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Effectiveness of high-intensity laser therapy in the treatment of shoulder impingement syndrome: a systematic review and meta-analysis of randomised clinical trials

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Abstract

Introduction. High-intensity laser therapy (HILT) is a recent resource promoted as an alternative to relieve pain and improve function in patients with subacromial impingement syndrome (SAIS). The aim of this review was to assess the effects of HILT on pain in patients with SAIS.

Methods. Electronic databases, including PubMed, Web of Science, Scopus, CINAHL, Science Direct, Cochrane Library, the PEDro database, and Google Scholar (updated to January 8, 2025), were searched for clinical trials comparing HILT with other physical therapy treatments in patients with SAIS. The main outcomes evaluated were pain intensity, range of motion (ROM), and disability for different scales and instruments. The results of VAS, range of motion, CMS, and SPADI were analysed, evaluating the quality of RCTs with the Cochrane risk of bias (RoB) 2.0 tool and the evidence with the GRADE approach.

Results. Nineteen studies were included, generally presenting a low RoB, except for outcome data measurement and bias due to deviations from the intended intervention. RCTs reported a reduction in pain and an improvement in functionality in the meta-analysis. VAS MD = –1.56 cm (95% CI: –2.1,1.0); CMS MD = 4.0% (95% CI: 1.7, 6.2). Furthermore, there were significant improvements in flexion and abduction favouring HILT: flexion MD = 12.8° (95% CI: 2.5, 23.1);abduction MD = 15.3° (95% CI: 4.4,26.1). Only changes in pain and ROM were both statistically significant ($p < 0.05$) and clinically significant.

Conclusions. This SR supports the effects of HILT on pain, ROM, and disability. It agrees with previous reviews on LLLT, validating both treatment options. Although the evidence was assessed as important, methodological inconsistencies are noted in some RCTs that could affect the certainty.

Key words: systematic review, phototherapy, shoulder impingement syndrome, laser therapy, shoulder pain, high-intensity laser therapy

Introduction

Shoulder pain is a common reason for medical consultation, ranking third in musculoskeletal pain after back and knee pain [1]. The prevalence of shoulder pain is 1 to 4.8% in the general population, with around 50% experiencing persistent pain for over six months [1–3]

Subacromial impingement syndrome (SAIS) is the leading cause of shoulder pain, accounting for 44–65% of cases and primarily affecting women aged 45–64 [1, 4]. SAIS results in inflammation or rotator cuff tendon degeneration due to subacromial space conflicts (primary SAIS) or misalignment of the humeral head caused by muscle imbalances (secondary SAIS) [5]. Additionally, risk factors like smoking, sleep positions, repetitive shoulder activities, and acromion shape are important considerations [3]. SAIS has three clinical stages [6]: (1) oedema and inflammation with pain during and after movement; (2) fibrosis and tendinitis with inflammation, weakness, crepitus, limited range of motion (ROM), and arm-raising difficulty; and (3) osteophytes and subacromial tendon rupture. The first stage is more common in individuals under 25 years of age, while the latter two are more prevalent after 40 [1, 6].

SAIS treatment includes medications, injections, and surgery for severe cases, while conservative therapy emphasises physical therapy [7]. Despite surgery rates, studies show no significant difference in pain and disability reduction compared to conservative management [1, 7]. Different physical therapy modalities, such as shoulder girdle exercises, manual therapy, transcutaneous electrical nerve stimulation (TENS), and low-level laser therapy (LLLT), have proven to be effective in the treatment of SAIS [8–10].

LLLT effectively manages SAIS by reducing pain and enhancing ROM and functionality, especially when combined with exercises [10, 11]. LLLT is a safe, non-invasive phototherapy using high-concentration red or infrared photons to modulate biological processes (photobiomodulation), with powers below 0.5 W that do not heat biological tissues [12, 13]. LLLT turns on enzymes in the respiratory chain (complex IV); increases ATP, DNA, and RNA synthesis; and increases metabolism. It also slows nerve conduction and releases β-endorphins. It also reduces inflammatory mediators, promotes collagen production, and aids nerve regeneration [12–14].

In recent years, new treatment technologies involving high-power lasers (HILT) have been developed for managing musculoskeletal pain [15, 16]. HILT and LLLT share similar biophysical characteristics, differing only in their emission powers (HILT being greater than 0.5 W). Higher power enables

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quicker energy delivery to tissues, resulting in varying degrees of heating and coverage of larger treatment areas [16].

Due to the growing interest in HILT as a way to treat pain in the musculoskeletal system and the proven effectiveness of LLLT in SAIS, clinical trials (RCTs) have started to investigate the effects of HILT in this condition [17–21]. However, given the novelty of this resource, there is uncertainty regarding the quantity, quality, and outcomes of these RCTs supporting HILT for SAIS treatment. Consequently, the purpose of this systematic review (SR) is to assess the existing evidence regarding the effectiveness of HILT as a therapy for SAIS.

Subjects and methods

Design

This SR followed PRISMA guidelines and was registered in the National Institute for Health Research's International Prospective Register of Systematic Reviews (PROSPERO) under ID CRD42023387399 [22, 23].

The research question was structured using the PICO approach (population, intervention, comparison, and outcome). The study focused on patients with SAIS who underwent HILT, compared to those receiving other physical therapy interventions, with or without sham HILT. The primary outcome assessed pain intensity changes using tools like the visual analogue scale (VAS), the numerical scale (NPRS), or other validated scales. Changes in ROM (measured by goniometry) and disability (measured with established questionnaires like the Disability of Arm, Shoulder, and Hand Questionnaire, the Shoulder Pain and Disability Index [DASH], or the Constant-Murley Shoulder Outcome Score, [CMS]) were considered secondary outcomes.

Search strategy

Medline (via PubMed), Web of Science, Scopus, CINAHL, Science Direct, Cochrane Library, the Evidence-Based Physiotherapy Database (PEDro), and Google Scholar databases were searched for HILT in SAIS RCTs (updated to January 8, 2025). The search was conducted employing a curated set of keywords extracted from the MeSH (Medical Subject Headings) dictionary. These keywords encompassed "Lasers", "Laser Therapy", "Phototherapy", "High-intensity Laser Therapy", "Class IV laser","Musculoskeletal Pai", "Shoulder Pain", "Shoulder Impingement Syndrome", "Joint Diseases", and "Rotator Cuff Tear Arthropathy". These terms were combined using boolean connectors "OR" and "AND" to create the search algorithm: (((((*"Lasers"*) *OR* (*"Laser Therapy"*)) *OR* (*"Phototherapy"*)) *OR* (*"High-Intensity Laser Therapy"*)) *OR* (*"Class IV laser"*)) *AND* (((((*"Musculoskeletal Pain"*) *OR* (*"Shoulder Pain"*)) *OR* (*"Shoulder Impingement Syndrome"*)) *OR* (*"Joint Diseases"*)) *OR* (*"Rotator Cuff Tear Arthropathy"*)). Furthermore, filters for "Clinical Trial" and "Randomised Controlled Trial" were used to ensure the identification of clinical trials in the search results.

Selection criteria

Three independent researchers (AC-B, FP-A, and ES-O) collectively assessed article titles and abstracts from the databases using the Rayyan web tool (https://www.rayyan.ai/), making inclusion or exclusion decisions based on predefined criteria. The review used the following inclusion criteria: (A) human clinical trials with a SAIS diagnosis, (B) studies in English, Portuguese or Spanish, (C) HILT alone or in combination with other physical therapy modalities, (D) comparisons with other physical therapy treatments with or without placebo, and (E) changes in pain intensity measured by different scales or instruments as the main outcome. Exclusions comprised literature reviews, systemic reviews of HILT and SAIS linked to other musculoskeletal or neurological disorders, and studies with incomplete or inaccessible texts. No time limitation has been set for the search, considering the recent emergence of HILT and the potential limitation in the quantity of available studies.

Risk of bias (RoB)

The RCTs' methodological quality was initially assessed using the PEDro scale (ICC 0.53–0.91) for an initial overview [24]. Additionally, researchers used the Cochrane Collaboration risk of bias 2 tool (RoB 2.0) to evaluate bias based on investigator judgment [25]. Studies with PEDro scores above five were categorised as having good (6–8 points) or excellent methodological quality (9–10 points). Using the RoB tool, studies with two or more high RoBs were deemed low quality [25]. Concordance in RoB evaluation among researchers was assessed using the kappa statistic [26].

Statistical analysis

For statistical analysis, the Review Manager Software (RevMan 5.4) from the Cochrane Collaboration was utilised [27]. Heterogeneity across studies was evaluated using the chi-square (χ^2) test and the I^2 statistic, categorised as follows: unimportant (0–40%), moderate (30–60%), substantial (50–90%), or considerable (75–100%). Depending on the degree of heterogeneity observed, the researchers employed either the Mantel-Haenszel fixed-effects method or the DerSimonian and Laird random-effects method to calculate the pooled effect using mean differences (MDs) for the outcomes of interest, along with their corresponding 95% confidence intervals (CI) [28].

Evidence recommendation

The evaluation of the quality of evidence employed the GRADE approach (Grading of Recommendations, Assessment, Development, and Evaluation), considering criteria such as RoB, inconsistency, indirectness of evidence, imprecision, and publication bias [29]:

RoB. Highs are present if there are deficiencies in blinding or hidden allocation criteria, potentially leading to an overestimation of treatment effects.

Inconsistency. Depends on heterogeneity equal to or exceeding 50% for an interesting outcome.

Indirect evidence. Identified when the characteristics of treated individuals deviated from those of the broader population with the health condition or when comparing HILT treatment to less common interventions in the available evidence or clinical practice.

Imprecision. Depends on whether the CIs for the pooled effect in meta-analyses intersect the line of no effect, which suggests a lack of clarity in favouring one of the two treatment groups. Furthermore, the optimal sample size will be evaluated, requiring a representative participant number exceeding 200 to consider the effect as clinically relevant.

Publication bias. Depends on the number of studies related to the relevant outcome, with a cutoff of at least three studies to mitigate bias effectively.

Evidence levels, ranging from high to very low, were assigned, with an initial high-quality rating for each level due to the exclusive inclusion of RCTs in this review [29]. Factors affecting one or two GRADE domains may potentially lead to a downgrade of the evidence quality by one or two levels. The assessment of evidence importance will involve a comparison to ascertain whether statistically significant weighted MDs align with the literature's definition of minimal clinically important differences (MCID).

To ensure a comprehensive synthesis of evidence regarding HILT and its effects in SAIS, researchers used the GRADEpro GDT tool for guideline development to facilitate a summary table of evidence for outcomes that demonstrated statistical significance in the meta-analysis (https://www.gradepro.org).

Results

Search results

The initial database search generated a preliminary 3,174 articles (PubMed = 42; Scopus = 483; Web of Science = 108; CINAHL = 201; Science Direct = 2,087; Cochrane Central = 201; the PEDro database = 7; and Google Scholar = 15). Following the removal of duplicate articles, 29 documents remained for further analysis. However, ten articles were excluded as they pertained to studies on HILT for frozen shoulder (n = 5), LLLT in SAIS (n = 2), two case reports (n = 2), and HILT in post-stroke patients with hemiplegic shoulder pain (n = 1). This led to a final selection of 19 articles for analysis [17–21, 30–43]. Figure 1 illustrates the PRISMA flowchart outlining the article search and selection process.

Appendix 1 provides a summary of the search strategy and results for each database.

Methodological quality and risk of bias

Methodological quality assessed by the PEDro scale indicated an overall good-to-excellent quality, averaging 7 points (Table 1) [24]. Major methodological gaps were noted in the concealment allocation and blinding of participants and assessors. However, criteria such as random participant assignment, pre-treatment group comparisons, participant follow-up, and intergroup treatment comparisons were generally fulfilled.

Figure 2 shows the RoB 2.0 assessment conducted by three investigators (HDB, ACB, and NSV) on the included studies. The RoB assessments resulted in a consensus among evaluators, with a kappa coefficient of 0.90. The primary high RoB was linked to measurements in the outcome data (57.7%) and bias due to deviations from the intended intervention (26.0%). Conversely, bias in the measure of outcome data (0%), bias in missing outcome data (89.4%), and bias in the randomisation process (15.7%) were deemed to have a low RoB. Considering the presence of these results, they yielded an overall risk of (31.6%).

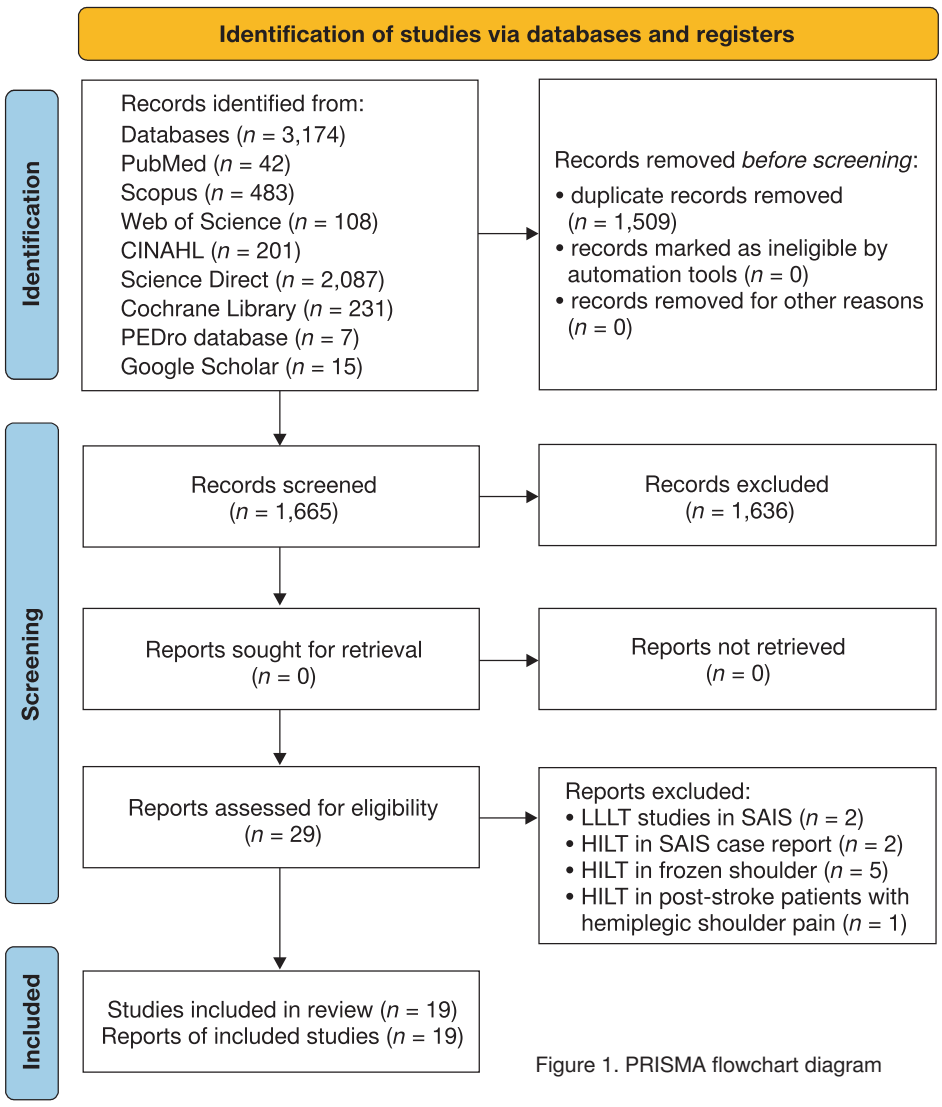


Figure 1. PRISMA flowchart diagram

Table 1. Characteristics of studies comparing HILT for shoulder impingement syndrome

No.	Author (year) country	Study	PEDro score	Total (*n*) group composition (*n*) Mean age (mean ± *SD*)	Inclusion criteria	Exclusion criteria	Intervention	HILT dose	Sessions	Outcomes	Evaluations
1	Santamato et al. (2009) [17] Italy	Short-term effects of high-intensity laser therapy versus ultrasound therapy in the treatment of people with subacromial impingement syndrome: a randomized clinical trial	8/10	*n* = 70 EG = 35 (15, 20) CG = 35 (13, 22) 54.1 ± 9.0	– SAIS diagnosis (stage 1 or 2) – Pain on arm abduction (painful arch) – Shoulder pain (at least 1 month)	– Corticosteroid injection (last 4 weeks) – Shoulder surgery – Acromioclavicular osteoarthritis – Calcic tendinopathy – Cervical radicular pain – Autoimmune diseases – Systemic lupus erythematosus – Diabetes – Neurological pathologies	EG: HILT CG: US	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 1.000 W – Dose: 6 W, continuous 760 mJ/cm^2 and 1.000 J – Time: 10 min – Application: scanning	10 s (2 weeks)	– PI (VAS) – Function (CMS) – Function (SST)	T0: baseline T1: post-treatment (2 weeks)
2	Ghomi et al. (2014) [18] Iran	The comparison of high-power laser and routine physiotherapy in the treatment of supraspinatus tendinitis	8/10	*n* = 40 EG = 20 (8, 12) CG = 20 (9, 11) 38.3 ± 9.0	– SAIS diagnosis – Three of five positive orthopaedic tests (Painful arch, Hawkins–Kennedy, Jobe, Jackson, palpation tenderness)	– Rheumatoid diseases – Complete rupture (supraspinatus tendon) – Corticosteroid injection (last month) – Cervical radiculopathy	EG: HILT + US + TENS + TE CG: US + TENS + TE	– Wavelength: 630, 808, 930 and 980 nm (combined) – Power output: 8 W – Dose: 8 W, continuous, 6–10 J/cm^2 and NS J – Time: 5 min – Application: scanning	6 s (2 weeks)	– PI (VAS) – Disability (DASH)	T0: baseline T1: post-treatment (2 weeks)
3	Karaca (2016) [19] Turkey	Effectiveness of high-intensity laser therapy in subacromial impingement syndrome	/	*n* = 42 EG = 42 (17♂, 25♀) 56.6 ± 11.2	– SAIS diagnosis (stage 1 or 2) – Prior HILT treatment	– Decreased shoulder PROM – Cervical spondylosis – Cervical radicular pain – Rheumatoid diseases – Acromioclavicular/glenohumeral osteoarthritis – Calcic tendinopathy – Diabetes – Thyroid disease – Shoulder surgery – Neurological disorders – Corticosteroid injections (last 6 months)	EG: HILT	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 12 W – Dose: phase 1 = 8 W, pulsed, 12 J/cm^2 and 300 J (session 1 to 3); phase 2 = 7 W, continuous, 100 J/cm^2, 2.500 J (session 4 to 9) – Time: phase 1 = 2 min and 30 s; phase 2 = 5 min and 57 s – Application: scanning	9 s (3 weeks)	– PI (SPADI) – Disability (SPADI) – Function (UCLA)	T0: baseline T1: post-treatment (3 weeks)
4	Pekyavas and Baltaci (2016) [20] Turkey	Short-term effects of high-intensity laser therapy, manual therapy, and Kinesio taping in patients with subacromial impingement syndrome	6/10	*n* = 70 EG = 19 (NS) CG1 = 15 (NS) CG2 = 20 (NS) CG3 = 16 (NS) age NS	– SAIS diagnosis	– Other shoulder injury – Acute inflammation – Neurological symptoms – Scoliosis – Rheumatic diseases – Obesity – Neck surgery	EG: HILT + manual therapy + KT + TE CG1: TE CG2: KT + TE CG3: manual therapy + KT + TE	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 3.000 W – Dose: phase 1 = mean power NS, pulsed, 510 mJ/cm^2 and 1.000 J; phase 2 = mean power NS, pulsed, 610 mJ/cm^2 and 50 J; phase 3 = mean power NS, pulsed, 710 mJ/cm^2 and 1.000 J – Time: 30 min – Application: scanning	15 s (3 weeks)	– PI (VAS) – PI (SPADI) – ROM (GNM) – Disability (SPADI)	T0: baseline T1: post-treatment (3 weeks)
5	Ökmen et al. (2017) [21] Turkey	Comparison of the efficacy of high intensity laser and ultrasound therapies in chronic shoulder pain; randomized controlled single blind study	6/10	*n* = 141 EG = 71 (22, 49) CG = 70 (23, 7) 58.5 ± 9.6	– Age 35–75 years – Shoulder pain (at least 3 months) – SAIS diagnosis (supported by imaging)	– Frozen shoulder – Previous PT treatments – Malignancy – Radicular pain – Cervical myofascial pain syndrome – Acute shoulder trauma – History of shoulder fracture – Shoulder surgery – Rheumatoid disease	EG: HILT + HP + TENS+balneao-therapy + TE CG: US + HP + TENS+balneao-therapy + TE	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 12 W – Dose: phase 1 = 8 W, pulsed, 20 J/cm^2 and 500 J (session 1 to 4); phase 2 = 7 W, continuous, 100 J/cm^2, 2.500 J (session 5 to 14) – Time: phase 1 = 4 min and 10 s; phase 2 = 5 min and 57 s – Application: scanning	14 s (2 weeks)	– PI (VAS) – PI (SPADI) – Disability (SPADI)	T0: baseline T1: post-treatment (3 weeks) T2: follow-up (1 month)
6	Zafar and Kumar (2017) [30] India	Comparison of laser and ultrasound therapy for the management of shoulder rotator cuff muscles injury	7/10	*n* = 20 EG = 10 (10, 0) CG = 10 (10, 0) 33.6 ± 4.2	– SAIS diagnosis (stage 1 or 2) – Painful resisted muscle contraction – Age 20–55 years – Painful ROM (at least 1 month) – Limited shoulder ABD and FLEX	– Diabetes – Neck pain history – Neurological symptoms/disorders – Calcic tendinopathy – Hyperthyroidism – Shoulder surgery	EG: HILT + TE CG: US + TE	– Wavelength: 905 nm (diode GaAlAS) – Power output: 25 W – Dose: 25 W, pulsed and 1.5 J/cm^2 (energy delivered NS) – Time: 10 min – Application: scanning	20 s (4 weeks)	– PI (VAS) – PI (SPADI) – ROM (GNM) – Disability (SPADI)	T0: baseline T1: during treatment (3 weeks) T2: post-treatment (4 weeks)

7	Zafar and Kumar (2017) [31] India	Role of ultrasound with laser to improve function in rotator cuff injury for age group 40–55 years	7/10	*n* = 20 EG = 10 (10, 0) CG = 10 (10, 0) 46.2 ± 8.1	– Unilateral SAIS diagnosis (stages 1 and 2) – Painfully resisted isometric contraction – Age 20–55 years – Pain in shoulder movements (at least 1–3 months) – Shoulder ROM limitations – Positive clinical and radiological exam	– Diabetes – Complete rupture (supraspinatus tendon) – History of surgery (extremity or neck) – History of a neck/head injury – Neurological symptoms – Tendon calcification (X-ray) – Hyperthyroidism – History of cardio-vascular accidents	EG: HILT + TE CG: US + TE	– Wavelength: 905 nm (diode GaAlAS) – Power output: 25 W – Dose: 25 W, pulsed and 1.5 J/cm^2 (energy delivered NS) – Time: 10 min – Application: scanning	20 s (4 weeks)	– ROM (GNM)	T0: baseline T1: post-treatment (4 weeks) T2: post-treatment (12 weeks)
8	Ökmen and Ökmen (2017) [32] Turkey	Comparison of photobiomodulation therapy and suprascapular nerve-pulsed radiofrequency in chronic shoulder pain: a randomized controlled, single-blind, clinical trial	5/10	*n* = 59 EG = 29 (12, 17) CG = 30 (13, 17) 52.4 ± 8.7	– SAIS diagnosis – Age 30–75 years – Shoulder pain (at least 3 months)	– ROM limitations greater than 20% – Previous PT treatment (6 months) – Malignancy – Cervical pain – History of trauma or fractures – Metallic implants – Rheumatoid diseases	EG: HILT CG: radiofrecuency	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 12 W – Dose: phase 1 = 8 W, pulsed, 20 J/cm$_2$ and 500 J; phase 2 = 7 W, continuous, 100 J/cm^2 and 2500 J – Time: phase 1 = 4 min and 10 s; phase 2 = 5 min and 57 s (total = 10 min 7 s) – Application: scanning	12 s (4 weeks)	– PI (VAS) – PI (SPADI) – Disability (SPADI) – QoL (NHP)	T0: baseline T1: post-treatment (2 weeks) T2: follow-up (1 month) T3: follow-up (3 months) T4: follow-up (12 months)
9	Elsodany et al. (2018) [33] Egypt	Long-term effect of pulsed Nd:YAG laser in the treatment of patients with rotator cuff tendinopathy: a randomized controlled trial	5/10	*n* = 60 EG = 30 (NS) CG = 30 (NS) 50.2 ± 3.6	– Shoulder pain (at least 3 months) -Shoulder ABD limitation – IR and ER of the shoulder limitation – Positive orthopaedic tests (Neer, Jobe, Hawkins, and external rotation lag sign)	– Shoulder surgery – Malignancy – Rheumatic diseases	EG: HILT + TE CG: TE	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 3.000 W – Dose: phase 1 = 10.5 W, pulsed, 20 J/cm^2 and 1.000 J; phase 2 = 10.5 W, pulsed, 100 J/cm^2 and 500 J; phase 3 = 10.5 W, pulsed, 20 J/cm^2 and 1.000 J – Time: 15 min – Application: scanning (phase 1 and 3), punctual (phase 2)	14 s (2 weeks)	– PI (VAS) – ROM (GNM) – Disability (SPADI)	T0: baseline T1: post-treatment (4 weeks) T2: follow-up (3 months) T3: follow-up (6 months)
10	Aceituno-Gómez et al. (2019) [34] Spain	Efficacy of high-intensity laser therapy in subacromial impingement syndrome: a three-month follow-up controlled clinical trial	6/10	*n* = 43 EG = 21 (7, 16) CG = 22 (11, 12) 59.0 ± 8.9	– SAIS diagnosis – 18–75 years – VAS pain of 7 or less – Shoulder FLEX greater than 100°	– No physical therapy in the last month – Calcium tendonitis – Complete rupture (rotator cuff tendons) – Adhesive capsulitis – Fibromyalgia – Altered thermal sensitivity – No contraindications exist for HILT	EG: HILT + TE CG: Sham HILT + TE	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 15 W – Dose: phase 1 = 12 W, pulsed, 50 J/cm^2 and NS J; phase 2 = 15 W, pulsed, 250 J/cm^2 and NS J – Time: NS – Application: scanning	15 s (3 weeks)	– PI (VAS) – PPT (ALG) – Disability (SPADI) – Function (CMS) – Disability (Q-DASH)	T0: baseline T1: post-treatment (2 weeks) T2: follow-up (1 month) T3: follow-up (3 months)
11	Cheng et al. (2020) [35] Taiwan	The immediate effect of high-intensity laser therapy on pain relief and shoulder function in patients with subacromial impingement syndrome	/	*n* = 20 EG = 20 (8, 12) 50.5 ±6.6	– SAIS diagnosis (at least 3 months) – Over 25 years of age	– Shoulder concomitant pathologies (tendinopathy, adhesive capsulitis, others) – A complete rotator cuff tear – Acromioclavicular osteoarthritis – Dislocation or acute trauma of the shoulder – Corticosteroid injection – Malignancy – Shoulder surgery – Pregnancy – Acute infections – Rheumatoid disease – Pacemaker Neurological disorders	EG: HILT	– Wavelength: 830 nm (diode GaAlAS) – Power output: 1.5 W – Dose: 1.5 W, pulsed and 2.0 J/cm^2 and 150 J – Time: 15 min – Application: scanning (6 points)	15 s (3 weeks)	– PI (VAS) – ROM (GNM) – Function (CMS)	T0: baseline T1: post-treatment (1 day)

12	Kamal et al. (2020) [36] Egypt	Effect of high-power laser on shoulder mobility in sub acromial impingement syndrome: randomized controlled trial	7/10	*n* = 40 EG = 20 (10, 10) CG = 20 (10, 10) 37.1 ± 11.3	– SAIS diagnosis (stage 1 or 2) – Age 28–45 years	– Corticosteroid injection (last 6 months) – Reduced shoulder ROM – Cervical radiculopathy – Rheumatoid disease – Shoulder surgery – Acromioclavicular/glenohumeral osteoarthritis – Cervical spondylosis – Calcic tendinopathy – Thyroid disease – Diabetes – Ischemic heart disease – Pacemaker – Neurological disorders	EG: HILT + TE CG: TE	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 3.000 W – Dose: phase 1 = 8 W, pulsed, 850 mJ/cm² and 4.000 J; phase 2 = 8 W, pulsed 350 mJ/cm² and 4.000 J; phase 3 = 8 W, pulsed, 850 mJ/cm² and 2.000 J – Time: 15 min – Application: scanning (phase 1 and 3), punctual (phase 2)	12 s (6 weeks)	– PI (VAS) – ROM (GNM) – Tendon thickness (USG)	T0: baseline T1: post-treatment (6 weeks)
13	Kamal et al. (2021) [37] Egypt	High-power laser versus phonophoresis in subacromial impingement syndrome: randomized controlled trial	7/10	*n* = 40 EG = 20 (10, 10) CG = 20 (10, 10) 37.1 ± 11.4	– SAIS diagnosis (stage 1 or 2) – Age 28–45 years	– Corticosteroid injection (last 6 months) – Reduced shoulder ROM – Cervical radiculopathy – Rheumatoid disease – Shoulder surgery – Acromioclavicular/glenohumeral osteoarthritis – Cervical spondylosis – Calcic tendinopathy – Thyroid disease – Diabetes – Ischemic heart disease – Pacemaker – Neurological disorders	EG: HILT + TE CG: phonoforesis + TE	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 3.000 W – Dose: phase 1 = 8 W, pulsed, 850 mJ/cm² and 4.000 J; phase 2 = 8 W, pulsed, 350 mJ/cm² and 4.000 J; phase 3 = 8 W, pulsed, 850 mJ/cm² and 2.000 J – Time: 15 min – Application: scanning (phase 1 and 3), punctual (phase 2)	12 s (6 weeks)	– PI (VAS) – ROM (GNM) – Tendon thickness (USG)	T0: baseline T1: post-treatment (6 weeks)
14	Sirbu et al. (2021) [38] Romania	The short-term outcomes of Multiwave Locked System (MLS) laser therapy versus a combination of transcutaneous nerve stimulation and ultrasound treatment for subacromial pain syndrome	5/10	*n* = 47 EG = 22 (9, 13) CG = 25 (13, 12) 58.6 ± 10.2	– SAIS diagnosis (at least 3 months)	– Rheumatic diseases – Heart failureneurological deficit – Spinal disorders – Shoulder/neck surgery – Referred pain – Analgesic drugs – Corticosteroid injections	EG: HILT + TE CG: US + TENS + TE	– Wavelength: 808 and 905 nm (dual) – Power output: NS W – Dose: NS W, pulsed, 2.8 J/cm² and NS J – Time: 5 min – Application: scanning	10 s (3 weeks)	– PI (VAS) – Function (CMS) – Disability (SPADI)	T0: baseline T1: post-treatment (3 weeks)
15	Aydin et al. (2021) [39] Turkey	The effect of high-intensity laser therapy on pain and functionality in patients with chronic shoulder pain	6/10	*n* = 56 EG = 28 (13, 15) CG = 28 (17, 8) 64.3 ±7.25	– Chronic shoulder pain – Age 18–75 years	– Lack of cooperation to perform exercises – Communication/psychiatric problems – Heart problems – Orthopedic problems	EG: HILT + US + TENS + ITFC + HP + TE CG: US + TENS + ITFC + HP + TE	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 12 W – Dose: 10 W, pulsed, 12 J/cm² and NS J – Time: 2 min – Application: NS	15 s (3 weeks)	– PPT (ALG) – ROM (GNM) – Strength (DNM) – Disability (DASH)	T0: baseline T1: post-treatment (3 weeks)
16	Dost and Eken (2021) [40] Turkey	Comparison of the efficacy of high intensity laser and ultrasound therapies in shoulder impingement syndrome: a randomized clinical trial		*n* = 70 EG = 35 (14, 21) CG = 35 (12, 23) 47.1 ± 8.7	– SAIS diagnosis – Chronic shoulder pain – Pain on active shoulder elevation and resisted contraction – Diagnosis confirmed by MRI	– History of shoulder trauma – Rotator cuff tear (MRI) – Rheumatic disease – Neurological disease – Infection – Pregnancy – Malignant – Corticosteroid injection – Adhesive capsulitis – Physical therapy treatment (last 6 months)	EG: HILT CG: US	– Wavelength: 850 nm (diode GaAlAS) – Power output: NS – Dose: NS W, continuous, 3 J/cm² (energy delivered NS), and 15 J – Time: 5 min – Application: punctual	10 s (2 weeks)	– PI (VAS) – PPT (ALG) – Disability (SPADI)	T0: baseline T1: post-treatment (2 weeks) T2: follow-up (4 weeks)
17	Zaki et al. (2022) [41] Iran	Comparison of low level and high power laser combined with kinesiology taping on shoulder function and musculoskeletal sonography parameters in subacromial impingement syndrome: a randomized placebo-controlled trial	8/10	*n* = 30 EG = 10 (5, 5) CG1 = 10 (4, 6) CG2 = 10 (4, 6) 48.6 ± 12.8	– Age 40–60 years – BMI 25–30 kg/m² – SAIS diagnosis (stage 1 or 2) – Shoulder painful arc between 40–120° – Pain intensity for VAS 4–8 cm – Pain and weakness in ABD and resisted ER – Positive Neer, Yocum, and Hawkins Kennedy tests	– Pregnancy – Shoulder surgery – Shoulder dislocation – Corticosteroid injection in the last 6 months – Frozen shoulder – Acromioclavicular osteoarthritis – Rotator cuff disorder – Use of anti-inflammatory/pain relievers – Cervical referral pain	EG: HILT + KT CG1: LLLT + KT CG2: sham HILT + KT	– Wavelength: 810 and 980 nm (dual, diode) – Power output: 7 W – Dose: phase 1 = 4 W, pulsed, 250 mJ/cm², 1.000 J; 4 W, pulsed, 250 mJ/cm², 50 J; phase 3 = 4 W, pulsed, 250 mJ/cm², 1.000 J – Time: 9 min – Application: scanning (phase 1 and 3), punctual (phase 2)	7 s (2 weeks)	– PI (VAS) – PI (SPADI) – Disability (SPADI) – Subacromial structures (MSKUS)	T0: baseline T1: post-treatment (2 weeks)

18	Yilmaz et al. (2022) [42] Turkey	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	8/10	*n* = 63 EG = 32 (11, 21) CG = 31 (10, 21) 50.7 ± 7.6	– Age 30–75 years – Shoulder pain for at least 6 weeks – SAIS diagnosis – Tolerate HILT – Tolerate shoulder exercises	– Injection with corticosteroids – History of acute trauma – Shoulder surgeries – Calcification greater than 2 cm in rotator cuff tendons – Finding of total tear of the rotator cuff – Cervical myofascial pain – Cervical radiculopathy – Rheumatic disease – Neurological symptoms – Peacemaker	EG: HILT + TE CG: sham HILT + TE	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 3.000 W – Dose: phase 1 = mean power NS, pulsed, energy density in subphases (810 mJ/cm², 970 mJ/cm², 1.070 mJ/cm²) and 1.374 J; phase 2 = mean power NS, pulsed, energy density in subphases (310 mJ/cm², 510 mJ/cm², 610 mJ/cm² and 360 mJ/cm²) and 33J; phase 3 = mean power NS, pulsed, energy density in subphases (810 mJ/cm², 970 mJ/cm², 1.070 mJ/cm²) and 1.374 J – Time: 25 min – Application: scanning (phase 1 and 3), punctual (phase 2)	15 s (3 weeks)	– PI (VAS) – ROM (GNM) – Strength (ISK) – Function (CMS) – QoL (SF-36)	T0: baseline T1: post-treatment (3 weeks) T2: follow-up (12 weeks)
19	Yeşilyaprak et al. (2023) [43] Turkey	The addition of exercise to high-intensity laser therapy improves treatment effectiveness on pain and muscle strength in patients with subacromial pain syndrome: a randomized trial	8/10	*n* = 30 EG1 = 15(11, 4) EG2 = 15 (7, 8) 49.6 ± 9.6	– ≥ 18 years – SAIS diagnosis – Shoulder pain less than 7/10 of VAS	– Upper extremity fracture or surgery – Frozen shoulder – Full-thickness rotator cuff tear – Shoulder instability – Systemic musculoskeletal disease – Shoulder pain with cervical motion – HILT contraindication	EG1: HILT EG2: HILT + TE	– Wavelength: 1.064 nm (Nd:YAG) – Power output: 12 W – Dose: phase 1 and 3 = 10 W, pulsed 25 Hz, 10 J/cm² and 1000 J; phase 2 = 10 W, pulsed, 25 Hz, 1 J/cm² and 50 J – Time: 2 min – Application: scanning (phase 1 and 3), punctual (phase 2)	10 s (3 weeks)	– PI (VAS) – ROM (GNM) – Function (CMS) – Disability (SPADI)	T0: baseline T1: post-treatment (3 weeks)

ABD – abduction, ALG – algometry, BMI – body mass index, CG – control group, CMS – Constant-Murley Scale, DASH – disabilities of the arm, shoulder and hand, DNM – dynamometry, EG – experimental group, ER – external rotation, FLEX – flexion, GNM – goniometry, HILT – high-intensity laser therapy, HP – hydrocollator pack, IR – internal rotation, ISK – isokinetic strength evaluation, ITFC – interferential currents, KT – kinesiotape, LLLT – low-level laser therapy, MRI – magnetic resonance imaging, MSKUS – musculoskeletal ultrasound, Nd:YAG – neodymium-doped yttrium aluminum garnet, NHP – Nottingham Health Profile, NS – not specifics, PI – pain intensity, PT – physical therapy, PPT – pain pressure threshold, Q-DASH – quick disabilities of the arm, shoulder and hand, QoL – quality of life, ROM – range of motion, SAIS – subacromial impingement syndrome, SF-36 – short-form 36 health survey, SPADI – shoulder pain and disability index, SST – Simple Shoulder Test, TE – therapeutic exercise, TENS – transcutaneous electrical nerve stimulation, UCLA – University of California Los Angeles Questionnaire, US – therapeutic ultrasound, USG – ultrasonography, VAS – visual analogue scale

Figure 2. Risk of bias summary. The review authors' judgments about each risk of bias item for each included study

Characteristics of the RCTs

Table 1 provides a concise overview of essential details from the RCTs, encompassing study groups, selection criteria, interventions, assessments, and relevant outcomes. These trials were conducted across various countries, including Italy [17], Iran [18, 41], Turkey [19–21, 32, 39, 40, 43], India [30, 31], Egypt [33, 36, 37], Taiwan [35], Spain [34], and Romania [38], spanning from 2009 to 2023.

A total of 871 participants diagnosed with SAIS were included, with an average age of 46.9 years (SD ± 8.8), comprised of 379 women and 322 men, and two studies lacked gender information. Among these, 449 received HILT, while 422 controls underwent conventional physical therapy. In the experimental group (EG), 141 patients exclusively received HILT [17, 19, 32, 35, 40], and 308 participants received HILT alongside US [18, 39], therapeutic exercises [18, 20, 21, 30, 31, 33, 34, 36–38, 43], TENS [18, 20, 21, 39], thermotherapy [21, 39], Kinesio Tape [20,42], and interferential current [39]. Controls (GCs) were treated with US [17, 18, 30, 31, 38–41], therapeutic exercises [18, 20, 21, 30, 31, 33, 34, 36–38, 43], interferential current [39], radiofrequency [32], thermotherapy [21, 41], Kinesio Tape [20, 41], and LLLT [41]. Furthermore, two studies employed placebo HILT [34, 41, 42].

Table 2. Outcomes and statistical comparisons for HILT groups in the included studies

Study	Outcome	HILT							CG							*p*-value intergroup post-treatment
		T0: baseline	T1: post-treatment	T2: follow-up	T3: follow-up	*p*-value intragroup T0–T1	*p*-value intragroup T0–T2	*p*-value intragroup T0–T3	T0: baseline	T1: post-treatment	T2: follow-up	T3: follow-up	*p*-value intragroup T0–T1	*p*-value intragroup T0–T2	*p*-value intragroup T0–T3	
Santamato et al. (2009) [17]	PI (VAS, cm) mean ± *SD*	6.3 ± 1.8	2.4 ± 1.4 (2 weeks)	/		< 0.01*	/		6.6 ± 1.5	4.4 ± 1.4 (2 weeks)	/		< 0.01*	/		< 0.01*
	Function (CMS, score) mean ± *SD*	63.2 ± 8.7	75.9 ± 7.0 (2 weeks)						63.1 ± 7.1	72.1 ± 7.0 (2 weeks)			0.03*			0.03*
	Function (SST, score) mean ± *SD*	7.2 ± 2.3	9.7 ± 2.0 (2 weeks)						6.9 ± 2.2	8.7 ± 2.0 (2 weeks)			0.06			0.06
Ghomi et al. (2014) [18]	PI (VAS, cm) mean ± *SD*	7.6 ± 0.8	3.5 ± 1.5 (2 weeks)	/		< 0.05*	/		7.2 ± 1.3	5.03 ± 1.5 (2 weeks)	/		< 0.05*	/		< 0.05*
	Disability (DASH,%) mean ± *SD*	58.8 ± 12.5	33.6 ± 6.8 (2 weeks)						51.8 ± 11.9	45.7 ± 1.0 (2 weeks)						
Karaca (2016) [19]	PI (SPADI,%) median(IQR)	31(17–50)	10(0–46) (3 weeks)	/		< 0.01*	/		without CG							N/A
	Disability (SPADI,%) median(IQR)	42(12–80)	20(0–56) (3 weeks)													
	Function (UCLA, score) median(IQR)	20(11–26)	29(16–35) (3 weeks)													
Pekyavas and Baltaci (2016) [20]	PI (VAS, cm)	NS		/		NS	/		NS		/		NS	/		NS
	PI (SPADI,%) mean ± *SD*	76.4 ± 4.9	4.2 ± 5.1 (3 weeks)			0.000*			65.8 ± 12.6	13.1 ± 13.2 (3 weeks)			< 0.05*			0.967
	Shoulder0ER (GNM,grades) mean ± *SD*	49.7 ± 23.0	78.6 ± 11.8 (3 weeks)						72.0 ± 19.9	82.8 ± 8.8 (3 weeks)						0.073
	Shoulder ABD (GNM, grades) mean ± *SD*	130.3 ± 31.1	167.8 ± 9.2 (3 weeks)						157.2 ± 28.0	173.7 ± 2.7 (3 weeks)						0.031*
	Shoulder FLEX (GNM, grades) mean ± *SD*	140.0 ± 29.4	172.4 ± 7.4 (3 weeks)						160.9 ± 23.5	176.5 ± 2.7 (3 weeks)						0.265
	Disability (SPADI, %) mean ± *SD*	80.2 ± 13.1	7.4 ± 4.5 (3 weeks)						58.6 ± 21.9	14.6 ± 12.3 (3 weeks)						0.906
Ökmen et al. (2017) [21]	PI (VAS, cm) mean ± *SD*	6.6 ± 1.6	4.6. ± 1.7 (2 weeks)	2.67 ± 1.3 (4 weeks)	/	< 0.01*		/	6.9 ± 1.9	5.5 ± 1.7 (2 weeks)	4.2 ± 1.4 (4 weeks)	/	< 0.001*		/	0.003*
	PI (SPADI,%) mean ± *SD*	24.4 ± 10.2	25.2 ± 8.8 (2 weeks)	15.5 ± 7.2 (4 weeks)					36.1 ± 9.4	28.4 ± 9.0 (2 weeks)	23.4 ± 8.0 (4 weeks)					0.034*
	Disability (SPADI, %) mean ± *SD*	45.1 ± 17.9	33.2 ± 14.5 (2 weeks)	21.1 ± 11.5 (4 weeks)					49.2 ± 16.5	39.3 ± 14.8 (2 weeks)	32.5 ± 13.0 (4 weeks)					0.015*
Zafar and Kumar (2017) [30]	PI (VAS,cm) mean ± *SD*	7.5 ± 0.5	5.2 ± 0.6 (3 weeks)	3.2 ± 0.6 (4 weeks)	/	< 0.001*		/	7.6 ± 0.8	6.9 ± 0.5 (3 weeks)	6.1 ± 1.0 (4 weeks)	/	< 0.01*		/	< 0.001*
	PI (SPADI,%) mean ± *SD*	33.1 ± 3.7	30.1 ± 4.8 (3 weeks)	22.6 ± 7.0 (4 weeks)					36.8 ± 2.0	33.2 ± 4.7 (3 weeks)	22.9 ± 4.5 (4 weeks)					0.431
	Shoulder FLEX (GNM, grades) mean ± *SD*	51.3 ± 6.6	69.4 ± 5.9 (3 weeks)	90.4 ± 5.9 (4 weeks)					53.6 ± 8.5	60.7 ± 5.8 (3 weeks)	66.9 ± 5.7 (4 weeks)					< 0.001*
	Shoulder ABD (GNM, grades) mean ± *SD*	53.5 ± 6.3	70.2 ± 4.6 (3 weeks)	93.8 ± 3.7 (4 weeks)					54.1 ± 7.0	57.4 ± 4.5 (3 weeks)	61.5 ± 4.9 (4 weeks)					
	Disability (SPADI,score) mean ± *SD*	52.0 ± 5.7	36.1 ± 3.2 (3 weeks)	20.5 ± 2.9 (4 weeks)					56.7 ± 3.4	49.9 ± 5.8 (3 weeks)	46.8 ± 9.9 (4 weeks)					

Zatar and Kumar (2017) [31]	Shoulder FLEX (GNM, grades) mean ± *SD*	47.0 ± 3.9	96.8 ± 4.0 (4 weeks)	133.1 ± 2.3 (12 weeks)	/	<0.001*	/	45.8 ± 6.5	82.3 ± 4.4 (4 weeks)	122.9 ± 3.8 (12 weeks)	/	< 0.001*	/	< 0.001*		
	Shoulder ABD (GNM, grades) mean ± *SD*	46.8 ± 3.6	98.2 ± 3.5 (4 weeks)	133.6 ± 1.2 (12 weeks)				44.2 ± 5.1	81.0 ± 2.5 (4 weeks)	120.4 ± 2.6 (12 weeks)						
	Shoulder ER (GNM, grades) mean ± *SD*	29.9 ± 2.2	60.7 ± 3.0 (4 weeks)	71.2 ± 2.5 (12 weeks)				28.6 ± 1.4	55.3 ± 2.0 (4 weeks)	63.4 ± 1.3 (12 weeks)						
	Shoulder IR (GNM, grades) mean ± *SD*	33.8 ± 3.6	53.5 ± 2.5 (4 weeks)	63.9 ± 1.6 (12 weeks)				29.3 ± 2.6	49.6 ± 2.6 (4 weeks)	59.9 ± 1.3 (12 weeks)						
Öksen and Öksen (2017) [32]	PI(VAS,cm) median(IQR)	6.3(19-85)	2.0(8–40) (2 weeks)	1.3(0–6.1) (4 weeks)	2.0(0.8–4.0) (12 weeks)	< 0.01*		6.4(1.9-8.5)	2.0(0.8-4.0) (2 weeks)	1.6(0-6.1) (4 weeks)	2.2(0.8-4.0) (12 weeks)					0.952
	PI (SPADI,%) median(IQR)	39(19-48)	11(0–39) (2 weeks)	8(0–41) (4 weeks)	12(0–39) (12 weeks)			37.5(19-48)	11.5(0-39) (2 weeks)	10(0-41) (4 weeks)	13.5(2-39) (12 weeks)					0.715
	Disability (SPADI,%) median(IQR)	47(26-73)	12(1–47) (2 weeks)	7(0–53) (4 weeks)	13(2–47) (12 weeks)			45.5(26-73)	11(1-47) (2 weeks)	11(0-53) (4 weeks)	14(2-47) (12 weeks)					0.988
	QoL (NH,score) median(IQR)	308.9 (97-502.3)	202.8 (10–502.3) (2 weeks)	79.3 (0–391.9) (4 weeks)	75.4 (0–330.4) (12 weeks)			289.3 (41.4-502.3)	147.6 (0-468.2) (2 weeks)	78.4(0-468.2) (4 weeks)	76.5(0-254.2) (12 weeks)					0.103
Elsodany et al. (2018) [33]	PI (VAS,cm) mean ± *SD*	7.9 ± 0.6	1.8 ± 0.6 (4 weeks)	1.9 ± 0.6 (12 weeks)	1.8 ± 0.6 (24 weeks)	< 0.001*		7.7 ± 1.0	4.3 ± 0.7 (4 weeks)	4.7 ± 0.5 (12 weeks)	4.9 ± 0.7 (24 weeks)	< 0.001*		< 0.001*		
	Active shoulder ABD (GNM,grades) mean ± *SD*	92.9 ± 10.8	132.3 ± 9.8 (4 weeks)	132.2 ± 9.8 (12 weeks)	132.1 ± 9.9 (24 weeks)			91.9 ± 10.2	112.5 ± 9.8 (4 weeks)	110.8 ± 9.6 (12 weeks)	110.1 ± 9.6 (24 weeks)					
	Passive shoulder ABD (GNM,grades) mean ± *SD*	137.8 ± 6.8	168.5 ± 6.2 (4 weeks)	168.3 ± 6.2 (12 weeks)	168.1 ± 6.5 (24 weeks)			136.3 ± 5.6	158.7 ± 5.9 (4 weeks)	157.2 ± 6.2 (12 weeks)	155.8 ± 6.1 (24 weeks)					
	Active shoulder ER (GNM,grades) mean ± *SD*	39.9 ± 3.3	75.3 ± 3.3 (4 weeks)	75.1 ± 3.4 (12 weeks)	75.0 ± 3.5 (24 weeks)			39.5 ± 2.7	56.9 ± 3.6 (4 weeks)	56.8 ± 3.9 (12 weeks)	55.3 ± 3.8 (24 weeks)					
	Passive shoulder ER (GNM, grades) mean ± *SD*	53.9 ± 3.5	80.1 ± 3.3 (4 weeks)	97.9 ± 3.3 (12 weeks)	97.8 ± 3.4 (24 weeks)			55.1 ± 3.1	65.5 ± 3.6 (4 weeks)	64.9 ± 3.6 (12 weeks)	64.3 ± 3.7 (24 weeks)					
	Active shoulder IR (GNM, grades) mean ± *SD*	29.5 ± 2.9	53.3 ± 2.5 (4 weeks)	53.1 ± 2.5 (12 weeks)	52.9 ± 2.4 (24 weeks)			28.6 ± 2.6	44.0 ± 2.3 (4 weeks)	39.7 ± 2.5 (12 weeks)	39.3 ± 2.5 (24 weeks)					
	Passive shoulder IR (GNM, grades) mean ± *SD*	53.6 ± 3.6	80.1 ± 3.3 (4 weeks)	79.9 ± 3.3 (12 weeks)	79.9 ± 3.3 (24 weeks)			55.1 ± 3.1	65.5 ± 3.6 (4 weeks)	63.9 ± 3.5 (12 weeks)	63.5 ± 3.5 (24 weeks)					
	Disability (SPADI,%) mean ± SD	75.1 ± 2.9	21.9 ± 1.3 (4 weeks)	22.0 ± 1.3 (12 weeks)	22.0 ± 1.2 (24 weeks)			75.9 ± 2.6	35.8 ± 1.9 (4 weeks)	41.1 ± 2.8 (12 weeks)	41.4 ± 2.6 (24 weeks)					
Aceituno-Gómez et al. (2019) [34]	PI (VAS, cm) mean ± *SD*	5.4 ± 1.5	3.6 ± 1.9 (2 weeks)	3.6 ± 2.4 (4 weeks)	1.8 ± 1.8 (12 weeks)	< 0.001*		6.2 ± 1.0	4.1 ± 1.8 (2 weeks)	3.0 ± 2.6 (4 weeks)	2.6 ± 2.4 (12 weeks)	< 0.001*		< 0.001*		NS
	PPT (ALG, kg/cm^2) mean ± SD	2.5 ± 0.9	3.4 ± 1.0 (2 weeks)	3.6 ± 1.1 (4 weeks)	4.4 ± 1.2 (12 weeks)			2.9 ± 0.6	3.5 ± 0.9 (2 weeks)	4.0 ± 1.0 (4 weeks)	4.4 ± 1.5 (12 weeks)	> 0.05	< 0.05*			
	Disability (SPADI,%) mean ± *SD*	41.8 ± 20.6	20.2 ± 16.1 (2 weeks)	20.5 ± 19.8 (4 weeks)	11.0 ± 14.5 (12 weeks)	< 0.001*		51.8 ± 16.1	23.0 ± 17.2 (2 weeks)	16.3 ± 16.1 (4 weeks)	13.6 ± 17.1 (12 weeks)					
	Function (CMS, score) mean ± *SD*	49.9 ± 10.4	61.6 ± 9.6 (2 weeks)	65.2 ± 8.0 (4 weeks)	68.5 ± 7.4 (12 weeks)			41.7 ± 9.8	57.5 ± 9.0 (2 weeks)	62.9 ± 9.9 (4 weeks)	66.3 ± 8.9 (12 weeks)	< 0.001*				
	Disability (Q-DASH, %) mean ± *SD*	39.2 ± 16.0	19.5 ± 13.2 (2 weeks)	17.7 ± 18.5 (4 weeks)	9.9 ± 10.7 (12 weeks)			46.2 ± 16.1	23.1 ± 16.6 (2 weeks)	17.5 ± 17.0 (4 weeks)	14.8 ± 17.1 (12 weeks)					

Cheng et al. (2020) [35]	PI (VAS, cm) mean ± *SD*	6.6 ± 0.9	3.1 ± 0.6 (1 day)	/	< 0.05*	/	without CG						N/A
	Shoulder FLEX (GNM, grades) mean ± *SD*	126 ± 15	138 ± 17 (1 day)										
	Function (CMS, score) mean ± *SD*	38 ± 4	59 ± 7 (1 day)										
Kamal et al. (2020) [36]	PI (VAS, cm) mean ± *SD*	6.7 ± 0.6	1.5 ± 0.4 (6 weeks)	/	< 0.01*	/	6.5 ± 0.6	3.7 ± 0.7 (6 weeks)	/	< 0.01*	/	< 0.01*	
	Shoulder ABD (GNM, grades) mean ± *SD*	105.1 ± 3.2	152.5 ± 2.9 (6 weeks)				105.1 ± 3.2	116.3 ± 3.7 (6 weeks)					
	Shoulder FLEX (GNM, grades) mean ± *SD*	105.1 ± 3.2	157.8 ± 4.6 (6 weeks)				104.7 ± 3.4	121.2 ± 15.7 (6 weeks)					
	Tendon thickness (USG, mm) mean ± *SD*	6.4 ± 0.6	3.9 ± 0.3 (6 weeks)				6.5 ± 0.6	5.2 ± 0.4 (6 weeks)					
Kamal et al. (2021) [37]	PI (VAS, cm) mean ± *SD*	6.9 ± 0.6	1.7 ± 0.6 (6 weeks)	/	< 0.01*	/	6.9 ± 0.8	3.9 ± 0.7 (6 weeks)	/	< 0.01*	/	< 0.01*	
	Shoulder ABD (GNM, grades) mean ± *SD*	105.4 ± 3.3	153.5 ± 3.0 (6 weeks)				105.3 ± 3.5	117.5 ± 3.9 (6 weeks)					
	Shoulder FLEX (GNM, grades) mean ± *SD*	106.3 ± 3.2	157.9 ± 4.6 (6 weeks)				105.8 ± 3.7	123.2 ± 15.9 (6 weeks)					
	Tendon thickness (USG, mm) mean ± *SD*	6.7 ± 0.7	4.0 ± 0.4 (6 weeks)				6.5 ± 0.7	5.4 ± 0.6 (6 weeks)					
Sirbu et al. (2021) [38]	PI (VAS,cm) median(IQR)	8(7-8.25)	3(2-4) (3 weeks)	/	< 0.01*	/	8(8-9)	4(3-6) (3 weeks)	/	< 0.01*	/	0.03*	
	Function (CMS, score) mean ± SD	26.3 ± 11.7	63.1 ± 18.1 (3 weeks)				22.6 ± 9.9	54.0 ± 17.6 (3 weeks)				0.09	
	Disability (SPADI,%) mean ± *SD*	67.9 ± 14.0	22.9 ± 16.8 (3 weeks)				66.9 ± 12.5	33..3 ± 17.1 (3 weeks)				0.04*	
Aydin et al. (2021) [39]	Mean PPT (ALG, kg/cm^2) mean ± *SD*	50.3 ± 0.4	54.8 ± 0.4 (3 weeks)	/	< 0.01*	/	55.3 ± 0.4	54.7 ± 0.4 (3 weeks)	/	> 0.05	/	< 0.01*	
	Shoulder FLEX (GNM, grades) mean ± *SD*	110.3 ± 9.4	144.5 ± 8.2 (3 weeks)				108.8 ± 8.4	141.8 ± 6.9 (3 weeks)		< 0.01*		0.10	
	Shoulder EXT (GNM, grades) mean ± *SD*	44.4 ± 2.7	59.6 ± 2.1 (3 weeks)				44.1 ± 2.0	137.9 ± 1.8 (3 weeks)				0.88	
	Shoulder ABD (GNM, grades) mean ± *SD*	107.9 ± 10.2	141.6 ± 9.4 (3 weeks)				106.7 ± 9.2	137.9 ± 8.1 (3 weeks)				0.15	
	Shoulder IR (GNM,grades) mean ± *SD*	53.7 ± 4.8	69.4 ± 4.7 (3 weeks)				53.4 ± 4.9	69.8 ± 4.5 (3 weeks)				0.80	
	Shoulder ER (GNM,grades) mean ± *SD*	54.6 ± 5.1	69.8 ± 4.1 (3 weeks)				54.6 ± 5.1	69.9 ± 4.1 (3 weeks)				0.89	
	Elbow FLEX (GNM,grades) mean ± *SD*	103.3 ± 4.4	122.6 ± 3.6 (3 weeks)				103.3 ± 4.4	121.8 ± 3.3 (3 weeks)				0.84	
	Disability (DASH,%) mean ± *SD*	67.7 ± 4.4	38.7 ± 2.8 (3 weeks)				67.7 ± 4.4	38.6 ± 3.1 (3 weeks)				0.92	
	Mean shoulder strength (DNM, lb) mean ± *SD*	44.1 ± 2.2	46.9 ± 1.5 (3 weeks)				37.1 ± 2.9	47.6 ± 1.4 (3 weeks)				0.39	
	Mean elbow strength (DNM, lb) mean ± *SD*	48.0 ± 1.0	59.5 ± 1.7 (3 weeks)				48.2 ± 0.9	59.6 ± 1.2 (3 weeks)				0.55	

Dost and Eken (2021) [40]	PI (VAS, cm) mean ± *SD*	6.4 ± 1.1	4.6 ± 2.0 (2 weeks)	4.9 ± 1.3 (4 weeks)	/	< 0.01*	< 0.01*	/	6.3 ± 1.1	4.0 ± 1.6 (2 weeks)	3.7 ± 1.6 (4 weeks)	/	< 0.01*		/	0.24
	PPT (ALG, kg/cm^2) mean ± *SD*	61.4 ± 22.2	59.1 ± 19.0 (2 weeks)	56.8 ± 9.9 (4 weeks)		0.52	0.26		65.1 ± 19.7	60.6 ± 12.3 (2 weeks)	58.0 ± 6.9 (4 weeks)		0.26	0.08		0.67
	Disability (SPADI, score) mean ± *SD*	64.4 ± 15.2	49.1 ± 16.9 (2 weeks)	49.9 ± 13.6 (4 weeks)		< 0.01*	< 0.01*		64.5 ± 13.5	40.0 ± 17.0 (2 weeks)	38.6 ± 15.4 (4 weeks)		< 0.01*			< 0.05*
Zaki et al. (2022) [41]	PI difference (VAS) mean ± SD	NS	3.4 ± 2.0 (2 weeks)	/		< 0.01*	/		NS	2.4 ± 1.3 (2 weeks)	/		< 0.01*	/		< 0.01*
	PI difference (SPADI, %) mean ± SD		23.1 ± 9.6 (2 weeks)							22.8 ± 18.1 (2 weeks)						
	Disability difference (SPADI, %) mean ± *SD*		19.5 ± 16.6 (2 weeks)							15.4 ± 14.9 (2 weeks)						
Yilmaz et al. (2022) [42]	PI (VAS, cm) mean ± *SD*	6.6 ± 0.9	4.9 ± 0.8 (3 weeks)	4.9 ± 0.8 (12 weeks)	/	< 0.01*	< 0.01*	/	6.3 ± 0.6	5.1 ± 0.9 (3 weeks)	5.5 ± 1.1 (12 weeks)	/	< 0.01*		/	< 0.01*
	PI at movement (VAS, cm) mean ± *SD*	7.3 ± 0.7	5.2 ± 0.9 (3 weeks)	5.0 ± 0.9 (12 weeks)					6.8 ± 0.8	5.5 ± 1.1 (3 weeks)	5.9 ± 1.2 (12 weeks)					
	PI at night (VAS, cm) mean ± *SD*	6.9 ± 0.9	5.0 ± 0.8 (3 weeks)	4.9 ± 0.8 (12 weeks)					6.6 ± 0.9	5.4 ± 1.1 (3 weeks)	5.8 ± 1.2 (12 weeks)					
	Shoulder FLEX (GNM, grades) mean ± *SD*	152.8 ± 34.3	172.1 ± 21.5 (3 weeks)	177.1 ± 11.7 (12 weeks)					167.4 ± 19.8	174.5 ± 10.5 (3 weeks)	177.0 ± 8.2 (12 weeks)					
	Shoulder ABD (GNM, grades) mean ± *SD*	151.8 ± 34.4	172.8 ± 18 (3 weeks)	176.5 ± 12 (12 weeks)					160.9 ± 31.2	171.9 ± 15.3 (3 weeks)	173.2 ± 14.9 (12 weeks)					0.089
	Shoulder IR (GNM, grades) mean ± *SD*	78.1 ± 16.1	86.8 ± 7.2 (3 weeks)	89.3 ± 3.5 (12 weeks)					86.1 ± 10.2	88.3 ± 6.3 (3 weeks)	88.3 ± 6.3 (12 weeks)		0.102	0.102		< 0.01*
	Shoulder ER (GNM, grades) mean ± *SD*	77.9 ± 15.2	86.8 ± 7.2 (3 weeks)	89.3 ± 3.5 (12 weeks)					84.6 ± 12.5	88.3 ± 6.3 (3 weeks)	88.3 ± 6.3 (12 weeks)		0.06	0.06		
	Mean IR-PT (ISK DNM, grades/s) mean ± *SD*	15.1 ± 10.5	20.4 ± 14.7 (3 weeks)	21.4 ± 12.2 (12 weeks)					11.9 ± 10.1	14.9 ± 13.8 (3 weeks)	15.1 ± 13.8 (12 weeks)		< 0.01*			
	Mean ER-PT (ISK DNM, grades/s) mean ± *SD*	7.5 ± 3.5	9.3 ± 5.6 (3 weeks)	10.7 ± 7.5 (12 weeks)					7.0 ± 3.2	7.0 ± 3.0 (3 weeks)	7.5 ± 5.2 (12 weeks)		0.835	0.690		
	Function (CMS, score) mean ± *SD*	57.2 ± 9	75.3 ± 6.4 (3 weeks)	75.8 ± 9.4 (12 weeks)					63.1 ± 9.6	72.0 ± 9.5 (3 weeks)	70.4 ± 8.9 (12 weeks)		< 0.01*			
	QoL (SF-36, score) mean ± *SD*	41.6 ± 20.6	61.3 ± 13.5 (3 weeks)	63.7 ± 16 (12 weeks)					52.5 ± 19.9	58.6 ± 18.2 (3 weeks)	57.3 ± 19.4 (12 weeks)					

Yeşilyaprak et al. (2023) [43]	PI (VAS, cm) mean ± *SD*	5.6 ± 1.9	1.4 ± 1.0 (1 month)	/	< 0.01*	/	without CG	N/A
	Active shoulder FLEX (GNM, grades) mean ± *SD*	164.8 ± 10.2	175.7 ± 3.7 (1 month)					
	Active shoulder ABD (GNM, grades) mean ± SD	157.3 ± 25.0	174.2 ± 7.9 (1 month)					
	Active shoulder IR (GNM, grades) mean ± *SD*	65.1 ± 5.5	72.1 ± 8.1 (1 month)					
	Active shoulder ER (GNM, grades) mean ± *SD*	85.7 ± 4.5	89.0 ± 3.3 (1 month)					
	Passive shoulder FLEX (GNM, grades) mean ± *SD*	167.1 ± 7.9	178.3 ± 2.2 (1 month)		0.002*			
	Passive shoulder ABD (GNM, grades) mean ± *SD*	160.1 ± 22.3	176.9 ± 5.6 (1 month)		0.001*			
	Passive shoulder IR (GNM, grades) mean ± *SD*	67.3 ± 6.1	75.0 ± 7.9 (1 month)		0.006*			
	Passive shoulder ER (GNM, grades) mean ± *SD*	87.9 ± 3.0	89.7 ± 2.1 (1 month)		0.050			
	Function (CMS, score) mean ± *SD*	57.9 ± 9.0	78.4 ± 6.3 (1 month)		< 0.01*			
	Disability (SPADI, %) mean ± *SD*	59.1 ± 16.0	25.7 ± 11.4 (1 month)					

ABD – abduction, ALG – algometry, CG – control group, CMS – Constant-Murley Scale, DAHS – disabilities of the arm, DNM – dynamometry, ER-PT – external rotation peak torque, ER – external rotation, EXT – extension, FLEX – flexion, GNM – goniometry, HILT – high-intensity laser therapy, IQR – interquartile range, IR-PT – internal rotation peak torque, IR – internal rotation, NS – not specified, PI – pain intensity, PPT – pain pressure threshold, Q-DASH – quick disabilities of the arm, QoL – quality of life, SF-36 – short-form 36 health survey, SPADI – shoulder pain and disability index, SST – simple shoulder test, UCLA – University of California Los Angeles, USG – ultrasonography, VAS – visual analogue scale; * $p < 0.05$

HILT treatments primarily targeted the deltoid, with the scanning technique being the predominant approach in most studies [17–21, 30–32, 34, 35, 38, 39]. Six studies utilised a combination of scanning and spot techniques [33, 36, 37, 41–43], while the spot technique alone was used in one RCT [40]. In 12 studies, 1064 nm Nd:YAG lasers were used [17, 19–21, 32–34, 36, 37, 39, 42, 43], while dual-wavelength devices (808–930 nm) were employed in 3 studies [35, 38, 41], and four studies used three different wavelengths within the infrared spectrum [18, 30, 31, 40]. The maximum power output ranged from 1.5 to 3000 W, with 8 and 12 W being the most common. The average energy delivered typically fell within the range of 2500–3000 J. The number of treatment sessions varied, ranging from 10 to 15 sessions over a span of 3 to 4 weeks. Additional HILT parameters, such as pulse rate, phase duration, energy density, and treatment duration, are summarised in Table 1.

Outcomes

In these studies, pain intensity was assessed via VAS [17–21, 30–35, 37, 37–43], while the SPADI was employed to evaluate shoulder pain [20, 21, 30, 32, 40, 41] and disability. Shoulder ROM was quantified using goniometry [20, 31, 33, 35–37, 39, 42, 43]. Also, pain pressure threshold [39,40], functional assessment with CMS [17, 34, 35, 38, 42, 43], quality of life with SF-36 [42] and NHP [32], tendon thickness with ultrasonography [36, 37], and muscle strength with dynamometry [39] or isokinetic assessment [42] were important outcomes.

Table 2 shows the results and comparisons between the studies and control groups. Both groups experienced a significant reduction in pain ($p < 0.05$) during the evaluation sessions [17–21, 30–43]. However, HILT demonstrates a more pronounced and lasting pain reduction after treatment and during follow-up sessions. For ROM and disability, both groups exhibit statistically significant differences before and after treatment ($p < 0.05$). HILT notably enhances ROM, but findings regarding disability are mixed, with conflicting results in certain studies [20, 21, 39].

Meta-analysis

Pain intensity

Ten studies were included in both the comprehensive meta-analysis and subgroup analyses to assess the effectiveness of HILT compared to other treatment modalities regarding pain intensity. Pain intensity was measured using the VAS and SPADI subscale. The pooled effect was determined utilising the random-effects model of DerSimonian and Laird [28]. At the end of the treatment, both the VAS (MD = –1.36 cm; 95% CI = –1.96, –0.75; $p < 0.01$) (Figure 3A) and the SPADI subscale (MD = –4.9%; 95% CI = –8.4, –1.4; $p < 0.01$, Figure 3B) showed a statistically significant reduction in pain intensity at rest in favour of HILT. However, subgroup analyses revealed no significant differences when comparing HILT versus placebo (MD = –0.24 cm; 95% CI = –0.63, –0.16; $p = 0.24$) (Figure 3E), HILT versus conventional physical therapy at one month (MD = –0.7 cm; 95% CI = –2.5, 1.1; $p = 0.05$) (Figure 3C) and three-month follow-up (MD = –1.43 cm; 95% CI = –3.13, –0.8; $p = 0.28$) (Figure 3D). The I^2 coefficient derived from the analyses indicated a substantial level of heterogeneity across the studies, except for pain intensity measured using the SPADI subscale and the comparison between HILT and placebo, where heterogeneity was

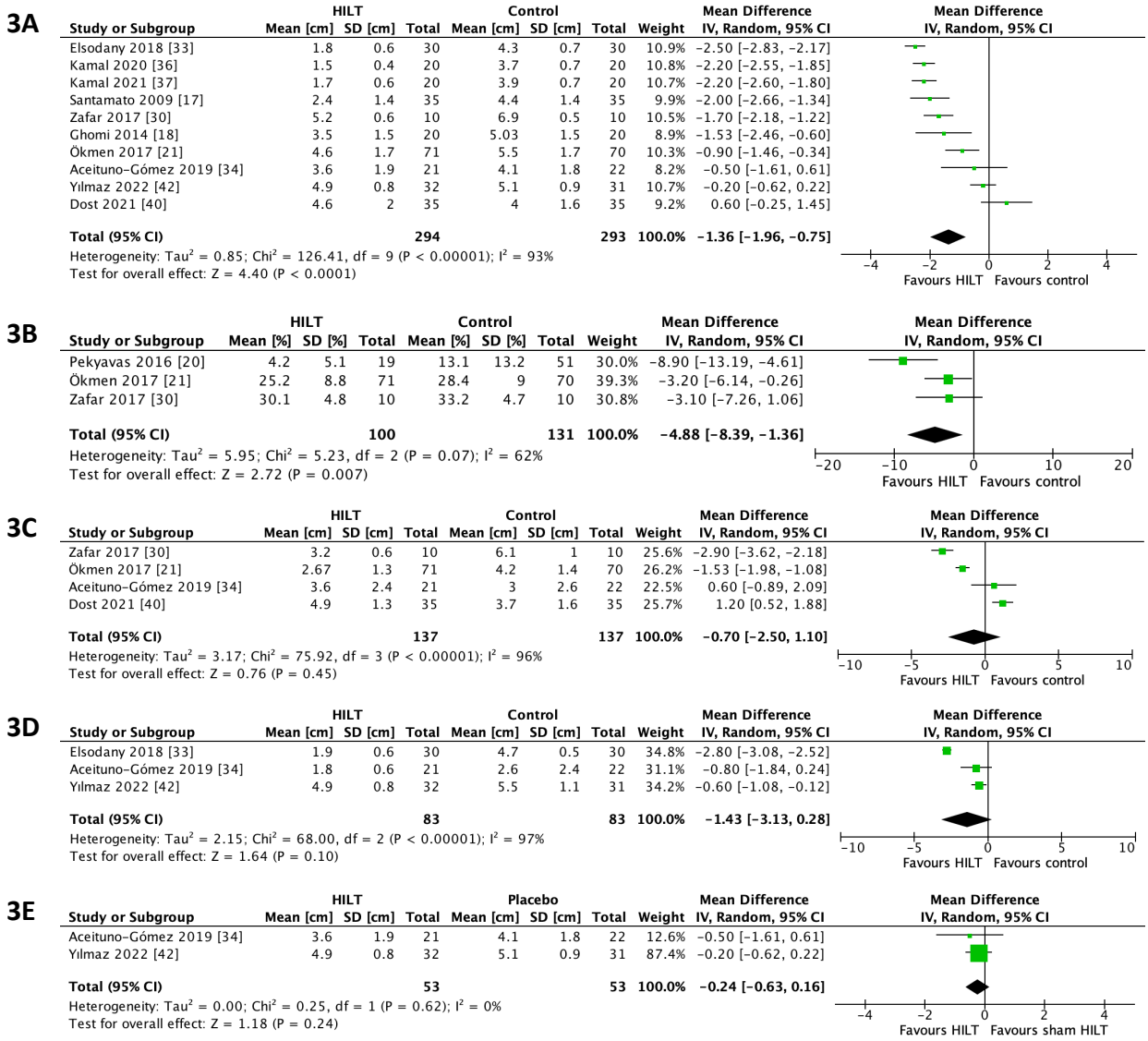


Figure 3. Forest plots for pain intensity at rest (VAS) at the end of treatment (3A), pain intensity at rest (SPADI, 3B), pain intensity at follow-up (1 month, 3C), pain intensity at follow-up (3 months, 3D) and HILT versus placebo (3E)

not statistically significant. The quality of evidence was deemed significant for pain intensity assessed with VAS but had low certainty, and it was not considered significant with a low level for the SPADI subscale (Table 3).

Shoulder ROM

A meta-analysis grouped data on shoulder ROM for abduction [20, 30, 31, 33, 36, 39, 42], flexion [20, 30, 31, 36, 37, 39, 42], external rotation [20, 30, 33, 39, 41], and internal rotation [30, 33, 39, 42]. The results revealed statistically significant changes in ROM for abduction (MD = 15.3°; 95% CI = 4.4, 26.1; $p < 0.01$, Figure 4A) and shoulder flexion (MD = 12.8°; 95% CI = 2.5, 23.1; $p < 0.01$, Figure 4B) after the treatment. However, no significant differences were observed between the groups in terms of external rotation movements (MD = 3.8°; 95% CI = –5.1, 12.6; $p = 0.4$, Figure 4C) and internal rotation (MD = 2.9°; 95% CI = –2.5,0.37; $p = 0.29$, Figure 4D) at the end of the treatment. All analyses exhibited a considerable I^2 index [29]. The evaluation of the evidence suggests important changes for shoulder abduction and flexion, although with a low level of certainty (Table 3). For the other CROMs, researchers assessed the evidence as not important due to the non-statistically significant changes [29].

Shoulder disability

The meta-analysis focused on shoulder disability (SPADI), upper limb disability (DASH), and shoulder functionality (CMS). No statistically significant MDs were observed between the groups for SPADI (MD = –4.4%; 95% CI = –10.8, –1.9; $p = 0.17$, Figure 4E) and for DASH (MD = –5.9%; 95% CI = –17.9, 6.0; $p = 0.33$). However, a significant difference was found for CMS (MD = 3.95 points; 95% CI = 1.7, 6.2; $p < 0.01$). The I^2 statistic was considerable for SPADI and DASH but was not significant in terms of functionality evaluated by CMS [28]. Grounded in this outcome, the evidence pertaining to the effectiveness of HILT in functioning with CMS is deemed not important and, with moderate certainty, was due to the RoB and inconsistency (Table 3) [27, 46].

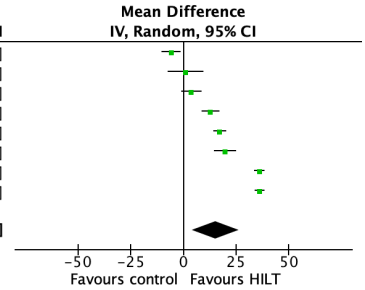
Discussion

The application of HILT in SAIS holds significant clinical importance, presenting a non-invasive therapeutic resource that has demonstrated efficacy in alleviating pain and enhancing mobility in many RCTs. The precise application of HILT plays a crucial role in modulating the analgesic response and inducing muscle relaxation through thermal effects. Consequently, this therapeutic approach emerges as a valuable

4A

Study or Subgroup	HILT Mean [grades]	HILT SD [grades]	HILT Total	Control Mean [grades]	Control SD [grades]	Control Total	Weight	Mean Difference IV, Random, 95% CI
Pekyavas 2016 [20]	167.8	9.2	19	173.7	2.7	51	12.5%	-5.90 [-10.10, -1.70]
Yılmaz 2022 [42]	172.8	18	32	171.9	15.3	31	11.9%	0.90 [-7.34, 9.14]
Aydin 2021 [39]	141.6	9.4	28	137.9	8.1	28	12.5%	3.70 [-0.90, 8.30]
Zafar 2017 [30]	70.2	4.6	10	57.4	4.5	10	12.6%	12.80 [8.81, 16.79]
Zafar 2017 [31]	98.2	3.5	10	81	2.5	10	12.7%	17.20 [14.53, 19.87]
Elsodany 2018 [33]	132.3	9.8	30	112.5	9.8	30	12.4%	19.80 [14.84, 24.76]
Kamal 2021 [37]	153.5	3	20	117.5	3.9	20	12.7%	36.00 [33.84, 38.16]
Kamal 2020 [36]	152.5	2.9	20	116.3	3.7	20	12.7%	36.20 [34.14, 38.26]
Total (95% CI)			**169**			**200**	**100.0%**	**15.26 [4.38, 26.13]**

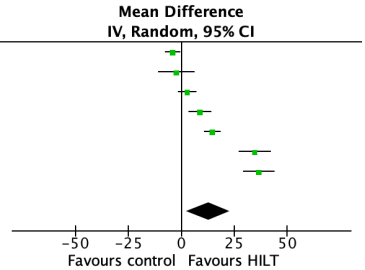
Heterogeneity: Tau² = 241.15; Chi² = 609.41, df = 7 (P < 0.00001); I² = 99%
Test for overall effect: Z = 2.75 (P = 0.006)



4B

Study or Subgroup	HILT Mean [grades]	HILT SD [grades]	HILT Total	Control Mean [grades]	Control SD [grades]	Control Total	Weight	Mean Difference IV, Random, 95% CI
Pekyavas 2016 [20]	172.4	7.4	19	176.5	2.7	51	14.7%	-4.10 [-7.51, -0.69]
Yılmaz 2022 [42]	172.1	21.5	32	174.5	10.5	31	13.6%	-2.40 [-10.72, 5.92]
Aydin 2021 [39]	144.5	8.2	28	141.8	6.9	28	14.6%	2.70 [-1.27, 6.67]
Zafar 2017 [30]	69.4	5.9	10	60.7	5.8	10	14.4%	8.70 [3.57, 13.83]
Zafar 2017 [31]	96.8	4	10	82.3	4.4	10	14.7%	14.50 [10.81, 18.19]
Kamal 2021 [37]	157.9	4.6	20	123.2	15.9	20	13.9%	34.70 [27.45, 41.95]
Kamal 2020 [36]	157.8	4.6	20	121.2	15.7	20	14.0%	36.60 [29.43, 43.77]
Total (95% CI)			**139**			**170**	**100.0%**	**12.79 [2.46, 23.12]**

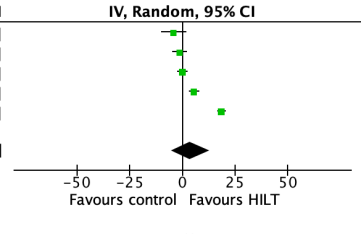
Heterogeneity: Tau² = 185.78; Chi² = 186.42, df = 6 (P < 0.00001); I² = 97%
Test for overall effect: Z = 2.43 (P = 0.02)



4C

Study or Subgroup	HILT Mean [grades]	HILT SD [grades]	HILT Total	Control Mean [grades]	Control SD [grades]	Control Total	Weight	Mean Difference IV, Random, 95% CI
Pekyavas 2016 [20]	78.6	11.8	19	82.8	8.8	51	18.9%	-4.20 [-10.03, 1.63]
Yılmaz 2022 [42]	86.8	7.2	32	88.2	6.3	31	20.0%	-1.40 [-4.74, 1.94]
Aydin 2021 [39]	69.8	4.1	28	69.9	4.1	28	20.3%	-0.10 [-2.25, 2.05]
Zafar 2017 [31]	60.7	3	10	55.3	2	10	20.3%	5.40 [3.17, 7.63]
Elsodany 2018 [33]	75.3	3.3	30	56.9	3.6	30	20.4%	18.40 [16.65, 20.15]
Total (95% CI)			**119**			**150**	**100.0%**	**3.76 [-5.09, 12.61]**

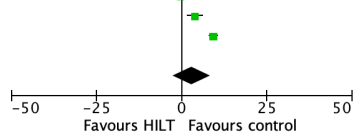
Heterogeneity: Tau² = 99.08; Chi² = 243.16, df = 4 (P < 0.00001); I² = 98%
Test for overall effect: Z = 0.83 (P = 0.40)



4D

Study or Subgroup	HILT Mean [grades]	HILT SD [grades]	HILT Total	Control Mean [grades]	Control SD [grades]	Control Total	Weight	Mean Difference IV, Random, 95% CI
Yılmaz 2022 [42]	86.8	7.2	32	88.3	6.3	31	23.9%	-1.50 [-4.84, 1.84]
Aydin 2021 [39]	69.4	4.7	28	69.8	4.5	28	25.0%	-0.40 [-2.81, 2.01]
Zafar 2017 [31]	53.5	2.5	10	49.6	2.6	10	25.2%	3.90 [1.66, 6.14]
Elsodany 2018 [33]	53.3	2.5	30	44	2.3	30	25.9%	9.30 [8.08, 10.52]
Total (95% CI)			**100**			**99**	**100.0%**	**2.93 [-2.50, 8.37]**

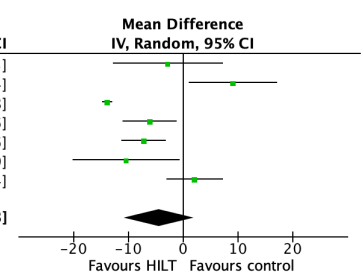
Heterogeneity: Tau² = 29.28; Chi² = 78.18, df = 3 (P < 0.00001); I² = 96%
Test for overall effect: Z = 1.06 (P = 0.29)



4E

Study or Subgroup	HILT Mean [score]	HILT SD [score]	HILT Total	Control Mean [score]	Control SD [score]	Control Total	Weight	Mean Difference IV, Random, 95% CI
Aceituno-Gómez 2019 [34]	20.2	16.1	21	23	17.2	22	11.9%	-2.80 [-12.75, 7.15]
Dost 2021 [40]	49.1	16.9	35	40	17	35	13.3%	9.10 [1.16, 17.04]
Elsodany 2018 [33]	21.9	1.3	30	35.8	1.9	30	16.7%	-13.90 [-14.72, -13.08]
Ökmen 2017 [21]	33.2	14.5	71	39.3	14.8	70	15.3%	-6.10 [-10.94, -1.26]
Pekyavas 2016 [20]	7.4	4.5	19	14.6	12.3	51	15.7%	-7.20 [-11.14, -3.26]
Sirbu 2021 [38]	22.9	16.8	22	33.3	17.1	25	12.0%	-10.40 [-20.11, -0.69]
Zafar 2017 [30]	52	5.7	10	49.9	5.8	10	15.1%	2.10 [-2.94, 7.14]
Total (95% CI)			**208**			**243**	**100.0%**	**-4.44 [-10.81, 1.93]**

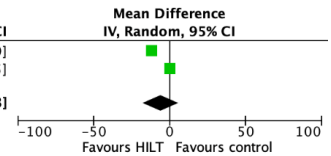
Heterogeneity: Tau² = 63.20; Chi² = 88.88, df = 6 (P < 0.00001); I² = 93%
Test for overall effect: Z = 1.37 (P = 0.17)



4F

Study or Subgroup	HILT Mean [percentage]	HILT SD [percentage]	HILT Total	Control Mean [percentage]	Control SD [percentage]	Control Total	Weight	Mean Difference IV, Random, 95% CI
Ghomi 2014 [18]	33.6	6.8	20	45.7	1	20	49.4%	-12.10 [-15.11, -9.09]
Aydin 2021 [39]	38.7	2.8	28	38.6	3.1	28	50.6%	0.10 [-1.45, 1.65]
Total (95% CI)			**48**			**48**	**100.0%**	**-5.93 [-17.88, 6.03]**

Heterogeneity: Tau² = 72.93; Chi² = 49.86, df = 1 (P < 0.00001); I² = 98%
Test for overall effect: Z = 0.97 (P = 0.33)



4G

Study or Subgroup	HILT Mean [score]	HILT SD [score]	HILT Total	Control Mean [score]	Control SD [score]	Control Total	Weight	Mean Difference IV, Random, 95% CI
Yılmaz 2022 [42]	75.3	6.4	32	72	9.5	31	31.5%	3.30 [-0.71, 7.31]
Santamato 2009 [17]	75.9	7	35	72.1	7	35	47.2%	3.80 [0.52, 7.08]
Aceituno-Gómez 2019 [34]	61.6	9.6	21	57.5	9	22	16.4%	4.10 [-1.47, 9.67]
Sirbu 2021 [38]	63.1	18.1	22	54	17.6	25	4.8%	9.10 [-1.14, 19.34]
Total (95% CI)			**110**			**113**	**100.0%**	**3.95 [1.69, 6.20]**

Heterogeneity: Tau² = 0.00; Chi² = 1.08, df = 3 (P = 0.78); I² = 0%
Test for overall effect: Z = 3.43 (P = 0.0006)

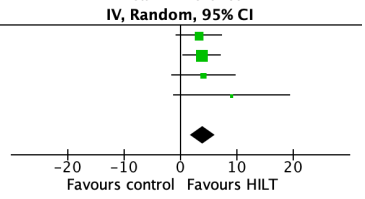


Figure 4. Forest plots for shoulder abduction (4A), shoulder flexion (4B), shoulder external (4C), internal rotation (4D), disability with SPADI and DASH (4E and 4F), and functionality with CMS (4G) at the end of treatment

Table 3. Summary of findings and quality of evidence (GRADE) for interesting outcomes

Certainty assessment							No. of patients		Effect		Certainty (level of evidence)	Importance[e]
no. of studies	study design	RoB	inconsistency	indirectness	imprecision	publication bias	HILT	conventional PT	relative (95% CI)	absolute (95% CI)		
Pain intensity at rest (VAS; 0 to 10 cm)												
10	RCT	serious[a] (-1)	serious[b] I^2 = 93% (-1)	not serious[c] (0)	not serious[d] (0)	no (0)	294	293	–	MD 1.36 cm lower (1.96 lower to 0.75 lower)	⊕⊕○○ low	important
Pain intensity at rest (SPADI; 0 to 100%)												
3	RCT	serious[a] (-1)	serious[b] I^2 = 62% (-1)	not serious[c] (0)	not serious[d] (0)	no (0)	100	131	–	MD 4.9 % lower (8.4 lower to 1.4 lower)	⊕⊕○○ low	not important
Shoulder abduction (goniometry; 0 to 180°)												
8	RCT	serious[a] (-1)	serious[b] I^2 = 99% (-1)	not serious[c] (0)	not serious[d] (0)	no (0)	169	200	–	MD 15.3° higher (4.4 higher to 26.1 higher)	⊕⊕○○ low	important
Shoulder flexion (goniometry; 0 to 180°)												
7	RCT	serious[a] (-1)	serious[b] I^2 = 97% (-1)	not serious[c] (0)	not serious[d] (0)	no (0)	139	170	–	MD 12.8° higher (2.5 higher to 23.1 higher)	⊕⊕○○ low	important
Functionality (CMS: 0 to 100 points)												
4	RCT	serious[a] (-1)	not serious[b] I^2 = 0% (0)	not serious[c] (0)	not serious[d] (0)	no (0)	110	113	–	MD 4 points higher (1.7 higher to 6.2 higher)	⊕⊕⊕○ moderate	not important

CI – confidence interval, CMS – Constant-Murley Scale, MD – mean difference, PT – physical therapy, SPADI – Shoulder Pain and Disability Index, RCT – randomised controlled trial, VAS – visual analogue scale

[a] The high RoB was linked to the measurement of outcome data (57.7%) and bias due to deviations from the intended intervention (26%).

[b] The heterogeneity determines the inconsistency, depending on the I^2 statistic (≥ 50%).

[c] Considering a direct comparison of interventions and outcomes relevant to the study, with applicability to the clinical context, it was found that the indirect evidence held little significance.

d Imprecision was assessed by examining the width of the confidence intervals (CIs) for the pooled MD, the crossing of the no-effect line in the meta-analysis, and the sample size (n < 200).

[e] Importance was gauged based on whether the pooled effect, expressed as MD, met a value recognised in the literature as a clinically important change (MCID).

option for addressing SAIS, offering therapeutic benefits without the associated drawbacks of more invasive procedures or LLLT. In essence, HILT provides a promising alternative for the management of this clinical condition.

This SR aimed to assess HILT's analgesic effects in SAIS patients compared to other physical therapies. The primary findings indicate potential effectiveness in reducing pain, improving functionality, and improving ROM in shoulder abduction and flexion. However, due to heterogeneity among RCTs and methodological issues, a cautious interpretation is necessary, influencing the overall recommendation based on the evidence.

HILT and shoulder pain

This SR shows the effectiveness of HILT in reducing pain among SAIS patients. HILT exhibits a significant reduction of –1.4 cm (95% CI: –2.0, –0.8) when compared to other treatments, including isolated exercise [30, 31, 33, 36, 37, 42], exercise combined with phonophoresis [37], ultrasound [17, 18, 30], thermotherapy [21], TENS [21], and HILT placebo [34]. Notably, this pain reduction surpasses the CMID threshold (CMID = –1.4 cm) established for individuals with rotator cuff injuries [44]. Nonetheless, while clinically meaningful reductions in pain intensity were noted even at 1- and 3-month follow-ups, there were no statistically significant differences compared to conventional physical therapy interventions. This implies that HILT is effective in the short and medium term, but other treatments may produce similar effects, albeit with a delay. These findings regarding HILT's effects on pain intensity with VAS align with prior research on LLLT in shoulder tendinopathies. These studies have found that laser therapy reduces pain by –1.3 cm (95% CI: –1.7 to –2.4) and –2.4 cm (95% CI: –1.3 to –2.8) compared to other physical or exercise therapy methods and sham LLLT, respectively [11]. This suggests similar analgesic effects and supports the idea that these lasers share a common physical mechanism of action. However, more research is needed to directly compare the effectiveness of HILT and LLLT, as no study in the review conducted such a comparison. These findings endorse laser therapy's efficacy in alleviating shoulder pain, resulting in an important GRADE rating despite some uncertainty due to bias and variability. Currently, HILT is regarded as a clinically equivalent alternative to LLLT, making the choice between

these approaches contingent on resource availability, cost considerations, or individual patient preferences.

The VAS outcomes align with those from the SPADI subscale, where HILT exhibits a greater pain reduction compared to the control treatment, with a difference of –5.0% (95% CI: –8.4, –1.39). It's worth noting that this difference falls below the CMID threshold of 14 to 20% that is established for the SPADI [45]. It should be considered that only three studies utilised the SPADI subscale [20, 21, 30], rendering the VAS results more reliable. Notably, no significant discrepancies in pain intensity at treatment completion emerged in the HILT versus placebo comparison. Notably, this analysis hinged on just two studies [34, 42], highlighting the need for more extensive research for definitive outcomes.

In patients with SAIS, an important clinical metric is the Patient Acceptable Symptom Status (PASS) Assessment, which employs VAS scores to identify the highest symptom level deemed acceptable by patients. An average PASS of 3 cm has been established as acceptable (95% CI: 2.3, 3.7). While not directly assessed in the referenced RCTs, the pain intensity at the end of treatment aligns with the acceptable PASS for several RCTs [17, 18, 30, 31, 37].

In SAIS rehabilitation, exercise integration is crucial due to the central role of muscle weakness [46, 47]. Several RCTs in this study integrated exercises within HILT protocols. Given that there is a strong link between SAIS and rotator cuff and postural muscle weakness, physical therapy is very important for three very important reasons: managing symptoms (using HILT or other methods), strengthening muscles, and postural re-education [46].

HILT and ROM

The results show that HILT is better than traditional physical therapy at increasing the ROM of the shoulder in flexion and abduction by an average of 15.3° (95% CI: 4.4–26.1) and 12.9° (95% CI: 2.5–23.1), respectively. These improvements are greater than the minimal detectable change (MDC), which is 8° for flexion and 4° for abduction [48], and align with the MCID reported, ranging from 11° to 16° [49]. Increased shoulder flexion and abduction influence scapular plane arm lifting, which is limited in SAIS patients [1, 5]. This movement improves movement patterns, strengthens the rotator cuff, and prevents injuries [50].

The thermal and analgesic benefits of HILT increase ROM. Heating the tissues relaxes muscles and interrupts the cycle of painful muscle spasms [51, 52]. At the same time, pain reduction diminishes abnormal afferent information that affects movement performance [53]. Since it was applied directly to the deltoid, which controls abduction and flexion, the HILT likely had a greater effect on ROM. Importantly, focused HILT administration to specific rotator muscles may improve shoulder rotation. The limited number of RCTs on the rotation ROM may make it difficult to draw conclusions.

Although HILT can enhance movement, it is recommended to combine it with more targeted interventions, such as exercises or manual therapy, for optimal results [54].

HILT and disability

According to SPADI and CMS, HILT is effective in reducing disability by –6.6% (95% CI: –12.5, –0.6) and enhancing functionality by 4 points (95% CI: 1.7, 6.2), respectively. In patients with rotator cuff injuries, the SPADI values for disability are lower than the MCID (8 to 13 points, or 10 to 16%), while the CMS values for functionality are concordant with the MCID (2 to 16 points) [55, 56].

Disability has gained increasing importance in clinical trials. This outcome is crucial, as treatments should not only evaluate the influence of symptoms on functionality, a relevant aspect for patients [57]. Although HILT is primarily intended to alleviate pain, its secondary effect on disability is significant, as pain frequently induces a dread of moving that restricts functionality. Furthermore, this dread of movement frequently contributes to the condition's chronicity [58–60].

Recommendations

This review emphasises the variability of parameters in the use of HILT in studies, which makes establishing a standard dose challenging. Nevertheless, a dosage based on common parameters is proposed: wavelength 1064 nm, average power 8–12 W, total energy 3050 J for three phases (1000 J, 50 J, and 2000 J), continuous mode for phases 1 and 3, pulsed mode for phase 2, scanning application on the deltoid (phases 1 and 3), and punctual on pain spots (phase 2).

Furthermore, the number of sessions should range between 12 to 15 over the course of four weeks. To improve treatment outcomes, it is suggested that resistance and postural exercises be added to HILT [46, 47, 54]. In addition, the literature suggests investigating approaches that incorporate the neuroscience of pain, motor imagery techniques, and behavioural modification, especially in chronic pain [46].

Limitations

This SR underscores its commitment to transparency, aligning with the rigorous PRISMA guidelines and ensuring the registration of the protocol in PROSPERO. However, it is imperative to recognise certain inherent limitations.

(1) The inability to exclude articles in languages other than English and Spanish represents a notable constraint, given the multinational origin of randomised controlled trials (RCTs), spanning countries like Turkey, Iran, India, and Taiwan. The potential existence of pertinent articles in other languages, particularly within the 'grey literature', introduces a degree of limitation [61]. Similarly, efforts should be directed towards mitigating this issue, considering the use of eight search sources, with some encompassing grey literature, notably Google Scholar.

(2) Confronting substantial heterogeneity among the included studies has rendered the formulation of more conclusive findings regarding the evidentiary support for HILT addressing pain, ROM, and disability a complex task.

(3) Methodological limitations, including challenges related to bias due to deviations from the intended intervention or measurement of the outcome data, observed in certain RCTs warrant acknowledgement, as these aspects may exert an influence on the robustness and interpretability of the reported results.

Conclusions

This review supports the efficacy of HILT in reducing pain in patients with SAIS. Significant improvements in shoulder flexion and abduction are observed, as well as a decrease in associated disability. These results are consistent with previous reviews on LLLT, supporting the validity of both treatment options. However, additional comparative studies are needed for a more precise evaluation of the effectiveness of both types of therapeutic lasers.

The authors highlighted the importance of evidence, but methodological inconsistencies in some RCTs affecting the certainty of results must be considered.

Ethical approval

The conducted research is not related to either human or animal use.

Disclosure statement

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Conflicts of interest

The authors state no conflicts of interest.

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Appendix 1

Search strategy (last updated January 8, 2025)

Keywords		Identification of studies via databases and registers							Identification of studies via other methods	Total
		PubMed	Scopus	WoS	CINAHL	Science Direct	Cochrane Library	PEDro	Google Scholar	
S1	*„Lasers"*	5,040	1,152,633	163,427	10,623	1,000,197	25,963			2,357,883
S2	*„Laser Therapy"*	4,404	33,219	11,229	12,021	8,887	7,707			77,467
S3	*„Phototherapy"*	1,869	27,709	11,049	6,772	11,021	4,048			62,468
S4	*„High-intensity Laser Therapy"*	70	158	128	94	25	217			692
S5	*„Class IV laser"*	6	34	22	14	61	31			168
S6	S1 OR S2 OR S3 OR S4 OR S5	9,526	1,174,871	182,228	25,681	1,020,191	29,578			2,442,075
S7	*„Musculoskeletal Pain"*	1,141	14,839	12,232	5,180	11,358	3,237			47,987
S8	*„Shoulder Pain"*	1,535	20,068	8,404	7,064	11,063	4,827			52,961
S9	*„Shoulder Impingement Syndrome"*	373	2,800	555	1,609	553	891			6,781
S10	*„Joint Diseases"*	909	31,617	4,141	10,599	23,405	2,474			73,145
S11	*„Rotator Cuff Tear Arthropathy"*	6	654	123	54	457	54			1,348
S12	S7 OR S8 OR S9 OR S10 OR S11	3,682	67,033	24,628	23,528	44,201	10,777			173,849
S13	S7 OR S12	42*	483*	108*	201*	2,087*	231*	7**	12,600** (15 articles found)	3,174

* search algorithm used for formal databases: *("Lasers" OR "Laser Therapy" OR "Phototherapy" OR "High Intensity Laser Therapy" OR "Class IV laser") AND ("Musculoskeletal Pain" OR "Shoulder Pain" OR "Shoulder Impingement Syndrome" OR "Joint Diseases" OR "Rotator Cuff Tear Arthropathy")*
** manually searched