



High- and Low-Level Laser Therapy for the Treatment of Orthopedic Pain: A Systematic Review

Gabrielly Santos Pereira¹, Joelington Dias Batista², Jobson Dias Batista², Ludimila Dias Silva², Josie Resende Torres da Silva¹, João Eduardo de Araújo³, Marcelo Lourenço da Silva^{1*}

¹Laboratory of Neuroscience, Neuromodulation and Study of Pain (LANNED), Federal University of Alfenas (UNIFAL-MG), Alfenas, MG, Brazil

²Orthopain Pain Institute, Anápolis, GO, Brazil

³Department of Health Sciences, Ribeirão Preto Medical School, University of São Paulo, São Paulo, Brazil

*Correspondence to

Marcelo Lourenço da Silva,
Email: marcelo.lourenco@unifal-mg.edu.br

Received: May 20, 2025

Accepted: August 19, 2025

ePublished: October 1, 2025

Abstract

Introduction: Chronic orthopedic pain is a leading cause of disability worldwide, compromising physical function, independence, and quality of life. While pharmacological treatments are widely used, their prolonged use is often limited by side effects and suboptimal efficacy. Among non-pharmacological approaches, photobiomodulation—particularly low-level laser therapy (LLLT) and high-intensity laser therapy (HILT)—has emerged as a promising strategy due to its analgesic, anti-inflammatory, and regenerative properties. However, evidence regarding its clinical efficacy remains heterogeneous and fragmented.

Methods: This systematic review was conducted in accordance with PRISMA guidelines and based on the PICO framework. Comprehensive searches were performed in PubMed, Embase, Scopus, LILACS, and Cochrane CENTRAL. Eligible studies were randomized controlled trials (RCTs) published in English, Spanish, or Portuguese over the past five years, involving adults (≥18 years) with orthopedic pain treated with LLLT or HILT. Outcomes of interest included pain intensity, physical function, and quality of life. Exclusion criteria included non-randomized trials, pediatric populations, and studies that did not isolate the effects of laser therapy.

Results: From 59,873 records initially retrieved, eight RCTs met the inclusion criteria. The studies addressed diverse musculoskeletal conditions such as knee osteoarthritis, chronic low back pain, patellofemoral pain syndrome, plantar fasciitis, subacromial impingement, and lateral epicondylalgia. Both LLLT and HILT demonstrated efficacy in reducing pain and enhancing physical function. In several studies, HILT was associated with faster symptomatic improvement. Nevertheless, considerable heterogeneity in laser parameters, treatment protocols, and outcome measures hindered direct comparison and meta-analysis.

Conclusion: The current evidence supports the use of both LLLT and HILT as safe and effective adjuncts in the management of orthopedic pain. Future trials should adopt standardized protocols and long-term follow-up to better define clinical guidelines and optimize treatment outcomes.

Keywords: Photobiomodulation therapy; Laser therapy; Low-level; Laser therapy; High-intensity; Musculoskeletal pain; Pain management; Physical therapy modalities.



Introduction

Orthopedic pain is one of the most common complaints in healthcare settings, affecting individuals across all age groups and significantly impairing quality of life, independence, and physical function. Approximately 1.71 billion people worldwide suffer from musculoskeletal pain, which encompasses a wide range of disorders, including tendinopathies, osteoarthritis, chronic low back pain, and traumatic musculoskeletal injuries.¹ These conditions are often chronic in nature and are a major cause of disability worldwide. They also impose substantial socioeconomic burdens due to increased healthcare utilization, long-term rehabilitation needs, reduced work productivity, and premature retirement.^{2,3}

Traditional management approaches for orthopedic pain typically include pharmacological treatments such as non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids, opioids, and antidepressants. Although effective in the short term, these options carry the risk of adverse effects—particularly with long-term use—including gastrointestinal complications, renal impairment, dependency, and tolerance.⁴ In response, clinical guidelines and research have increasingly recommended the use of non-pharmacological strategies, particularly in chronic cases, to reduce drug dependence and address pain more holistically.⁵

Among these non-pharmacological strategies, laser therapy, also known as photobiomodulation, has gained

attention due to its potential to modulate pain and enhance tissue repair. This therapy uses specific wavelengths of light to stimulate biological responses at the cellular and tissue levels. Laser therapy is typically classified into Low-Level Laser Therapy (LLLT) and High-Intensity Laser Therapy (HILT), based on the power output and depth of penetration. Both modalities have been used to treat orthopedic conditions, but their mechanisms of action and clinical applications differ significantly.^{6,7}

LLLT operates mainly through photochemical and photophysical mechanisms, modulating mitochondrial activity to increase ATP production, reduce oxidative stress, and influence the expression of inflammatory cytokines. These effects contribute to decreased pain perception, enhanced local circulation, and accelerated tissue regeneration.^{8,9} LLLT is generally applied for superficial musculoskeletal conditions, such as tendinitis, plantar fasciitis, and early-stage osteoarthritis.

Conversely, HILT combines photochemical effects with controlled thermal action, which promotes vasodilation, deep tissue penetration, and neuromuscular relaxation. Its higher output enables therapeutic effects at greater tissue depths, making it suitable for treating more complex or deep-seated conditions such as chronic low back pain, muscle spasms, and post-surgical musculoskeletal pain.¹⁰

Although both LLLT and HILT are well-documented for their analgesic and anti-inflammatory effects, there remains no clear consensus regarding the superiority of one modality over the other for specific orthopedic conditions. This uncertainty is primarily due to methodological variability among studies, including differences in laser wavelength, energy dosage, treatment duration, and outcome measures. For instance, while some trials suggest that HILT may offer faster symptom relief and deeper tissue penetration,¹¹ others report comparable effects between LLLT and HILT when appropriately dosed.^{12,13} Furthermore, systematic reviews by Bjordal et al¹⁴ and Stausholm et al¹⁵ have emphasized that even within LLLT studies, inconsistent dosimetry and outcome reporting hinder the establishment of standardized clinical guidelines.

Studies have often focused on one technique in isolation, and direct head-to-head comparisons are scarce. Moreover, available trials frequently vary in laser parameters (e.g., wavelength, dose, application time, and frequency), sample size, and outcome measures, contributing to heterogeneity in the evidence base and limiting reproducibility.^{15,16}

This lack of standardization presents a significant challenge for clinicians and policymakers who must make informed decisions about integrating photobiomodulation into orthopedic rehabilitation protocols. Furthermore, few systematic reviews have comprehensively compared LLLT and HILT in terms of both efficacy and safety in the management of orthopedic pain, leaving an important

gap in the literature regarding the optimal use of laser therapy in this context.

Therefore, the present systematic review aims to synthesize the available evidence on the effectiveness of high- and low-level laser therapies in reducing pain and improving function in adults with orthopedic pain. The primary objective is to compare clinical outcomes such as pain intensity and functional recovery between the two laser modalities. A secondary objective is to assess their impact on quality of life and report any adverse effects associated with their use. This review intends to provide clinicians with clearer, evidence-based guidance for selecting the most appropriate laser therapy modality in orthopedic care.

Methods

This systematic review was conducted to evaluate the effects of HILT and LLLT on the management of orthopedic pain in adults. The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and reproducibility. Additionally, the PICO strategy (Table 1) was used to structure the research question and guide the study selection:

A comprehensive literature search was conducted across multiple databases (Table 2), including PubMed/MEDLINE, Embase, Scopus, LILACS, and the Cochrane Central Register of Controlled Trials (CENTRAL). The search included studies published from May 13, 2015, with no restriction on the end date. Only studies published in English, Spanish, or Portuguese were included in this systematic review due to the language proficiency of the review team. This decision ensured accurate interpretation of study methodologies, results, and risk of bias assessments, thereby enhancing the internal validity of the synthesis. Additional studies were identified through manual reference screening, expert consultation, and searches in trial registries and conference proceedings.

Inclusion criteria consisted of randomized controlled trials (RCTs) involving adult patients (≥ 18 years) with orthopedic pain, evaluating HILT or LLLT compared to placebo, no treatment, or conservative treatments, and reporting outcomes related to pain, function, or quality of life.

Exclusion criteria included non-randomized trials, studies on non-orthopedic or neuropathic conditions, studies with combined interventions that did not isolate the laser effect, pediatric populations, review articles, editorials, studies without full text or quantitative results, and duplicates (removed using the Rayyan platform).

The study selection process involved two stages: (1) title and abstract screening, and (2) full-text review according to eligibility criteria. Two independent reviewers conducted the screening and data extraction, with disagreements

Table 1. PICO Strategy

PICO Components	Definitions
P	Adults (≥ 18 years) with orthopedic pain (e.g., osteoarthritis, tendinopathy, post-surgical pain)
I	HILT or LLLT
C	Placebo, sham, no treatment, or other conservative interventions (e.g., physiotherapy, TENS)
O	Pain reduction, improvement in function, quality of life, and adverse events

Abbreviations: LLLT, low-level laser therapy; HILT, high-intensity laser therapy.

Table 2. Search Strategy by Database

Database	Search Terms
PubMed	((("Laser Therapy"[MeSH] OR "Low-Level Light Therapy"[MeSH] OR "Lasers"[MeSH] OR "laser therapy"[tiab] OR "low-level laser therapy"[tiab] OR "high-intensity laser therapy"[tiab])) AND (("Musculoskeletal Pain"[MeSH] OR "Orthopedic Procedures"[MeSH] OR "orthopedic pain"[tiab] OR "musculoskeletal pain"[tiab])) AND (("Pain Management"[MeSH] OR "Recovery of Function"[MeSH] OR "pain management"[tiab] OR "functional recovery"[tiab]))
Embase	('laser therapy'/exp OR 'low level laser therapy'/exp OR 'high intensity laser therapy'/exp OR 'laser therapy':ab,ti OR 'low-level laser therapy':ab,ti OR 'high-intensity laser therapy':ab,ti) AND ('orthopedic pain'/exp OR 'musculoskeletal pain'/exp OR 'orthopedic pain':ab,ti OR 'musculoskeletal pain':ab,ti) AND ('pain management'/exp OR 'functional recovery'/exp OR 'pain management':ab,ti OR 'functional recovery':ab,ti)
Scopus	(TITLE-ABS-KEY("laser therapy" OR "low-level laser therapy" OR "high-intensity laser therapy")) AND (TITLE-ABS-KEY("orthopedic pain" OR "musculoskeletal pain")) AND (TITLE-ABS-KEY("pain management" OR "functional recovery"))
LILACS	((tw:("Laser Therapy" OR "Low-Level Laser Therapy" OR "High-Intensity Laser Therapy" OR "Terapia a Laser" OR "Terapia por Luz de Baixa Intensidade" OR "Terapia por Laser de Alta Intensidade"))) AND ((tw:("Musculoskeletal Pain" OR "Orthopedic Pain" OR "Dor Musculosquelética" OR "Dor Ortopédica"))) AND ((tw:("Pain Management" OR "Functional Recovery" OR "Controle da Dor" OR "Recuperação Funcional")))
Cochrane CENTRAL	("Laser Therapy" OR "Low-Level Light Therapy" OR "High-Intensity Laser Therapy") AND ("Orthopedic Pain" OR "Musculoskeletal Pain") AND ("Pain Management" OR "Functional Recovery")

resolved through discussion or consultation with a third reviewer. Data were organized into structured tables highlighting sample size, population characteristics, intervention details, outcomes, and conclusions.

The methodological quality of the included studies was assessed using the Cochrane Risk of Bias 2.0 (RoB 2) tool. Two independent investigators conducted the risk of bias assessment, and any disagreements were resolved through discussion with a third reviewer. The certainty of evidence for each primary outcome was evaluated using the GRADE (Grading of Recommendations, Assessment, Development and Evaluation) approach. The primary objective of this review was to assess the effectiveness of HILT and LLLT in reducing orthopedic pain and improving functional capacity. The secondary objective was to explore the safety of laser therapy and its impact on the quality of life.

This systematic review employed a qualitative synthesis approach. Although all included studies were randomized controlled trials, a meta-analysis was not performed due to substantial heterogeneity in intervention protocols, including differences in laser parameters (e.g., wavelength, energy density, treatment duration), types of lasers (LLLT vs. HILT), outcome measures, and clinical populations. These variations limit the comparability and statistical pooling of data. Therefore, a narrative synthesis was chosen to summarize and interpret the findings in a structured manner.

Results

Selection of Studies

Initially, 59,873 records were identified through comprehensive database searches, including PubMed (n=31,954), Embase (n=27,773), Scopus (n=22), LILACS (n=12), and the Cochrane Central Register of Controlled Trials (n=112). After removing duplicates, a total of 35,924 records remained and were screened based on their titles and abstracts.

Of these, 35,844 records were excluded for not meeting the inclusion criteria—primarily because they were non-randomized studies, focused on non-orthopedic conditions, involved pediatric populations, did not evaluate laser therapy as an isolated intervention, or were published in languages other than English, Spanish, or Portuguese, or outside the last 10 years. The remaining 80 articles underwent full-text review for eligibility.

Upon full-text assessment, 72 studies were excluded: 32 for using non-controlled designs, 19 for addressing conditions outside the orthopedic scope (e.g., neuropathic or oncologic pain), 11 for combining multiple interventions without isolating laser therapy effects, and 10 for lacking relevant outcome data or full access to the manuscript.

At the end of the selection process, 8 RCTs met all eligibility criteria and were included in the qualitative synthesis.

The PRISMA flow diagram summarizing this selection process is presented in [Figure 1](#).

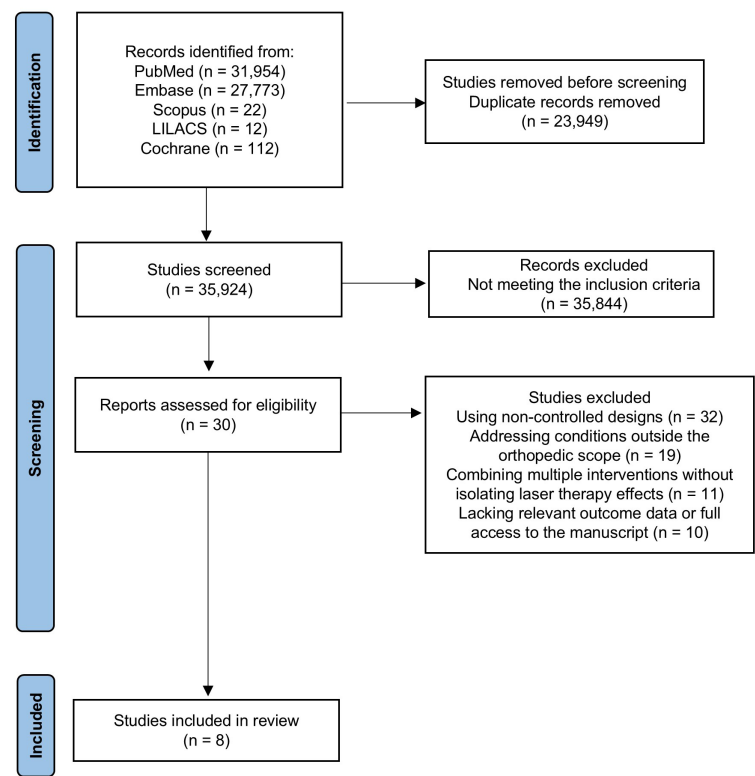


Figure 1. PRISMA Flow Diagram Showing the Selection Process of Studies Included in the Systematic Review

	Risk of bias domains							Overall
	D1	D2	D3	D4	D5	D6	D7	
Study								
Stausholm et al. (2022)	+	+	+	+	+	+	-	+
Ozlu & Atilgan (2024)	-	-	+	+	+	-	-	-
Alayat et al. (2014)	+	+	+	+	+	+	-	+
Samaan et al. (2022)	-	-	+	+	+	+	-	-
Karaca et al. (2022)	-	-	+	+	+	+	-	-
Yilmaz et al. (2022)	+	+	+	+	+	+	-	+
Siriratna et al. (2022)	+	+	+	+	+	+	-	+
Naruseviciute & Kubilius (2020)	-	+	-	+	+	+	-	-

Domains:
D1: Bias due to confounding.
D2: Bias due to selection of participants.
D3: Bias in classification of interventions.
D4: Bias due to deviations from intended interventions.
D5: Bias due to missing data.
D6: Bias in measurement of outcomes.
D7: Bias in selection of the reported result.

Judgement
Critical
Moderate
Low

Figure 2. Risk of Bias Summary for the Randomized Controlled Trials Included in the systematic review

Risk of Bias

The risk of bias for the eight RCTs included in this systematic review was assessed using the Cochrane RoB 2 tool. The evaluation considered seven standard domains: bias due to confounding, bias in the selection of participants into the study, bias in the classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in the measurement of outcomes, and bias in the selection of the reported result. The outcomes of this assessment were graphically illustrated using the ROBVIS (Risk Of Bias VISualization) platform. As depicted in Figure 2, the

overall risk of bias was rated as “low” in four studies, and “some concerns” in four studies. Most trials showed low risk of bias in the domains related to measurement of the outcome and selection of the reported result, suggesting that outcome assessments were largely appropriate and free from selective reporting. Nevertheless, concerns were common in the randomization process. In particular, Ozlu and Atilgan,¹⁷ Karaca et al,¹⁸ and Siriratna et al¹⁹ did not clearly describe their methods for sequence generation or allocation concealment, leading to classification as having “some concerns” in this domain.

Additionally, performance bias due to lack of blinding was evident in studies such as Karaca et al,¹⁸ Ozlu and Atilgan,¹⁷ and Samaan et al,²⁰ where the absence of adequate blinding raised the likelihood of subjective influences on outcomes like pain intensity. The domain concerning deviations from intended interventions was flagged in some trials due to insufficient reporting on protocol adherence and participant compliance. Meanwhile, attrition bias was generally low across studies, although Naruseviciute and Kubilius²¹ did not provide clear information on participant retention or dropout management, resulting in “some concerns” regarding missing outcome data.

Study Quality Assessment

The eight RCTs included in this review encompassed a total of 477 participants with various musculoskeletal

conditions, such as knee osteoarthritis, chronic low back pain, patellofemoral pain syndrome, lateral epicondylalgia, subacromial impingement, and plantar fasciitis. While all studies adhered to RCT design, the methodological rigor and reporting standards varied.

Most studies clearly defined their interventions and employed validated outcome measures. Notably, Stausholm et al²² presented a high-quality placebo-controlled trial with adequate blinding and standardized protocols, increasing both internal and external validity. Similarly, Yilmaz et al²³ and Alayat et al²⁴ implemented double-blind designs or placebo arms, enhancing the reliability of their findings.

However, several trials presented limitations. In particular, studies by Ozlu and Atilgan¹⁷ and Karaca et al¹⁸ lacked clarity regarding allocation concealment, raising concerns about selection bias. Other limitations included the absence of blinding of outcome assessors,²⁰ small sample sizes,^{18,19} short follow-up durations,²⁴ or unregistered protocols,²¹ which compromise reproducibility and increase the risk of reporting bias.

Overall, while the included trials provided valuable insights into the efficacy of LLLT and HILT, methodological inconsistencies—particularly regarding randomization procedures, blinding, and long-term assessment—underscore the need for more rigorously designed studies to support firm clinical recommendations.

In summary, the included studies varied in terms of laser parameters, comparator interventions, follow-up duration, and outcome measures, making direct comparison challenging. However, all studies demonstrated statistically and clinically significant improvements in pain, function, or patient satisfaction, supporting the role of photobiomodulation—both HILT and LLLT—as effective non-pharmacological interventions in orthopedic pain management. A detailed summary of the study designs, sample sizes, intervention characteristics, outcome measures, and key findings is presented in [Table 3](#).

Discussion

This systematic review reinforces the growing relevance of photobiomodulation, specifically LLLT and HILT, as viable adjunctive strategies in the treatment of chronic orthopedic pain. While both modalities have demonstrated clinical benefits across a variety of musculoskeletal conditions, the evidence also underscores substantial heterogeneity in intervention protocols, outcomes, and populations studied.

Across the included RCTs, both LLLT and HILT were associated with improvements in pain, range of motion, and functional outcomes. These findings corroborate the prior literature suggesting that laser therapy contributes to analgesia and tissue recovery through mechanisms such as modulation of inflammatory mediators and

mitochondrial bioenergetics. As demonstrated by Stausholm et al,²² combining LLLT with strength training in knee osteoarthritis patients improved sit-to-stand performance and reduced analgesic use, although pain thresholds improved more in the placebo group at earlier time points—suggesting that non-specific effects and patient expectations may play a role in laser therapy responsiveness.

A deeper look into study outcomes reveals that HILT appears to outperform LLLT in certain clinical contexts, likely due to its deeper tissue penetration and photothermal effects. For instance, studies by Alayat et al²⁴ and Yilmaz et al²³ found greater gains in muscle strength, quality of life, and functional capacity in groups treated with HILT compared to placebo or other modalities such as TENS or ultrasound. This is consistent with mechanistic findings from Tim et al,²⁵ who showed that different biophysical agents elicit dose-dependent inflammatory gene modulation in osteoblasts, indicating that both energy density and delivery mode critically affect biological responses.

From a mechanistic standpoint, photobiomodulation promotes tissue repair and analgesia through several biological pathways. LLLT and HILT stimulate mitochondrial cytochrome c oxidase activity, leading to increased ATP production, modulation of reactive oxygen species, and subsequent anti-inflammatory effects.⁶ HILT additionally induces photothermal effects that increase local blood flow and tissue extensibility, making it suitable for deeper or chronic musculoskeletal conditions.^{16,24} These mechanisms support the clinical observation that HILT may produce more immediate symptom relief than LLLT. Nevertheless, heterogeneity in treatment parameters—such as wavelength, energy density, application frequency, and target site—remains a critical limitation that challenges the standardization of clinical protocols and reduces reproducibility across studies. As noted by Glazov et al¹⁶ in a meta-analysis on LLLT for chronic low back pain, although moderate-quality evidence supports its short-term analgesic effects, variability in treatment protocols limits generalizability and complicates dose–response interpretations. This review corroborates these limitations, as beneficial effects of photobiomodulation were frequently observed but not uniformly consistent across studies. Notably, even among trials involving comparable patient populations, divergent outcomes were reported—likely attributable to variations in laser dosage, characteristics of the comparator groups, or use of adjunctive therapies. The available evidence also underscores the potential synergistic effects of combining photobiomodulation with exercise-based rehabilitation. Several studies have reported that the integration of laser therapy with neuromuscular training amplifies the therapeutic benefits, particularly in terms of pain modulation, functional restoration, and motor control.^{26,27}

Table 3. Results of Article Search and Selection

Study	Design, N	Population (Mean Age ± SD/Range)	Interventions	Outcome Measures	Results
Stausholm et al, 2022 ²²	Randomized placebo-controlled trial, n=50	Patients with knee osteoarthritis (mean age not specified) (mean age ≈ 65)	Group 1: LLLT (3 J, 904 nm)+strength training (n=26) Group 2: Placebo LLLT+strength training (n=24)	Pain (VAS: movement, rest, night), KOOS, sit-to-stand test, analgesic use, NSAID use, joint line PPT, ultrasound measures	No significant differences in primary outcomes between groups. At 52 weeks, the LLLT group showed reduced analgesic/NSAID use and improved sit-to-stand test. The placebo group had greater PPT gains at week 8. Both groups showed reduced pain.
Ozlu & Atilgan, 2024 ¹⁷	Single-blind RCT, n=45	Adults with PFPS (aged 25–45 years)	Group 1: HILT+exercise Group 2: US+TENS+exercise Group 3: US+IFC+exercise	Pain (VAS), knee flexion ROM, Q angle, pain threshold, quadriceps and hamstring strength, Kujala score, LEFS, TUG	All groups showed improvement, but group 1 (HILT) was significantly more effective at reducing pain, increasing knee ROM, and enhancing lower extremity function ($P=0.000$).
Alayat et al, 2014 ²⁴	Randomized blinded placebo-controlled trial, n=72	Male patients with chronic low back pain (mean age=32.81 ± 4.48 years)	Group 1: HILT+exercise Group 2: Placebo laser+exercise Group 3: HILT alone	Pain (VAS), lumbar ROM, RDQ, MODQ	All groups improved post-treatment. The HILT+exercise group showed significantly greater improvements in pain, ROM, and disability than HILT alone or placebo+exercise. Functional gains were maintained at 12-week follow-up in groups 1 and 2.
Samaan et al, 2022 ²⁰	Single-blinded randomized controlled trial, n=60	Patients with grade II–III knee osteoarthritis (HILT+ET: 55.4 ± 6.34 yrs; LIPUS+ET: 55.2 ± 4.77 years; Control: 57 ± 6.39 years)	Group 1: HILT+exercise therapy Group 2: LIPUS+exercise therapy Group 3: Exercise therapy only	Pain (VAS), knee ROM, proprioceptive accuracy, WOMAC	All groups showed improvement, but the HILT+ET group had significantly better outcomes than LIPUS+ET and control. Differences between all groups were statistically significant ($P<0.0001$).
Karaca et al, 2022 ¹⁸	Randomized controlled trial, n=42	Patients with lateral epicondylalgia (mean age ≈ 37 years)	Group 1: Physiotherapy only Group 2: Physiotherapy+ESWT Group 3: Physiotherapy+HILT	Pain (VAS), grip strength (hand dynamometer), function (Durooz Hand Index, PRTEE-Turkish version)	All groups improved in pain, grip strength, and function by week 6 ($P<0.05$). The HILT group showed superior outcomes across all measures compared to ESWT and physiotherapy alone ($P<0.05$).
Yilmaz et al, 2022 ²³	Double-blinded randomized placebo-controlled trial, n=63	Patients with subacromial impingement syndrome	Group 1: HILT+exercise (n=32) Group 2: Sham HILT+exercise (n=31)	Pain (VAS), shoulder ROM (goniometry), CMS, SF-36 (QoL), isokinetic muscle strength (IR and ER at 120°, 180°, 210°/s)	Both groups improved at 3 and 12 weeks. HILT+exercise showed significantly greater improvements in pain, ROM, functional capacity, QoL (SF-36), and isokinetic muscle strength compared to the sham group.
Siriratna et al, 2022 ¹⁹	Single-blinded randomized controlled trial, n=42	Patients with primary knee osteoarthritis (Kellgren-Lawrence grade 2–4)	Group 1: HILT (22.39 J/cm², 562.5 J/session)+conservative treatment Group 2: Sham laser+conservative treatment	Pain (VAS), Modified Thai WOMAC (T-WOMAC)	Both groups showed pain reduction; the HILT group had a significantly greater reduction in VAS ($P<0.05$). No significant between-group difference in T-WOMAC scores, but the trend favored HILT.
Naruseviciute & Kubilius, 2020 ²¹	Participant-blind randomized controlled trial, n=102	Patients with unilateral plantar fasciitis (outpatient setting)	Group 1: High-intensity laser therapy (HILT, n=51) Group 2: Low-level laser therapy (LLLT, n=51) 8 sessions over 3 weeks+1 patient education session	Pain (VAS), pain pressure threshold (algometry), plantar fascia thickness (ultrasound), patient perception of treatment efficacy (numeric rating scale)	No significant between-group differences in VAS, algometry, or ultrasound outcomes. Subjective treatment satisfaction was significantly higher in the HILT group (73% vs 51%).

Abbreviations: LLLT, Low-level laser therapy; HILT, high-intensity laser therapy; VAS, Visual analog scale; KOOS, Knee Injury and Osteoarthritis Outcome Score; PPT, pressure pain threshold; US, ultrasound; TENS, transcutaneous electrical nerve stimulation; IFC, interferential current; ROM, range of motion; LEFS, Lower Extremity Functional Scale; TUG, timed up and go; RDQ, Roland Disability Questionnaire; MODQ, Modified Oswestry Disability Questionnaire; LIPUS, low-intensity pulsed ultrasound; WOMAC, Western Ontario and McMaster Universities Arthritis Index; ESWT, extracorporeal shockwave therapy; DHI, Durooz Hand Index; PRTEE, patient-rated tennis elbow evaluation; CMS, Constant-Murley Score; SF-36, Short-Form Health Survey; KL, Kellgren-Lawrence; NRS, numeric rating scale.

For instance, protocols that incorporate LLLT alongside quadriceps strengthening exercises have yielded superior clinical outcomes in individuals with knee osteoarthritis when compared to either intervention applied in isolation.²² These findings reinforce the rationale for adopting a multimodal rehabilitation approach, wherein photobiomodulation serves as an adjunctive strategy to enhance patient readiness for physical activity and promote early and sustained engagement in therapeutic

exercise programs.

Nevertheless, several limitations persist across the current body of evidence. A substantial number of trials were conducted in single-center settings with relatively homogeneous samples, limiting the generalizability of their findings. Moreover, long-term follow-up was infrequently performed, and critical variables such as patient comorbidities, baseline activity levels, and prior therapeutic exposures were inconsistently reported.

Importantly, few studies incorporated health economic analyses or addressed device accessibility, which are essential considerations for broader implementation of photobiomodulation in routine clinical practice.

Conclusion

Photobiomodulation using both LLLT and HILT shows considerable therapeutic potential in the management of chronic orthopedic pain. Although HILT may provide advantages related to deeper tissue penetration and more immediate analgesic effects, both modalities appear to be effective when applied with appropriate clinical indications and optimized parameters. Nevertheless, the current heterogeneity in treatment protocols underscores the urgent need for rigorously designed randomized controlled trials employing standardized dosimetry, clear methodological reporting, and extended follow-up periods. Such efforts are essential to establish the efficacy, safety, and cost-effectiveness of laser-based interventions in evidence-informed musculoskeletal rehabilitation.

Registration Information

The systematic review protocol was registered with PROSPERO (CRD420251052163).

Authors' Contribution

Conceptualization: Gabrielly Santos Pereira, Joelington Dias Batista, Marcelo Lourenço da Silva.

Data curation: All authors.

Formal analysis: All authors.

Investigation: Gabrielly Santos Pereira, Joelington Dias Batista, Marcelo Lourenço da Silva.

Methodology: All authors.

Project administration: Marcelo Lourenço da Silva.

Resources: Joelington Dias Batista, Marcelo Lourenço da Silva.

Software: Joelington Dias Batista, João Eduardo de Araújo, Marcelo Lourenço da Silva.

Supervision: Joelington Dias Batista, João Eduardo de Araújo, Marcelo Lourenço da Silva.

Validation: Joelington Dias Batista, João Eduardo de Araújo, Marcelo Lourenço da Silva.

Visualization: All authors.

Writing—original draft: All authors.

Writing—review & editing: All authors.

Competing Interests

The authors declare no conflict of interest.

Data Availability Statement

Data will be made available on request.

Ethical Approval

This systematic review was conducted in accordance with the ethical standards for research synthesis and followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. As the study involved analysis of data from previously published research, no new data collection involving human or animal subjects was performed, and thus, ethical approval and informed consent were not required.

Funding

This study was supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001, and by Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG). Gabrielly Santos Pereira received a FAPEMIG scholarship as part of this research.

References

1. Cieza A, Causey K, Kamenov K, Hanson SW, Chatterji S, Vos T. Global estimates of the need for rehabilitation based on the Global Burden of Disease study 2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2021;396(10267):2006-17. doi: [10.1016/s0140-6736\(20\)32340-0](https://doi.org/10.1016/s0140-6736(20)32340-0).
2. Woolf AD, Pfleger B. Burden of major musculoskeletal conditions. *Bull World Health Organ*. 2003;81(9):646-56.
3. Briggs AM, Woolf AD, Dreinhöfer K, Homb N, Hoy DG, Kopansky-Giles D, et al. Reducing the global burden of musculoskeletal conditions. *Bull World Health Organ*. 2018;96(5):366-8. doi: [10.2471/blt.17.204891](https://doi.org/10.2471/blt.17.204891).
4. Chou R, Fanciullo GJ, Fine PG, Adler JA, Ballantyne JC, Davies P, et al. Clinical guidelines for the use of chronic opioid therapy in chronic noncancer pain. *J Pain*. 2009;10(2):113-30. doi: [10.1016/j.jpain.2008.10.008](https://doi.org/10.1016/j.jpain.2008.10.008).
5. Geneen LJ, Moore RA, Clarke C, Martin D, Colvin LA, Smith BH. Physical activity and exercise for chronic pain in adults: an overview of Cochrane reviews. *Cochrane Database Syst Rev*. 2017;1(1):CD011279. doi: [10.1002/14651858.CD011279.pub2](https://doi.org/10.1002/14651858.CD011279.pub2).
6. Hamblin MR. Mechanisms and applications of the anti-inflammatory effects of photobiomodulation. *AIMS Biophys*. 2017;4(3):337-61. doi: [10.3934/biophy.2017.3.337](https://doi.org/10.3934/biophy.2017.3.337).
7. Leal-Junior EC, Vanin AA, Miranda EF, de Tarso Camillo de Carvalho P, Dal Corso S, Bjordal JM. Effect of phototherapy (low-level laser therapy and light-emitting diode therapy) on exercise performance and markers of exercise recovery: a systematic review with meta-analysis. *Lasers Med Sci*. 2015;30(2):925-39. doi: [10.1007/s10103-013-1465-4](https://doi.org/10.1007/s10103-013-1465-4).
8. Farivar S, Malekshahi T, Shiari R. Biological effects of low-level laser therapy. *J Lasers Med Sci*. 2014;5(2):58-62.
9. Enwemeka CS, Parker JC, Dowdy DS, Harkness EE, Sanford LE, Woodruff LD. The efficacy of low-power lasers in tissue repair and pain control: a meta-analysis study. *Photomed Laser Surg*. 2004;22(4):323-9. doi: [10.1089/pho.2004.22.323](https://doi.org/10.1089/pho.2004.22.323).
10. Kheshie AR, Alayat MS, Ali MM. High-intensity versus low-level laser therapy in the treatment of patients with knee osteoarthritis: a randomized controlled trial. *Lasers Med Sci*. 2014;29(4):1371-6. doi: [10.1007/s10103-014-1529-0](https://doi.org/10.1007/s10103-014-1529-0).
11. Song HJ, Seo HJ, Lee Y, Kim SK. Effectiveness of high-intensity laser therapy in the treatment of musculoskeletal disorders: a systematic review and meta-analysis of randomized controlled trials. *Medicine (Baltimore)*. 2018;97(51):e13126. doi: [10.1097/md.00000000000013126](https://doi.org/10.1097/md.00000000000013126).
12. Huang Z, Ma J, Chen J, Shen B, Pei F, Kraus VB. The effectiveness of low-level laser therapy for nonspecific chronic low back pain: a systematic review and meta-analysis. *Arthritis Res Ther*. 2015;17:360. doi: [10.1186/s13075-015-0882-0](https://doi.org/10.1186/s13075-015-0882-0).
13. Silva UU, Servin ET, da Cunha Leal P, de Oliveira CM, Moura EC, de Melo Silva Júnior O. High-intensity laser for the treatment of pain: systematic review. *BrJP*. 2023;6(2):160-70. doi: [10.5935/2595-0118.20230030-en](https://doi.org/10.5935/2595-0118.20230030-en).
14. Bjordal JM, Couppe C, Chow RT, Tunér J, Ljunggren EA. A systematic review of low-level laser therapy with location-specific doses for pain from chronic joint disorders. *Aust J Physiother*. 2003;49(2):107-16. doi: [10.1016/s0004-9514\(14\)60127-6](https://doi.org/10.1016/s0004-9514(14)60127-6).

15. Stausholm MB, Naterstad IF, Joensen J, Lopes-Martins RÁ B, Sæbø H, Lund H, et al. Efficacy of low-level laser therapy on pain and disability in knee osteoarthritis: systematic review and meta-analysis of randomised placebo-controlled trials. *BMJ Open*. 2019;9(10):e031142. doi: [10.1136/bmjopen-2019-031142](https://doi.org/10.1136/bmjopen-2019-031142).
16. Glazov G, Yelland M, Emery J. Low-level laser therapy for chronic non-specific low back pain: a meta-analysis of randomised controlled trials. *Acupunct Med*. 2016;34(5):328-41. doi: [10.1136/acupmed-2015-011036](https://doi.org/10.1136/acupmed-2015-011036).
17. Ozlu O, Atilgan E. The effect of high-intensity laser therapy on pain and lower extremity function in patellofemoral pain syndrome: a single-blind randomized controlled trial. *Lasers Med Sci*. 2024;39(1):103. doi: [10.1007/s10103-024-04017-y](https://doi.org/10.1007/s10103-024-04017-y).
18. Karaca İ, Gül H, Erel S. Comparison of extracorporeal shock wave therapy and high-intensity laser therapy on pain, grip strength, and function in patients with lateral epicondylalgia: a randomized controlled study. *Lasers Med Sci*. 2022;37(8):3309-17. doi: [10.1007/s10103-022-03631-y](https://doi.org/10.1007/s10103-022-03631-y).
19. Siriratna P, Ratanasutiranont C, Manissorn T, Santiniyom N, Chira-Adisai W. Short-term efficacy of high-intensity laser therapy in alleviating pain in patients with knee osteoarthritis: a single-blind randomised controlled trial. *Pain Res Manag*. 2022;2022:1319165. doi: [10.1155/2022/1319165](https://doi.org/10.1155/2022/1319165).
20. Samaan S, Sedhom MG, Grace MO. A randomized comparative study between high-intensity laser vs low-intensity pulsed ultrasound both combined with exercises for the treatment of knee osteoarthritis. *Int J Rheum Dis*. 2022;25(8):877-86. doi: [10.1111/1756-185x.14361](https://doi.org/10.1111/1756-185x.14361).
21. Naruseviciute D, Kubilius R. The effect of high-intensity versus low-level laser therapy in the management of plantar fasciitis: randomized participant blind controlled trial. *Clin Rehabil*. 2020;34(8):1072-82. doi: [10.1177/0269215520929073](https://doi.org/10.1177/0269215520929073).
22. Stausholm MB, Naterstad IF, Alfredo PP, Couppé C, Fersum KV, Leal-Junior EC, et al. Short- and long-term effectiveness of low-level laser therapy combined with strength training in knee osteoarthritis: a randomized placebo-controlled trial. *J Clin Med*. 2022;11(12):3446. doi: [10.3390/jcm11123446](https://doi.org/10.3390/jcm11123446).
23. Yilmaz M, Eroglu S, Dundar U, Toktas H. The effectiveness of high-intensity laser therapy on pain, range of motion, functional capacity, quality of life, and muscle strength in subacromial impingement syndrome: a 3-month follow-up, double-blinded, randomized, placebo-controlled trial. *Lasers Med Sci*. 2022;37(1):241-50. doi: [10.1007/s10103-020-03224-7](https://doi.org/10.1007/s10103-020-03224-7).
24. Alayat MS, Atya AM, Ali MM, Shosha TM. Long-term effect of high-intensity laser therapy in the treatment of patients with chronic low back pain: a randomized blinded placebo-controlled trial. *Lasers Med Sci*. 2014;29(3):1065-73. doi: [10.1007/s10103-013-1472-5](https://doi.org/10.1007/s10103-013-1472-5).
25. Tim CR, Bossini PS, Kido HW, Malavazi I, von Zeska Kress MR, Carazzolle MF, et al. Effects of low-level laser therapy on the expression of osteogenic genes during the initial stages of bone healing in rats: a microarray analysis. *Lasers Med Sci*. 2015;30(9):2325-33. doi: [10.1007/s10103-015-1807-5](https://doi.org/10.1007/s10103-015-1807-5).
26. Maiya GA, Harihar A, Joseph GM, Arora E, Arany P, Bensadoun RJ, et al. Effectiveness of photobiomodulation and exercise-based rehabilitation on pain and functional recovery in patients with rotator cuff pathology. *Wound Repair Regen*. 2025;33(3):e70043. doi: [10.1111/wrr.70043](https://doi.org/10.1111/wrr.70043).
27. Dos Santos FF, Braga ML, Barroso MM, Oliveira VC, Oliveira MX. Effects of photobiomodulation therapy combined with exercise in patients who have chronic low back pain: protocol for a randomized controlled trial. *Phys Ther*. 2021;101(11):pzab201. doi: [10.1093/ptj/pzab201](https://doi.org/10.1093/ptj/pzab201).