

Literature review: Light and colour in myopia control

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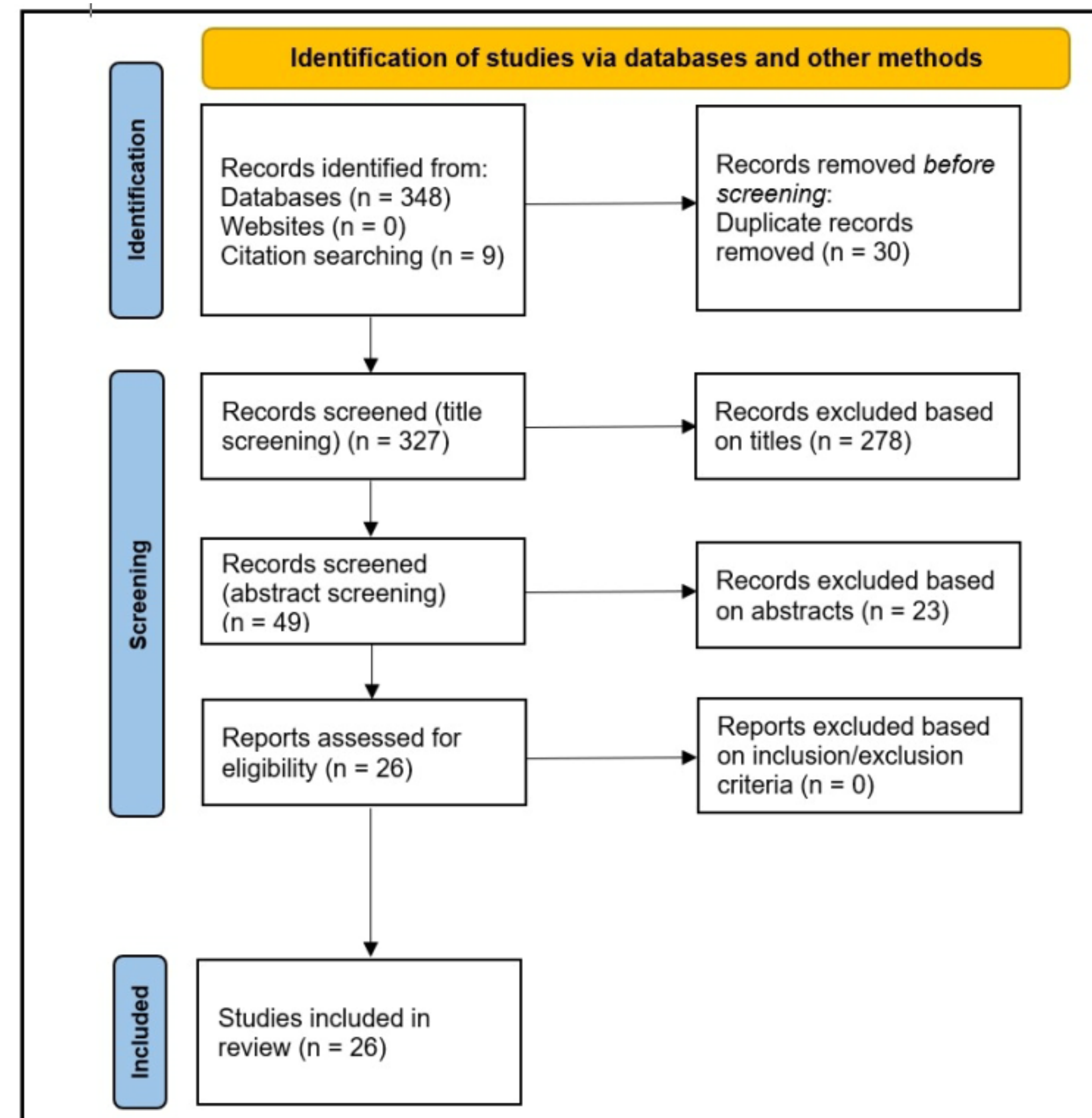
Background

- Increasing time outdoors reduces the risk of developing myopia. Likely mechanisms (Lingham et al., 2020) relate to outdoors having higher illuminance, a broader chromatic spectrum, a different effect on circadian rhythms, and different spatial frequency characteristics. Flicker may also be relevant.
- Myopia control interventions have been proposed based on manipulating exposure to light of different chromaticities, involving repeated low-level red-light stimulation (RLRL), blue light (BL), and violet light (VL).
- Purpose:** To review evidence on the effectivity (RCTs), effectiveness (real-world observational studies), and safety of coloured light interventions for myopia control. The review considers a diversity of interventions (RLRL, BL, VL) and adopts a narrative format, considering diverse approaches in a holistic way, to highlight synergies or contradictions.

Methods

- PubMed and Embase database searches completed on 9th November 2023 and updated on 12th July 2024 for:
(myopia+control OR myopia+management) AND (red+light OR blue+light OR violet)
- The review prioritises randomised controlled trials (RCTs), but also includes relevant observational (non-RCT) studies, instructive case studies, and laboratory research, when relevant to illustrate safety and potential mechanisms. Previous reviews were also considered.

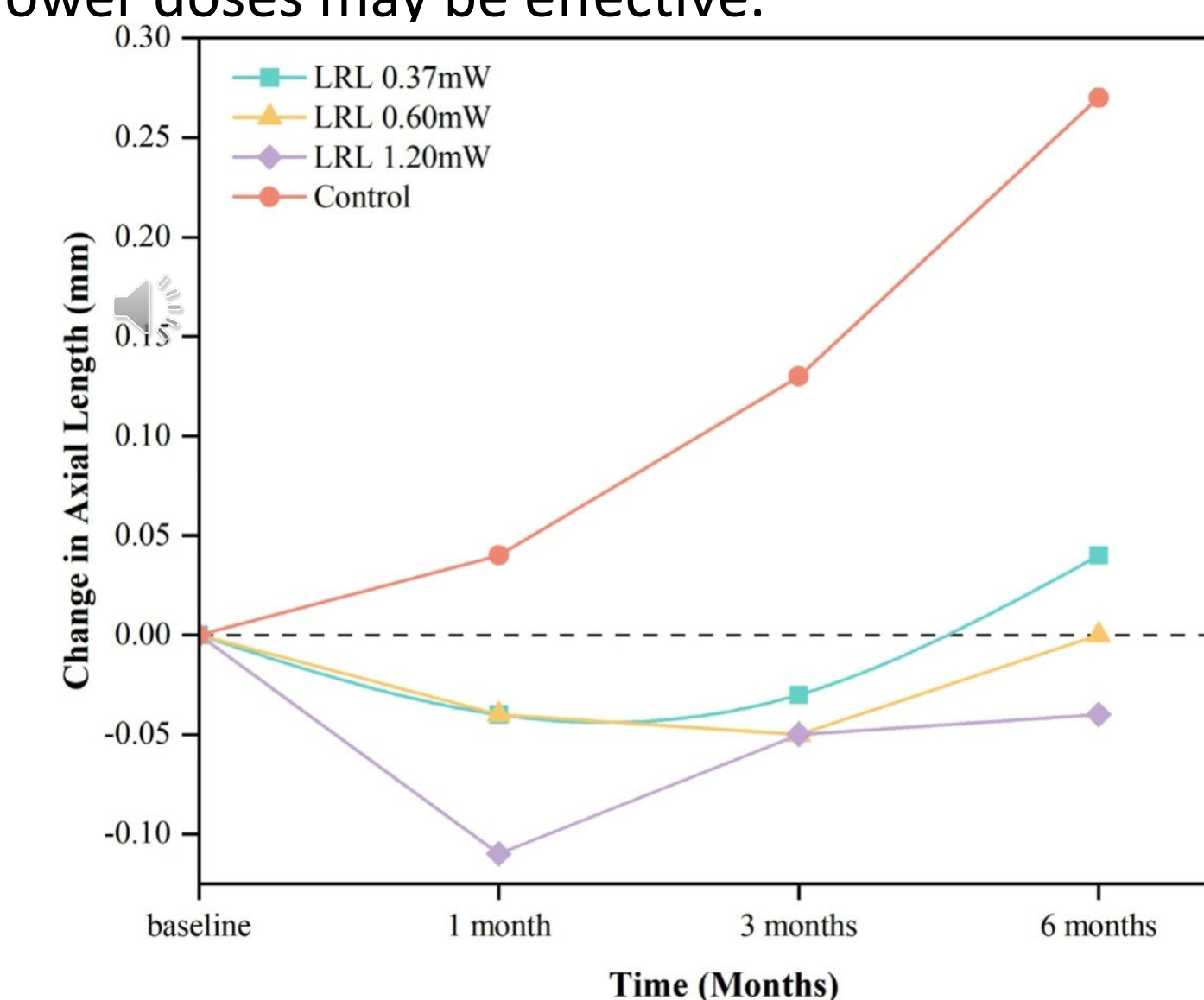
PRISMA flow diagram presenting the process of study identifications, screening and selection of relevant published papers



Results

- The searches yielded 26 relevant clinical investigations (RCTs and observational studies). Studies with follow-up of at least one year were tabulated, comprising 3 studies on VL and 10 on RLRL.
- Literature on VL and myopia progression is mostly retrospective and suggestive of a possible benefit from VL or, a possible disadvantage of VL-blocking lenses.
 - VL-emitting spectacles described by Torii and colleagues (2022) await validation in long-term RCTs.
- Research on blue light is limited and interventions are yet to be reported.
- Evidence for RLRL is more substantial, with several RCTs continuing for at least one year, producing significant treatment effects that are comparable to other myopia control interventions.
- One concern is that for all studies except Dong et al. (2023) and Zhou et al. (2023), the control group received no control intervention, failing to control for placebo effects.
- Zhou et al. (2023) report little difference between three doses (intensities) of RLRL. This could be explained by the efficacy of RLRL being attributable to a placebo effect, or by a ceiling effect, indicating that lower doses may be effective.

Figure: Changes in axial length in treatment groups over time for different powers of RLRL (LRL) or no therapy (Control) from Zhou et al. (2023). Reproduced from Efficacy of Different Powers of Low-Level Red Light in Children for Myopia Control by Zhou et al. (2023) under Creative Commons License.



- There is a lack of long-term follow-up data. Inspection of graphs in many studies reveals that nearly all the treatment effect occurs in the first six months of treatment.
 - It is possible that trials over several years will show a much weaker treatment effect per annum than indicated by the short-term trials completed to date.
- Insufficient exploration of rebound effect and lack of research on non-Chinese ethnicities and on adults.
- Several mechanisms have been proposed for RLRL (e.g. inflammation or phototoxic damage by Salzano et al. 2023), but this question is still unanswered. These authors and others questioned the safety of lasers used in RLRL.
- Ostrin and Schill (2024) evaluated the safety of two RLRL instruments and showed that the maximum permissible exposure (MPE) of these, and probably other instruments, is exceeded in typical RLRL therapy.
 - ANSI recommendations are that after reaching the MPE, light of similar intensity should not be viewed for at least 48 hours, which is contradicted by RLRL regimens.

Discussion

- It may seem intuitively unlikely that claims of effectivity for interventions that stimulate opposite ends of the spectrum (VL and RLRL) are valid.
 - If the narrow spectrum of artificial lighting is a factor in increasing myopia, then “stretching the spectrum” by stimulation of either end may be helpful.
- More research is needed on VL, and especially BL. Careful assessment of light levels and safety will be important, especially in view of issues raised about RLRL.
- Safety concerns raised about RLRL are profound and raise serious issues. In some studies, a significant adverse event was children reporting after treatment after-images that persist for 6 minutes or more after RLRL treatment.
- Children are particularly vulnerable to over-exposure to light, owing to larger pupil sizes and clearer media than adults.
 - Risks are likely to be greater for Western population who typically have less ocular pigmentation than Eastern populations.
- Even considering natural daylight, there is a lack of clear consensus, for young children, on the minimum recommended exposure to reduce the risk of myopia and the maximum recommended exposure to reduce the risk of light-induced ocular pathology in later life.
- In RLRL, the effects of narrow wavelength bands of intense stimulation on ocular health are poorly understood and therefore this intervention cannot be endorsed at present.

Conclusions

- Mechanisms for a benefit from daylight in myopia prevention are not fully understood but may include breadth of spectrum.
- Evidence for VL and especially BL in myopia control is limited.
- Several RCTs have confirmed short-term myopia control benefits from RLRL, but long-term effectivity is unknown.
- Important safety concerns have been raised about RLRL that mean that RLRL cannot be endorsed at present.

References

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