, pp. 288–291, 2013.

[32] M. Yamaura, M. Yao, I. Yaroslavsky, R. Cohen, M. Smotrich, and I. E. Kochevar, Low level light effects on inflammatory cytokine production by rheumatoid arthritis synoviocytes, *Lasers in Surgery and Medicine*, vol.41,no.4,pp.282–290,2009.

[33] C.Y.Chiou, B.Xuan, Q.Liu, T.Yamasaki, andT.Okawara, inhibition of interleukin-1-induced uveitis and corneal fibroblast proliferation by interleukin-1 blocker, *Journal of Ocular Pharmacology and Therapeutics*, vol. 16, no. 5, pp. 407–418, 2000.

[34] Jiang Y, Zhu Z, Tan X, et al. Effect of Repeated Low-Level Red-Light Therapy in Myopia Control in Children: A Multicenter Randomized Controlled Trial.[J]. *Ophthalmology*, 2021.10.1016/j.ophtha.2021.11.023.

[35] Xiong F, Mao T, Liao H, et al. Orthokeratology and Low-Intensity Laser Therapy for Slowing the Progression of Myopia in Children [J]. *BioMed Research International*, 2021, 2021(11):1-10.

[36] Xiangui He, PhD; Jingjing Wang, PhD; Zhuoting Zhu, PhD, et al. Effect of Repeated Low-level Red Light on Myopia Prevention Among Children in China With Premyopia A Randomized Clinical Trial. [J]. *Ophthalmology*, JAMA Network Open (2023). DOI: 10.1001/jamanetworkopen.2023.9612.

[37] Yu Jiang, MD, Zhuoting Zhu, MD, PhD, Xingping Tan, MD, Ian G. Morgan, PhD, Mingguang He, MD, PhD, et al. Effect of Repeated Low-Level Red-Light Therapy in Myopia Control in Children: A Multicenter Randomized Controlled Trial. [J]. *Ophthalmology* (2022), j.ophtha.2021.11.023.

[38] Fen Xiong, Tian Mao, Hongfei Liao, Xiaoqin Hu, Jinglin Y, et al.

Orthokeratology and Low-Intensity Laser Therapy for Slowing the Progression of Myopia in Children. [J]. BioMed Research International Volume 2021, Article ID 8915867, 10 pages.