

Modulated Light as Therapy for Ocular Disease Harmful or Helpful

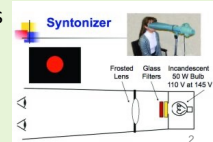
Dr. Cathy Stern, OD, FOVDR, FNORA, FCSO
CSO 201
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Scientists have known since at least the late 1800s that certain wavelengths of light in prescribed doses can be used to heal the tissue

In the vision care community, light is being used as Intense Pulsed Light Therapy (IPL) for dry eye And Red- light treatment for myopia control

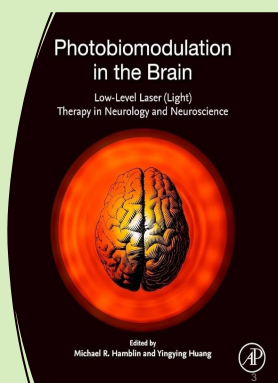
Optometric or Syntonic phototherapy for treating visual conditions such as strabismus, amblyopia, and photosensitivity with brain trauma



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Photobiomodulation (PBM) is the current term being used to describe light therapy that is non-thermal and utilizes non-ionizing radiation in the visible and near-infrared spectrum.

It was formerly called low-level laser (light) therapy or LLLT.



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Visible light being used and studied is primarily long wavelength red light or short-wavelength blue light.

Light's importance for treatment of:

- Dry eye
- Age-related macular degeneration
- Post-cataract surgery
- Migraine headaches
- Cognitive enhancement
- Brain injury
- Alzheimer's disease
- Parkinson's disease
- Other neurodegenerative diseases

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HISTORY OF PHOTOTHERAPY

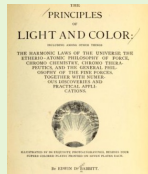
The modern use of light in medicine generally is credited as beginning with the work of Niels Ryberg Finsen, a Danish physician

He was awarded the Nobel Prize in Medicine in 1903 for his work using ultraviolet light to treat Lupus.

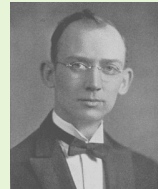
Publications over the next few years:

Light and Its Rays as Medicine
by Dr Seth Pancoast

The Principles of Light and Color
by Edwin Babbitt, MD



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In the 1920s, optometrist and physician Harry Riley Spittler determined that:

Imbalance in the autonomic nervous (ANS) was responsible for many visual conditions

Specific frequencies of light, delivered, through the eyes could be used to rebalance the ANS and thereby, correct many visual dysfunctions at their source

The new science was named "Syntonics" meaning to be responsive and in harmony with the environment

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PHOTOBIOMODULATION

In the 1960s it was found that: Treatment with a weak ruby laser could improve wound healing

The treatment was maligned for many years until the mechanism was made known through the work of Tiina Karu in Russia

Tiina Karu identified *cytochrome c oxidase* in the mitochondrial respiratory chain as a primary chromophore

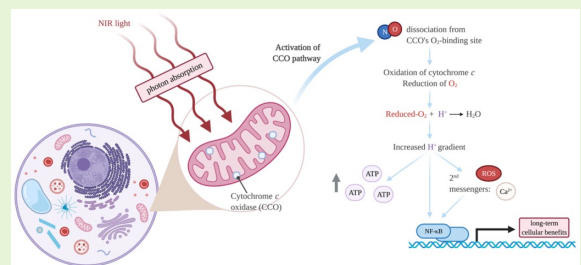
She showed that a brief exposure to light could have an effect on the organism that lasted for hours, days, or weeks

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Mechanism of Action



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Under stress, as from disease conditions, the mitochondria produce too much nitric oxide which attaches to cytochrome c oxidase molecules

Cytochrome c oxidase blocks adenosine triphosphate (ATP) synthase from producing ATP

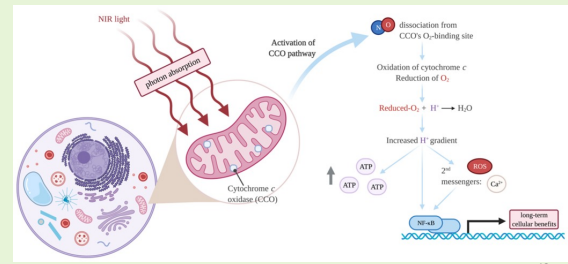
Without ATP, the cell cannot carry out its normal growth and repair

Red and near-infrared light cause the cytochrome c oxidase molecules to release the nitric oxide, allowing the resumption of ATP production

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Research has shown measurable improved cellular function within minutes to hours of the application of photobiomodulation



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For PBM to be successful, a light source is placed close to the eyes or in contact with the skin

This allows the light to penetrate the tissue and interact with chromophores in cells >> photophysical and photochemical changes

These changes:

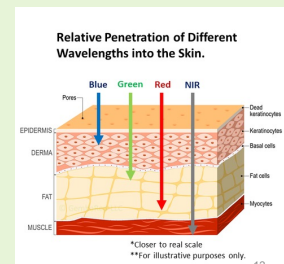
- accelerate wound healing
- increase circulation
- reduce acute inflammation
- mitigate acute and chronic pain
- help restore normal cellular function

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Red and near-infrared (650–940 nm) light penetrates most deeply into human tissue

Interest is increasing in the use of violet, green, and blue light (430– 550 nm) frequencies to also effect positive changes in human physiology



*Closer to real scale
**For illustrative purposes only

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THE NON-VISUAL OCULAR PATHWAY

A third light-sensitive receptor in the retina was identified in 2002 known as **intrinsically photosensitive retinal ganglion cells** (ipRGCs)

These retinal ganglion cells are:
Associated with the photopigment melanopsin
Are maximally sensitive to blue light

They number only about 2% of the retinal ganglion cells
Fibers from these cells bypass the visual cortex and travel to the suprachiasmatic nucleus (SCN) of the hypothalamus to coordinate the body's circadian rhythm

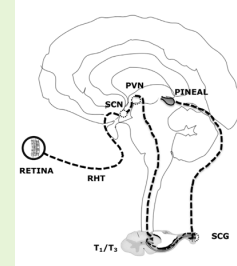
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The ipRGCs and their connection to the hypothalamus provides a model for the treatment efficacy of phototherapy

Sets up the introduction of light frequencies through the eyes as a way to institute changes in the endocrine system.



Neural control of melatonin pineal synthesis

RHT: retinohypothalamic tract.

SCN: suprachiasmatic nucleus.

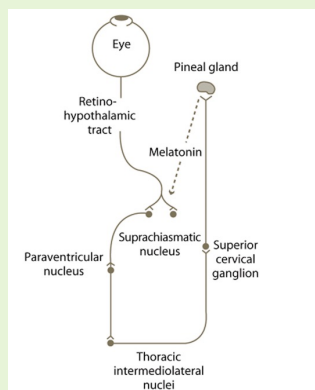
PVN: paraventricular nucleus.

SCG: superior cervical ganglion.

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CLINICAL PRACTICE

Optometric (Syntonic) phototherapy may be considered a form of photobiomodulation.

How our light sources and filters differ from what is now mostly LED application is not known as the formula
 $Dose (J/cm^2) = Power Density (mW/cm^2) \times Time (seconds) \times 0.001$
is related to lasers and not other light sources

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NEUROPROTECTION and AGE-RELATED MACULAR DEGENERATION

The retina is vulnerable to mitochondrial dysfunction, especially with increasing age

Retinal photoreceptors and ganglion cells contain a high density of mitochondria

This makes them an excellent target for the reduced cell death and mitigation of oxidative stress offered by photobiomodulation

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Janis Eells, PhD – an early researcher studying the effect of near-infrared light therapy for retinal healing

Early studies centered on the loss of vision in laboratory mice following methyl alcohol toxicity

The mice were subjected to near-infrared light before being given a toxic dose of methanol. The mice exposed to the light did not demonstrate the loss of vision and retinal damage seen in the untreated mice

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PHOTORECEPTOR NEUROPROTECTION

Nora Heinig of the Technische Universität (TU) Dresden, School of Medicine

Primarily looking at the neuroprotective effects of 670 nm red light and 810 nm near-infrared light on blue light-damaged murine primary photoreceptors

Improvement in mitochondrial respiration

Reduced retinal inflammation

Reduced mitochondrial-induced apoptosis

They also referenced earlier work showing that near-infrared light may:

Reduce photoreceptor death by 70%

Reduce drusen volume

Lower intraocular pressure for as long as several months.

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In 2016, Graham Merry, MBBS, showed that photobiomodulation also *reduced drusen volume*

While *improving visual acuity and contrast sensitivity* in dry age-related macular degeneration (ARMD)

More recently, Samuel Markowitz, MD, and colleagues led a controlled study on the use of red-light therapy for dry ARMD

Significant improvement in

contrast sensitivity

drusen volume

central drusen thickness

No adverse effects reported in the treatment group

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Valeda Light Delivery by LumiThera

Uses photobiomodulation to treat eye disease



Valeda is the first and only FDA –authorized treatment for dry age-related macular degeneration (AMD) to improve vision.

Valeda demonstrates improvements in clinical and anatomical outcomes, which support a disease-modifying benefit for patients with dry age-related macular degeneration (AMD).

Valeda has a proven and well-established safety profile.

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Valeda Light Delivery

Approved for the treatment of:
ocular damage and disease

Including

Inhibition of inflammatory mediators

Edema

Drusen deposition

Improvement of wound healing following
ocular trauma or surgery

*Increase in visual acuity and contrast sensitivity in
patients with degenerative diseases such as dry AMD*

Treatments are delivered in a series of nine sessions per eye over 3 weeks and each treatment session lasts less than 5 minutes per eye.

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MEIBOMIAN GLAND DYSFUNCTION AND DRY EYE

Eye doctors have two choices of light therapy for treating inflammatory eye disease

IPL uses light but the light is converted to heat with the chosen wavelengths selectively destroying blood vessels by targeting chromophores within the blood vessels

PBM is non- thermal and involves placing a mask over the face through which the light therapy is released



Marco Equinox LLLT device

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Marco Equinox Low-Level Light Therapy device

The mask covers the patient's forehead, entire eye area, and cheekbones

The *blue light mask* is used to kill bacteria such as in Staphylococcal blepharitis

After delivery of the light energy, porphyrin molecules on the cell membrane absorb the blue light > generating free radicals that disrupt the cell wall of some gram-positive bacteria > leading to cell death

Cells have a weak defense against the oxygen-induced damage Treatment is highly effective for dry eye conditions such as: blepharitis, meibomian gland dysfunction, chalazion or styte.

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Therabody at Best Buy – red and blue LEDs + vibration



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Shark CryoGlow Under- Eye Cooling + LED Anti-Aging & Skin Clearing Face Mask



MEDSPA-INSPIRED TREATMENTS
CLINICALLY TESTED TO
REDUCE FINE LINES & ACNE.

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MEIBOMIAN GLAND DYSFUNCTION AND DRY EYE

With few side effects, PBM offers a safer and less invasive alternative to pharmaceuticals and surgical interventions.

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MYOPIA AND RED-LIGHT THERAPY

Slowing myopia progression has become important

Even low levels of myopia increase the risk for glaucoma, macular degeneration, and retinal detachment

Mechanisms for red light suppressing myopia progression suggest that narrow band long wavelength light promotes hyperopia by retarding axial elongation, decreasing elongation of the vitreous chamber, and increasing choroidal thickness

Bright light suppresses form-deprivation myopia development by activating dopamine D1 receptor signaling in the retina

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Yu Jiang and colleagues used a home-based desktop light therapy device to administer red light of 650 nm wavelength at an illuminance level of approximately 1600 lux and a power of 0.29 mW for a 4-mm pupil.

Treatment was done under parental supervision for 3 minutes per session, twice daily with a minimum interval of 4 hours between sessions.

The treatment was administered 5 days per week.

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Subjects in the experimental group had far less myopic progression and axial length change than the control group

They reported a mean spherical equivalent refraction change over 6 months of -0.2D, and average axial length change of 0.13 mm in the treatment group versus a refraction change of -0.79D and axial length growth of 0.38 mm in the control group

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Results of a 6-month follow-up showed additional positive results 16% of subjects had reduced myopia
25% showed reductions in axial length

The therapy was well-tolerated with no adverse effects being reported by test subjects

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Jing Dong and colleagues administered repeated low-level red-light therapy (RLRL) to a group of Chinese children

Used a desktop red- light device with the experimental group receiving 100% light power and the sham group receiving 10% of the device's power.

Treatment was done at home, and they followed a similar schedule of 3-minute sessions twice daily with an interval of at least 4 hours between sessions.

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Cycloplegic refraction and axial length (AL) were measured at baseline and 6 months

Children in the treatment group had less myopia progression and axial elongation compared to the sham control group

At the final visit, distance visual loss was statistically significantly greater for children with myopia in the sham device group than for those in the red-light therapy group

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Mean spherical equivalent refraction change over 6 months was 0.06D in the treatment group and - 0.11D in the sham device control group

Average AL growth was less 0.02 mm in the treatment group compared with 0.13 mm in the sham control group.

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Recognized treatments for myopia including:

- low-dose atropine
- orthokeratology
- Unique spectacle lenses

These are 30% to 60% effective in delaying the onset of or progression of myopia

BUT they are not strong enough to restrain AL growth

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PBM therapy modestly decreases AL for myopia control Red-light irradiation was found to induce hyperopia

Red-light therapy may be a powerful tool in myopia prevention and control

Red light may be a safe treatment given its protective effect on both the cornea and retina.

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The effects of light wavelength, illuminance, and contrast on the progression of myopia

Retinal dopamine secretion is affected by light intensity and different light wavelengths

Related to the known effect of focus difference between shorter and longer wavelengths called *longitudinal chromatic aberration theory*

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Investigation of the efficacy and safety of 650 nm low-level red light for myopia control in children

The median 6-month change in AL was -0.06 for the treatment group and 0.14 mm for the control group (P. < 0.001)

The median 6-month spherical equivalent refraction was 0.125D for the treatment group and -0.25 for the control group (P. <.001).

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Conclusion

650 nm low-level red light was an effective and safe treatment

It significantly slowed myopia progression in the children treated It reversed myopia progression in over half the children treated

There were no adverse effects observed

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GLAUCOMA AND NEUROPROTECTION

Researchers would like to find treatments that are less invasive or with fewer side effects than current surgical and drug treatments

Photobiomodulation is one therapy being studied as a way to delay glaucoma by slowing down retinal ganglion cell death.

PBM's role in targeting mitochondria may offer protection and delay the onset of glaucoma

PBM may stimulate neural progenitor cells

Leading to a role in slowing down retinal ganglion cell death Or in part regenerating tissue damaged by glaucoma

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AMBLYOPIA

Adolescent/adult patients with amblyopia from 20/400 to 20/30 Treated for 30 seconds, 3-4x per week for 2 weeks with 780 nm light
Control patients showed no improvement in visual acuity Treated patients showed significant improvement in visual acuity

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AMETROPIA

90% showed an average acuity increase of three lines
89% of those with strabismus improved an average of 2.7 lines The beneficial effect was retained for at least 6 months

The exact mechanism of the treatment effect is unknown

Speculate that increased cellular metabolism and inter-neuronal communication via promotion of synaptogenesis may be responsible for the improvement in visual acuity

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MIGRAINE HEADACHE AND PAIN REDUCTION

Exposing migraine sufferers to a narrow band of green light was found to significantly reduce photophobia and headache severity

Rami Burstein, PhD, of the Harvard Brain Science Initiative 2017

Migraine photophobia and experience with color may originate in cone-driven retinal pathways > then fine-tuned in relay thalamic neurons outside the main visual pathway and preserved by the cortex

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Allay Lamp and Hooga sell a green light lamp that produces the narrow band of green light found to reduce migraine headache sensitivity

Recommend it to be the only light source in the room to be most effective



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BRAIN INJURY AND PHOTOBIOMODULATION

Double-blind study on the use of blue light treatment

Test subjects received 30- minute pulses of blue light each morning

Control subjects received pulses of amber light

Test subjects showed significant improvements in: Sleep timing

Daytime fatigue Executive functioning

MRIs showed increased volume of the posterior thalamus (pulvinar)

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Recent review and meta-analysis of TBI with in vivo mammalian models

Analysis favored light of 665 nm and 810 nm with no differences found between pulsed or continuous wave light delivery

Supports antiapoptotic, anti-inflammatory, and pro-proliferative effects, along with modulation of cellular metabolism

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SUMMARY

Modulated light to treat visual and systemic conditions now is considered a safe and effective tool.

Research has changed its mission from if light can heal to how light stimulates healing.

Initial research concentrated on the effect of modulated light in mitochondria and the cytochrome c oxidase molecule with its ability to allow the release of nitric oxide and assist the cells in increasing ATP production.

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Research is expanding to include many other positive effects for light as medicine.

ipRGC's and their connection to hypothalamus support the use of light in the maintenance of health

Autonomic system balance validates the use of light through the eyes to treat organic and functional vision disorders.

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REFERENCES

- Pancoast S. Light and its Rays as medicine, Kingdom. Philadelphia: Stoddart; 1877.
- Babbitt Edwin D. Principles of light and color. Orange, NJ: Babbitt & Co. East; 1878.
- Mester E, Szende B, Tota JG. Effect of laser on hair growth of mice. Kiserl Orvostud 1967;19:628–31.
- Karu TI, Afanas'eva NI. Cytochrome c oxidase as the primary photoacceptor upon laser exposure of cultured cells to visible and near IR-range light (Russian). Dokl Akad Nauk 1995;342(5):693–5.
- Eells JT, Wong-Riley MTT, VerHoeve J, et al. Mitochondrial signal transduction in accelerated wound and retinal healing by near-infrared light therapy. Mitochondrion 2004;4(5–6): 559–67.

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- Albarracin R, Eells J, Valter K. Photobiomodulation protects the retina from light-induced photoreceptor degeneration. Invest Ophthalmol Vis Sci 2011;52:3582–92.
- Merry GF, Munk MR, Dotson RS, et al. Photobiomodulation reduces drusen volume and improves visual acuity and contrast sensitivity in dry age-related macular degeneration. Acta Ophthalmol 2016;95(4):e270–7.
- Markowitz SN, Devenyi RG, Munk MR, et al. A Double-Masked, Randomized Sham-Controlled, Single-Center Study with Photobiomodulation for the Treatment of Dry Age-Related Macular Degeneration. Retina 2020;40(8):1471–82.
- Study of photobiomodulation to treat dry age-related macular degeneration (LIGHTSITE III). Case Medical Research 2019; <https://doi.org/10.31525/ct1-nct04065490>.

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50

- Park Y, Kim H, Kim S, et al. Effect of low-level light therapy in patients with Dry Eye: A prospective, randomized, observer-masked trial. Sci Rep 2022;12(1); <https://doi.org/10.1038/s41598-022-07427-6>.
- Markoulli M, Chandramohan N, Papas EB. Photobiomodulation (low-level light therapy) and dry eye disease. Clin Exp Optom 2021;104(5):561–6.
- Hung LF, Arumugam B, She Z, et al. Narrow-band, long-wavelength lighting promotes hyperopia and retards vision-induced myopia in infant rhesus monkeys. Exp Eye Res 2018;176:147–60.
- Chen S, Zhi Z, Ruan Q, et al. Bright Light Suppresses Form-Deprivation Myopia Development With Activation of Dopamine D1 Receptor Signaling in the ON Pathway in Retina. Invest Ophthalmol Vis Sci 2017;58:2306–16.

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51

51

- Jiang Y, Zhu Z, Tan X, et al. Effect of Repeated Low-Level Red-Light Therapy for Myopia Control in Children. Ophthalmology 2022;129(5):509–19.
- Dong J, Zhu Z, Xu H, et al. Myopia Control Effect of Repeated Low-Level Red-Light Therapy in Chinese Children: A Randomized, Double-Blind, Controlled Clinical Trial. Ophthalmology 2022.
- Huang Z, He T, Zhang J, et al. Red light irradiation as an intervention for myopia. Indian J Ophthalmol 2022;70(9):3198.
- Zhou L, Tong L, Li Y, et al. Photobiomodulation therapy retarded axial length growth in children with myopia: evidence from a 12-month randomized controlled trial evidence. Sci Rep 2023;13(1):3321.
- Zhang P, Zhu H. Light Signaling and myopia development: A review. Ophthalmol Ther 2022;11:939–57.

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Tian L, Cao K, Ma DL, et al. Investigation of the Efficacy and Safety of 650 nm Low-Level Red Light for Myopia Control in Children: A Randomized Controlled Trial. *Ophthalmology and Therapy* 2022;11(6):2259–70.

Bergandi L, Silvagno F, Grisolia G, et al. The Potential of Visible and Far-Red to Near- Infrared Light in Glaucoma Neuroprotection. *Appl Sci* 2021;11(13):5872.

Zhongshan Ophthalmic Center, Sun Yat-sen University. Effect of Repeated Low-Level Red- Light Therapy on Visual Field Damage in Primary Open-angle Glaucoma: A Randomized Cross-over Clinical Trial. *clinicaltrials.gov*. 2022. <https://clinicaltrials.gov/ct2/show/NCT05309811>.

Ivancic BT, Ivancic T. Low-Level Laser Therapy Improves Visual Acuity in Adolescent and Adult Patients with Amblyopia. *Photomedicine and Laser Surgery* 2012;30(3):167–71.

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Burstein R. Reply: Pupil area and photopigment spectral sensitivity are relevant to study of migraine photophobia. *Brain* 2017;140(1):e3.

Noseda R, Bernstein CA, Nir RR, et al. Migraine photophobia originating in cone-driven retinal pathways. *Brain* 2016;139(Pt 7):1971–86.

Green Light Exposure May Help Reduce Pain and Headaches. *Time*. October 27, 2022 <https://time.com/6225133/green-light-headaches-pain-relief/>.

Fibromyalgia: How Green Eyeglasses Can Ease Anxiety. *Healthline*. Oct. 2022. <https://www.healthline.com/health-news/fibromyalgia-how-green-eyeglasses-can-help-ease-pain-related-anxiety>

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Killgore WDS, Vanuk JR, Shane BR, et al. A randomized, double-blind, placebo-controlled trial of blue wavelength light exposure on sleep and recovery of brain structure, function, and cognition following mild traumatic brain injury. *Neurobiol Dis* 2020;134:104679.

Stevens AR, Hadis M, Milward M, et al. Photobiomodulation in Acute Traumatic Brain Injury: A Systematic Review and Meta-Analysis. *J Neurotrauma* 2023;40(3–4):210–27.

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