

package, in which LLLT (PBM) is used in addition to compression garment, may be a reasonable clinical option, and deserves further investigation through well-designed high quality RCTs.

Despite the clear statement by the WALT advocating standards of reporting of parameters when conducting studies involving laser therapy [53], there still seems to be inadequate information provided by authors of such studies. This is not uncommon and other systematic reviews have also highlighted these failures [59, 60]. Heterogeneity of the parameters used in the included studies and variable methods of application, along with differences in treatment regimes, all contribute to the difficulties of pooling information to make definitive statements regarding this use of LLLT (PBM) for BCRL. That being said, the normal genesis of treatment guidelines will result in many studies that show variation or contradictory results. Until patterns are recognized on a consistent basis across studies, the window of effective parameters cannot be identified. From all 11 studies included in this review, infrared wavelengths (808-905 nm) have been most commonly employed to date, and reported energy densities in the range of 1.5 J/cm²–2.4 J/cm² have delivered positive outcomes. In comparison, effective energy densities for tendinopathy range from 1.8 J/cm² to 19.2 J/cm² depending upon the location of the tendon [59]. The reported frequency and duration of treatment is however too varied to make any strong statements, but a minimum of 4 weeks seems to be required.

The current review has adopted robust methodology to minimize the risk of bias. Firstly, it implemented most of the items listed in the AMSTAR checklist [56], therefore has a high methodological quality score (internal validity) of 9/11 (two points were missing because of the lack of a priori review protocol registry and an assessment of publication bias due to the qualitative analysis methodology). Secondly, in terms of the external validity, reporting of this review strictly adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [61] to ensure research replication. Thirdly, for data synthesis, subgroup analyses stratified by control comparisons and outcome measures were performed to address the influence of clinical (as well as statistical) heterogeneity. Fourthly, conclusions of the review were synthesized from seven RCTs with high methodology quality.

The primary limitation of this systematic review derived from the small number of included studies and lack of conclusions regarding the longer-term effects of LLLT (PBM) for BCRL management. Findings of this review suggest future well-designed fully powered RCTs are needed to inform the superiority of different LLLT (PBM) interventions, and determine an optimal treatment protocol for this therapy.

Conclusions

Based upon the current systematic review, LLLT (PBM) in the management of BCRL is more effective for limb edema reduction than sham and no treatment at a short-term follow-up, and not more effective than other conventional treatments. Data suggest that LLLT (PBM) may be an effective treatment approach for women with BCRL. Due to the limited numbers of published trials available, there is a clear need for well-designed high-quality trials in this area. The optimal treatment parameters for clinical application have yet to be elucidated.

Additional files

Additional file 1: Search strategy (PDF). This file presents the search strategy used in this systematic review in four databases (PubMed, AMED, Web of Science and CNKI). (PDF 193 kb)

Additional file 2: Excluded articles after duplicates removal ($n = 66$) (PDF). This file presents references of the 66 articles that were excluded after duplicates removed. (DOCX 23 kb)

Abbreviations

AMSTAR: Assessment of Multiple Systematic Reviews; ATP: Adenosine triphosphate; BCRL: Breast cancer related lymphedema; LLLT: Low level laser therapy; NO: Nitric oxide; PBM: Photobiomodulation; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT: Randomized controlled trials; REDOX: Reduction–oxidation reaction; ROS: Reactive oxygen species; WALT: World Association for Laser Therapy



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