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Effects of High Versus Low Laser Therapy on Osteoarthritis: A Systematic Review of Global Randomized Controlled Trials and Local Studies Within Saudi Arabia

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Abstract

Osteoarthritis (OA) mangment often fall short, carry risks, or provide insignificant symptomatic benefits. One non-invasive treatment is laser-therapy, which has been gaining attention for its potential to modulate inflammation and enhance tissue repair, thus making it a potential therapy for OA. This systematic review aims to evaluate the efficacy of various laser therapy parameters and compare them to conventional treatments in Saudi Arabia while compiling and analyzing global studies. A systematic search was conducted for randomized controlled trials. Studies involving laser therapy for osteoarthritis of any joint were included. Data were extracted on laser specifications, outcomes, and adverse effects. Non-parametric statistical analyses were applied due to non-normal data distribution, and qualitative synthesis was performed to interpret the results. Fifty studies were included, comprising seven local papers from Saudi Arabia. Low-power laser therapy was the most used. This therapy led to significant improvements in pain and function, particularly when combined with exercise, and there were very few reported side effects. However, the evidence was limited due to differences in study design and small sample sizes. Laser therapy shows great potential as a non-invasive treatment for osteoarthritis. Standardized protocols and robust trials must confirm this and define its role in clinical practice.

Keywords: Osteoarthritis; Arthritis; Pain, Stiffness; Subchondral bone; Synovium; Joint; Bone spurs; Soft tissue; Cartilage

Introduction

Osteoarthritis (OA) remains the most common form of arthritis despite the presence of aspects that overlap with those of other arthritic conditions, such as persistent pain, stiffness, and loss of mobility, especially among the elderly [1]. The major objective is to understand the pathophysiological differences, one of which is the progressive destruction of the representative, joint surface and cartilage, together with gross changes within the subchondral bone, synovium, and other joint structures. Such changes lead to the development of bone spurs and shrinkage of soft tissue and cartilage, which can be seen as a narrowing of joint spaces during imaging replacement [2]. The end result is ultimately dysfunction regarding the compromised joint as well as excruciating pain. When it comes to causation, much is known about how OA is an effect of a great number of processes, including not only mechanical and biological but also metabolic and genetic factors that explain the complexity of this disease.

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The primary goals of traditional OA management put emphasis on symptom control and improving patients' quality of life [3]. Currently, the most common therapeutic approaches include pharmacological treatments such as analgesics and non-steroidal anti-inflammatory drugs (NSAIDs), physical therapy, and, in worst-case scenarios, surgical interventions like arthroplasty [4]. However, despite these treatment modalities, many patients continue to experience unabated pain and functional restraints. What is calling for, therefore, are other forms of therapy that have less adverse effects, especially on the side of pain management, and which do not involve operating or taking drugs for a long time [5].

In recent years, laser therapy has garnered attention as a promising non-invasive treatment option for OA. Laser therapy utilizes specific wavelengths of light to penetrate soft tissues, with the aim of inducing the natural healing process within our own body, which involves liberating agents of inflammation involved in healing and repair without the collateral damage as is often seen in inflammatory processes. Laser therapy was initially employed in dermatology, dentistry, and ophthalmology, but its mechanisms of action, that being, decreasing inflammatory markers, enhancing cellular repair, and modulating pain, exhibit its potential applicability in musculoskeletal conditions like osteoarthritis.

This study attempts to answer several key questions regarding the use of laser therapy in osteoarthritis mangment. One key investigation is the evaluation of the impact of different laser wavelengths on pain mitigation in patients with osteoarthritis, as variations in wavelength may significantly influence therapeutic outcomes. Additionally, the study aims to comprehend how alterations in the dosage of laser affect the healing of joint function, determining whether higher or lower dosages yield better results in managing osteoarthritic symptoms. Another important consideration is the comparison of outcomes between short-term and long-term laser therapy treatments, which may inform us of the sustainability of symptom relief over extended periods of time; this is important when deciding on the time period for regular treatment. Furthermore, the study investigates whether any significant complications or side effects are linked with the regular use of laser therapy in osteoarthritis management, clarifying its safety profile. Finally, the research will attempt to compare laser therapy with traditional osteoarthritis treatments to find out which of the two holds higher efficacy in the management of symptoms and overall improvement of patient satisfaction. Only from this can we discover viable alternatives to existing therapeutic options.

As interest in non-invasive, non-pharmacological treatments grows, laser therapy has garnered attention, especially for patients who are either unsuitable for surgical intervention or wish to avoid chronic medication use. While several studies have suggested that laser therapy may alleviate OA symptoms, there is still a lack of comprehensive data comparing the effectiveness of different types of laser therapy. Understanding the impact of varying wavelengths, dosages, and treatment durations is critical to establishing optimal treatment protocols, ensuring safety, and verifying clinical efficacy. Thus the primary objective of this study is to assess the efficacy of various forms of laser therapy in mitigation of pain and improvement of joint function in patients with osteoarthritis, with a specific focus on randomized controlled trials (RCTs) conducted in Saudi Arabia. This approach aims to provide insights into local treatment outcomes of the country.

The study will also systematically search for global studies on the subject matter, giving a more updated systematic review to complement the last review conducted some few years ago. This will involve the collection and synthesis of data that includes the effects of different laser parameters, such as wavelength, dosage, and treatment duration, on osteoarthritic symptoms. Furthermore, the study will evaluate the safety and side effect profile of laser therapy, using both local and global data to ensure a proper understanding of its application in osteoarthritis treatment.

The findings of this study will help refine treatment protocols for osteoarthritis, providing evidence-based recommendations for the use of laser therapy. This could guide clinicians in selecting optimal laser parameters (wavelength, dosage, treatment duration) and identifying patient populations who would benefit most from this non-invasive therapy. Furthermore, the safety profile outlined in this study will contribute to risk-benefit assessments in clinical settings, potentially expanding the use of laser therapy as a standard option in OA management.

Methods

This study was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

Eligibility Criteria

The study included all published RCTs that investigated the effectiveness of laser therapy on osteoarthritis in any joint, with the language restricted to English. Only adult patients diagnosed with osteoarthritis, based on the American College of Rheumatology (ACR) criteria or expert opinion from orthopedists or rheumatologists, were considered. Studies comparing different forms of laser therapy, with variations in parameters such as wavelength and exposure time, were included. Participants with severe cognitive impairments or other combined joint disorders were excluded.

Search Strategy

Relevant articles were identified using specific keywords

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such as "osteoarthritis," "degenerative arthritis," "arthrosis," and "OA," along with terms like "high-intensity laser therapy" or "low-intensity laser therapy." The search was conducted using electronic databases, including CENTRAL (Cochrane Central Register of Controlled Trials), MEDLINE, and PEDro (Physiotherapy Evidence Database). Additionally, a manual search of references from selected studies and relevant reviews was performed.

Study Selection

All identified studies were screened, initially by reviewing titles and abstracts, followed by a full-text review to determine eligibility. Our search date was June, 2024, for local studies and August 2024 for global studies. Any studies that did not meet the predefined inclusion criteria were excluded, and reasons for exclusion were documented. A forward and backward citation search was also conducted to identify additional relevant RCTs.

Data Extraction

Data from the eligible studies were extracted, including details such as author, sample size, average age, type of osteoarthritis, laser modality used, therapeutic effects, and adverse effects.

Data Analysis

Data was analyzed using SPSS software after importing from Microsoft Excel. The data on normality and homogeneity was first tested. While mostly homogenous, the data did not follow normality, and thus, only non-parametric tests were conducted, such as Kruskal-Walis. The chi-square test was conducted between nominal and continuous variables, while the bivariate correlation was conducted between continuous variables only. Qualitative analysis was also carried out to assess the evidence for symptomatic relief from laser therapy, taking into account the clinical heterogeneity and methodological quality of the studies. The interventions were grouped into high, low, or other laser therapies as per Cochrane Collaboration criteria.

Results

A total of seven studies conducted locally in Saudi Arabia were identified, alongside 43 randomized controlled trials (RCTs) from global sources (Figure 1).

Type of Osteoarthritis

All 7 local studies focused exclusively on the knee joint. Globally, the majority of studies (76.7%) involved males with knee osteoarthritis. Meanwhile, 4 studies (9.3%) investigated the temporomandibular joint, 3 (7.0%) focused on hand osteoarthritis, 2 (4.7%) examined cervical spine osteoarthritis, and only 1 (2.3%) study targeted the hip joint (Figure 2).

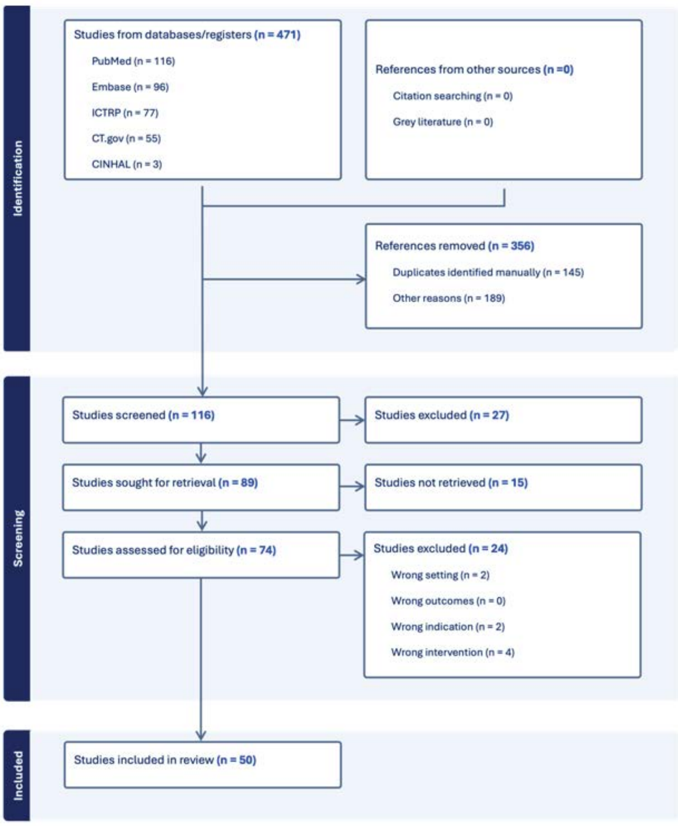

Figure 1: PRISMA Flowchart.

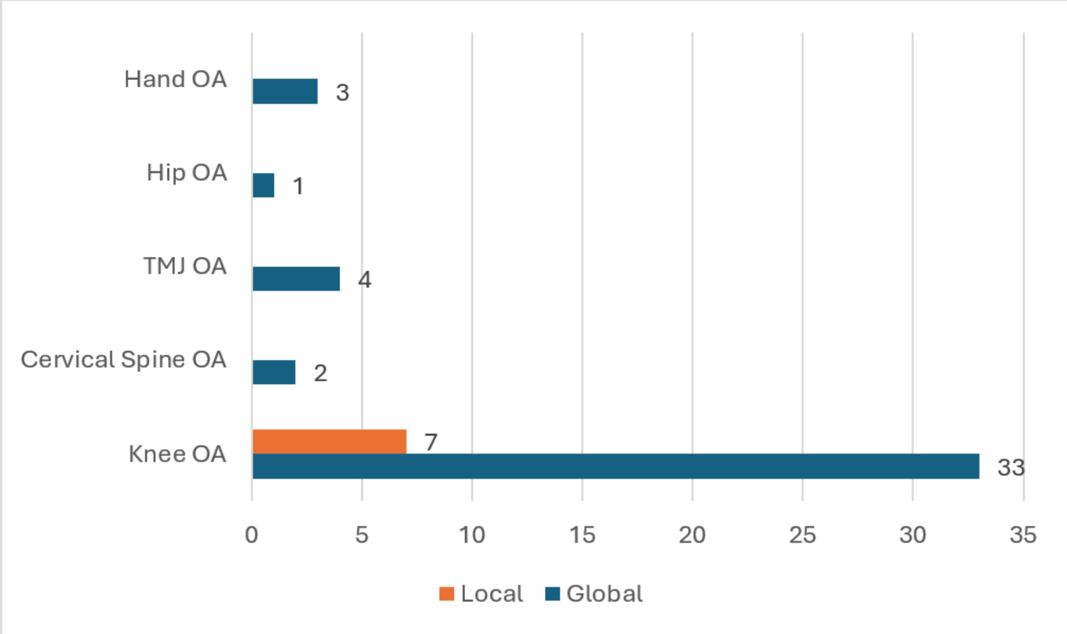

Figure 2: Subtypes of osteoarthritis found amongst studies.

Temporomandibular Joint

Among the four studies involving the temporomandibular joint (TMJ), two reported significant improvements in pain and function following mid-level laser therapy at a wavelength of 904 nm, administered three times a week for three weeks ($p<0.05$). Of the remaining two studies, one observed a slight improvement in pain and function after low-level laser therapy, while the other reported no significant changes in any parameter ($p>0.05$).

Thumb Carpometacarpal Joint

The three studies focusing on hand osteoarthritis each utilized different laser modalities. The study employing high-power laser therapy demonstrated a significant reduction in pain at the end of treatment ($p<0.001$). In contrast, the study using low-power laser therapy reported improvements in carpometacarpal opposition ($p=0.001$) and grip strength ($p=0.041$). Lastly, the study utilizing helium laser therapy documented a slight decrease in tenderness of the metacarpophalangeal and interphalangeal joints ($p<0.01$ and $p<0.05$, respectively).

Cervical Joint

Of the two studies examining cervical spine osteoarthritis, one reported a significant reduction in muscle spasms following low-power laser therapy at a wavelength of 830 nm, delivered over 10 sessions ($p<0.05$). However, the other study found no significant improvement when comparing laser therapy to the Saunders method of physiotherapy ($p>0.05$).

Hip Joint

The single study focusing on the hip joint reported significant improvements in pain and inflammatory markers after photobiomodulation therapy using low-level laser therapy and low-emission diodes (LED) ($p<0.05$).

Type of Intervention & placebo

There was a notable lack of studies directly comparing high-power and low-power laser therapies. Instead, most research focused on low-power laser therapy, either as a standalone treatment or in combination with other modalities such as exercise or pharmacological agents.

For the local studies, 3 (42.9%) investigated low-power laser therapy alone, while 2 (28.6%) examined low-power laser therapy combined with another modality. One study (14.3%) explored high-power laser therapy in combination with another modality, and only one made a direct comparison between low-power and high-power laser therapy.

Globally, 9 studies (20.9%) evaluated low-power laser therapy alone, while 12 (27.9%) investigated low-power laser therapy combined with another modality. There were 7 studies (16.3%) that focused on high-power laser therapy, and only 1 study (2.3%) assessed high-power laser combined with another modality. Additionally, 5 studies (11.6%) evaluated moxibustion laser therapy, 4 (9.3%) examined acupuncture laser therapy, and 3 (7.0%) explored combinations of photobiomodulation (Figure 3).

The most common comparator in these studies was a

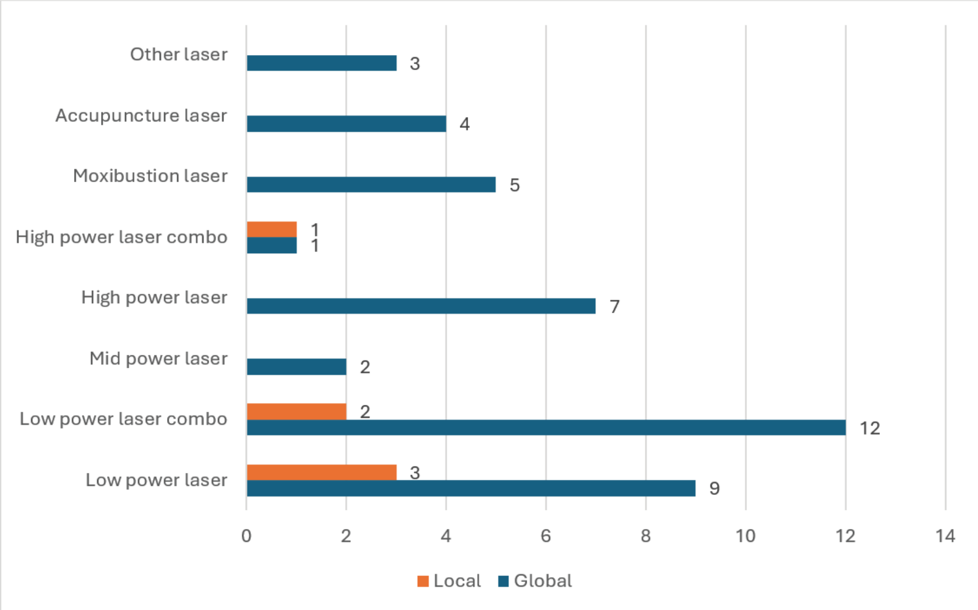

Figure 3: Different types of laser intervention amongst studies.

sham or placebo laser, used in 27 studies (62.8%). Of these, 9 (20.9%) used a sham laser in combination with other interventions. Only one study (2.3%) directly compared interventions without a placebo, while 6 studies (14.0%) did not include any comparator.

Outcomes

Laser versus Placebo

In terms of the superiority of intervention, all 7 local studies reported laser therapy as superior to placebo. Globally, 27 studies also found laser therapy to be more effective than placebo, while 5 studies reported no significant improvement when compared to placebo (Figure 4). Among studies comparing multiple laser modalities, 8 reported differences in efficacy between lasers, whereas 3 found no significant differences in performance.

Pain and Function Scales

Among the local studies, one study reported a significant improvement in the Visual Analog Scale (VAS) score after 4 weeks of laser therapy ($p<0.05$). Another local study demonstrated a significant improvement in VAS score after 6 weeks of treatment ($p=0.0014$), while three studies observed very significant improvements in VAS scores after 6 weeks ($p<0.0001$).

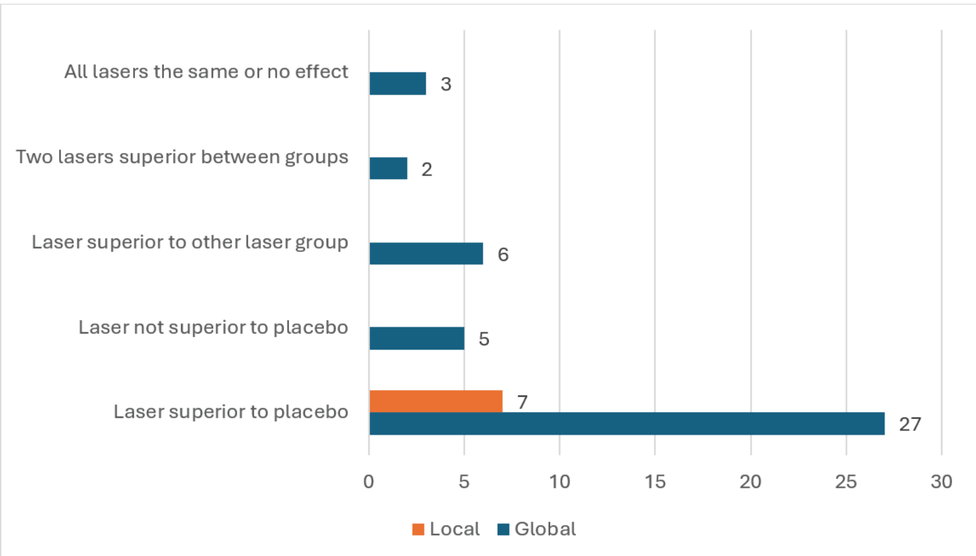

Figure 4: Different outcomes recorded from global studies.

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Globally, despite variations in pain assessment scales across studies, 9 out of 43 studies reported significant changes in VAS pain scores after laser therapy ($p<0.05$), while 3 studies reported very significant changes ($p<0.0001$). Additionally, 9 studies documented significant improvements in the Western Ontario and McMaster Universities Arthritis Index (WOMAC) score ($p<0.05$), while 4 studies reported very significant improvements ($p<0.01$) after laser therapy.

Modality Used in Combination

For studies combining laser therapy with other modalities, 3 local studies showed significant improvements in pain and movement when exercise was performed concurrently with laser therapy ($p<0.05$). Globally, 6 studies similarly reported significant improvements in pain and movement when exercise was combined with laser therapy ($p<0.05$). Furthermore, one global study highlighted several significant outcomes, including improvements in cadence ($p<0.009$), reductions in the duration of right limb support ($p<0.035$), and enhancements in gait speed ($p<0.005$).

Laser properties (Wavelength & sessions per weak)

The most commonly used wavelength range was between 800-1000nm, the average sessions done per week was 3 and the average duration was 5 weeks. A trend was noticed where a longer duration of therapy was matched with shorter sessions (Figure 5). Of the global studies that administered laser therapy at 3 sessions per week, 22 reported a positive outcome on at least one scale. The degree of watts used was highly variable and did not contribute to the significance of outcomes, despite the statistical analysis showing a significant change in watts with the choice of intervention ($p=0.025$). The same was true for change in wavelength with choice of intervention ($p=0.007$). Additionally, statistical analysis showed a significant correlation between the condition and mean age ($p=0.046$), condition, and sessions per week ($p=0.046$).

Adverse effects & Long-term outcomes

Studies did not explicitly report adverse effects, and of those that did, only mentioned warmness and irritation but these were not significant ($p>0.05$). Despite a few patients needing re-therapy, long-term outcomes were not given focus amongst the majority of studies.

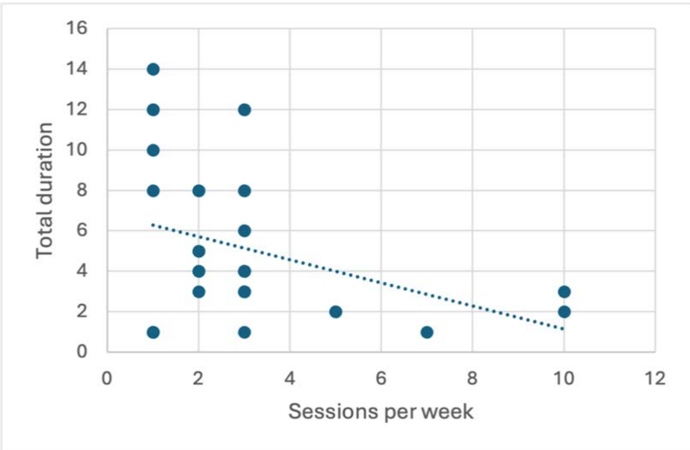

Figure 5: Total duration of therapy matched with sessions per week.

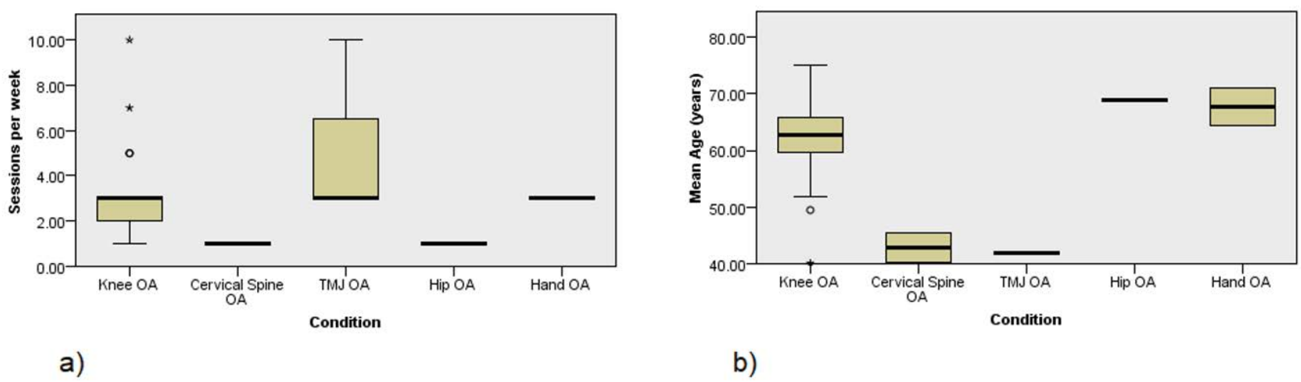

Figure 6: Independent sample Kruskal Walis test for global studies. a) Distribution of sessions per week across condition; b) Distribution of mean age (years) across condition.

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Statistical analysis

Normality testing using Sharpiro-wilk for both local and global studies showed that the data was not normally distributed ($p<0.05$). In comparison, homogeneity testing was significant ($p<0.05$) for a few factors but not overall.

Amongst global studies, independent samples of Kruskal walis showed significance in the distribution of mean age ($p=0.46$) and the distribution of sessions per week ($p=0.46$) across all categories of condition (Figure 6). Similarly, it also showed significance in the distribution of sample size ($p=0.48$), Watts ($p=0.25$), and wavelength ($p=0.007$) across all categories of intervention.

The chi-square between outcomes and intervention amongst global and local studies did not show any significance ($p=0.744$). Amongst local studies, Pearson's correlation was significant between the duration of therapy, number of males, and sessions per week used ($p<0.01$) (Table 1). Amongst global studies, Pearson's correlation was significant between sample sizes, number of males, and wavelength used ($p<0.01$) (Table 2). The entire synthesis of local and global studies is shown in Tables 3 and 4.

Risk of bias

Amongst local studies, only 3 studies raised concerns, despite the overall low risk of bias (Figure 7,8). The issue was mostly with what outcomes were considered and how they were recorded. Furthermore, a few weaknesses in the methodology lowered the overall robustness of the studies, leading to further suspicion of bias towards certain outcomes.

Table 1: Pearson's correlation for local studies.

		Duration (weeks)	Sessions per week	Wavelenght (nm)	Watt (mW)	Mean Age (years)	Males	Sample Size
Duration (weeks)	Pearson Correlation	1	-0.89	0.491	0.475	0.010	0.773	0.370
	Sig. (2-tailed)		0.007	0.263	0.341	0.983	0.042	0.414
	N	7	7	7	6	7	7	7

Table 2: Pearson's correlation for global studies.

		Watt (mW)	Wavelenght (nm)	Sessions per week	Duration (weeks)	Mean Age (years)	Males	Sample Size
Wavelenght (nm)	Pearson Correlation	-0.013	1	0.011	-0.016	0.044	0.862	0.882
	Sig. (2-tailed)	0.950		0.954	0.932	0.836	0.000	0.000
	N	28	29	29	29	25	26	29

Table 3: Synthesis of data from local studies.

Study Author	Sample Size	Gender Ratio (M/F)	Mean Age (years)	Condition	Intervention	Laser Specifications	Dosage	Comparator	Outcomes		Limitations
Al-Rashoud et al. [6]	49 (26 vs 23)	18/31	54	Knee osteoarthritis	active LLLT	Gallium aluminium arsenide laser device (30mW. 830nm wavelenght)	9 sessions (interval not mentioned)	placebo LLLT	VAS score improved in active laser group	mean -1.3 at 6 weeks (p=0.0014)	Lack of standard protocols for inclusion and exclusion criteria.
										mean -1.8 at 6 months (p=0.0003)	No standard therapy programmes regarding dose, period, type of laser and therapy application.
									SKAS score higher in active laser group	median -15 at 6 weeks (p=0.0035)	
										median -21 at 6 months (p=0.0006)	

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Al-Zahrani et al. [7]	30 (15 vs 15)	13/17	44.5	Knee osteoarthritis	Exercise + Laser therapy	(120V infrared, 904x10m wavelenght)	3 times a week for 4 weeks	Exercise	Range of motion improved in study group. Pain reduced in study group. No change in muscle strenght.	p<0.00001	Does not account for physicial limits amongst patients in performing exercises. Only range of motion accounted for.
Alayat et al. [8]	67	67 male only	53.85	Knee osteoarthritis	Group 1 (HILT + GCS + EX) Group 2 (GCS + EX)	Nd:YAG laser (10.5mW, 1064nm wavelenght)	2 times a week for 6 weeks	Group 3 (PL + EX)	VAS and WOMAC were significantly decreased in all groups after 6 weeks. ST was significantly decreased in Group 1.	p<0.0001	Withdrawal of patients during experiment. No report of deficiency in exercise from homes.
Al-ghadir et al. [9]	40 (20 vs 20)	23/18	56	Chronic Knee osteoarthritis	active LLLT	(50mW, 850nm wavelenght)	2 times a week for 4 weeks	placebo LLLT	VAS and WOMAC improved significantly in active laser group groups	VAS: 4.45±1.19 vs 6.05±1.35 (p<0.05) WOMAC: 3.25±2.61 vs 5.5±2.5 (p<0.05)	Small sample size, short follow up period
Gopal Nambi et al. [10]	34 (17 vs 17)	45836	59	Knee osteoarthritis	active LLLT + kinesio tape	FISIOLASER SCAN - Ga As diode laser (25mW, 905nm wavelenght)	3 times a week for 4 weeks	placebo LLLT + kinesio tape	Contact area, cartilage thickness	Contact area (lateral): 35.87 ± 32.76 vs. 75.87 ± 32.56 at 8 weeks (p <0.05) Cartilage thickness: -2.34 ± 10.22 vs. -1.74 ± 9.45 at 8 weeks (p<0.05)	Small sample size, absence of control group

Keshie et al. [11]	53	53 male only	54.6	Knee osteoarthritis	Group 1 (HILT+EX), Group 2 (LLLT+EX)	Group 1: Nd:Yag laser Group 2: Gallium-arsenide diode (800mW, 830nm wavelenght)	2 times a week for 6 weeks	Group 3 (PL + EX)	All treatment groups showed a significant reduction in VAS and WOMAC subscales after 6 weeks	VAS: 2.15±0.75 vs 2.97±0.848 vs 3.93±0.703 at 6 weeks (p>0.0001) WOMAC pain: 3.15±1.1 vs 36 4.77±1.11 vs 6.26±1.22 at 6 weeks (p>0.0001)	All patients were male only, and sample size was small.
S GN et al. [12]	34 (17 vs 17)	45836	59	Knee osteoarthritis	active LLLT	FISIOLASER SCAN HP4, EL12079-A01, Ga As super pulsed laser (25mW, 905 nm wavelenght)	3 days a week for 4 weeks	placebo LLLT	After 4 and 8 week treatment, active laser Active LLLT group shows more significant difference in VAS, MMP-3, 8, 13, and CTX-II.	VAS: 1.2 ± 0.2 vs 6.8 ± 1.3 (p<0.0001) CTX-II: 0.20 ± 0.01 vs 0.23 ± 0.02 (p<0.0001)	Small sample size, lack of control group, and short follow up time

Table 4: Synthesis of data from global studies

Study Author	Sample Size	Gender Ratio (M/F)	Mean Age (years)	Condition	Intervention	Laser Specifications	Dosage	Comparator	Outcomes		Limitations
Akaltun et al. [13]	40	12 / 29	58.24 ± 9.73	Knee osteoarthritis	Group 1 (HILT), Group 2 (EX)	BTL-6000 High Intensity Laser (12 W, 1064 nm wavelength) Nd:YAG Laser	5 sessions per week for 2 weeks	Group 3 (PL + EX)	VAS, WOMAC scores, femoral cartilage thickness, and FROM improved significantly.	p<0.05	Low number of patients who were not followed up for long terms, and the exercise status of the patients was not questioned.

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Alfredo et al. [14]	40	9 / 31	62.5	Knee osteoarthritis	active LLLT	gallium arsenide (60mW, 904 nm wavelenght)	3 times a week	placebo LLLT	The laser group had significant improvement in VAS & WOMAC between T1 and T2 and between T2 and T3. There was also significant improvement in range of motion and functionality between T2 and T3.	VAS ($p < 0.05$) & WOMAC ($p < 0.001$) between T1 and T2 and between T2 and T3 ($p=0.001$). ROM ($p=0.01$) and functionality ($p= 0.001$) between T2 and T3.	The small number of patients, the absence of a control group, and the absence of followup.
Alfredo et al. [15]	40 (20 vs 20)	-	-	Knee osteoarthritis	active LLLT + Ex	-	10 sessions over 3 weeks followed by 8 weeks of exercise	placebo LLLT + Ex	Daily consumption of rescue analgesics was significantly lower in the LLLT group at 6 months	$p<0.05$	Small sample size, short follow up.
Alfredo et al. [16]	40 (20 vs 20)	7 / 33	62.22	Knee osteoarthritis	active LLLT + Ex	gallium arsenide (60mW, 904 nm wavelenght)	3 times a week for 3 weeks, then combined LLLT + EX for 8 weeks in both groups	placebo LLLT + Ex	Reduced pain, disability, and intake of medication over a six-month period	Pain scores: 9.1 (1.3), 2.6 (2.3), 0.2 (0.9) and 0.2 (0.8) for the Laser Group 9.5 (8.0), 7.7 (5.3), 5.6 (2.4) and 7.4 (5.0) for the Placebo Group at 0,3,11 weeks and 6 months. Disability scores: 14.9 (4.7), 7.6 (4.8), 3.9 (4.2) and 3.5 (4.1) for the Laser Group 17.8 (14.7), 15.2 (11.5), 11.6 (6.4) and 15.8 (11.9) for the Placebo Group at 0,3, 11 weeks, and 6 months.	Small sample size, absence of true placebo group

Amendolia et al. [17]	90 (45 vs 45)	53 / 37	55±11.2	Knee osteoarthritis	HPLT+GS 1500mg	GS - Dona (905nm wavelength, 4.5 W)	12 sessions, 3 per week	HPLT + Placebo	VAS, ADL, SSCT, Zohlen's sign, (RASPING), & Rabot test showed significant difference between groups at 6 months	p<0.05	-
Angelova et al. [18]	72 (37 vs 35)	-	65	Chronic Knee osteoarthritis	HILT	Semiconductive neodymium laser IV produced by BTL (1064 wavelenght, 12 W)	7 sessions	Sham laser	VAS and dolorimetry decreased significantly in the therapeutic group after seven days	p<0.001	Low sample size, lack of assessment of structural changes
Basford et al. [19]	81	-	-	Thumb Osteoarthritis	Helium Neon Laser	HeNe 0.9mW	3 times a week for 3 weeks	Sham laser	Slightly lessened tenderness of the treated MCP and IP joints in laser group. Small increase in three-finger chuck pinch strength in laser group.	MCP: p<0.01 IP: p,0.05 Three finger chuck p<0.04	-
Bertolucci et al. [20]	32	-	-	TMJ degenerative joint disease	Mid laser treatment	COMBY -I infra-red laser (904nm wavelenght, 27 W)	9 sessions, 3 per week for 3 weeks	Placebo laser	Improvement in pain and biomechanics	p<0.01	-
Bertolucci et al. [21]	48 (16 vs 16 vs 16)	-	-	TMJ degenerative joint disease	Group 1: MENS Group 2: Mid Laser	COMBY -I infra-red laser (904nm wavelenght, 27 W)	9 sessions, 3 per week for 3 weeks	Group 3: Placebo laser	Both MENS and Mid-laser produced more significant changes than placebo, but Mid-laser treatment produced larger mean changes in PI and rTVO than MENS.	MENS: p<0.01 Mid-laser: p<0.05	-
Brosseau et al. [22]	88 (42 vs 46)	19 / 69	64.5	Hand Osteoarthritis	active LLLT	Eriel laser, top laser 250, class IIIb (860nm wavelenght, 60mW)	3 sessions a week for 6 weeks	Sham LLLT	Carpometacarpal opposition (P = 0.011), grip strength, and patient global assessment improved in active LLLT participants.	Carpometal opposition (P = 0.001) Grip strenght (P = 0.041) Patient global assessment (P=0.041)	-
Cantero-Tellez et al. [23]	43 (22 vs 21)	All female	71 ± 12	Thumb carpometacarpal Osteoarthritis	HILT	Class IV K-Laser, Mod. K1200 (Eltech K-Laser S.r.l.) (800 nm + 970 nm wavelenght, 3 W)	3 times a week	Placebo laser	LT group had greater reduction in VAS at end of intervention as well as at 12 week	(P < 0.001)	All female group, no combination therapy, short follow-up, no assessment of functional outcomes

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Chen et al. [24]	309 (158 vs 151)	77 / 232	64	Knee osteoarthritis	LM	SX10-C1 CO2 laser moxibustion (16um wavelenght, 16-18 W)	3 times a week for 4 weeks	Placebo LM	In LM group, 15-m walking times at both Week 4 and Week 12 were significantly reduced after treatment. LM group exhibited shorter 15-m walking times than placebo.	p<0.05	Study conducted at multiple sites, only two acupoints used, no assurance patients kept diary.
de Matos Brunelli Braghin et al . [25]	60 (15 vs 15 vs 15 vs 15)	13 / 47	60	Knee osteoarthritis	Group 1: Laser Group (LG) Group 2: Exercise Group (EG) Group 3: LG + EG	low-level laser (Photon Lase III, DMC, Sao Carlos, Brazil) (808nm wavelength, 100mW)	2 times a week for 2 months	Group 4: Control group	LG + EG showed best results	WOMAC: EG in pain (p = 0.006) and function (p = 0.01) LG+EG showed increase in the cadence (p = 0.009) and duration of single right limb support (p = 0.04). LG+EG and EG groups showed decrease in the duration of right limb support (p = 0.035 and p = 0.003) All groups showed improvement in gait speed after 8 weeks: LG versus CG (p = 0.03); EG versus CG (p = 0.04) and LEG versus CG (p = 0.005).	
de Oliveira et al. [26]	45 (15 each)	All female	69.3	Knee osteoarthritis	Group 1: LLLT Group 2: NMES Group 3: LLLT + NMES	THOR DD2 Control Unit (λ = 810 nm, 200 mW) infrared gallium-aluminium-arsenide diode laser probe	2 times a week for 8 weeks	-	Muscle thickness and anatomical cross-sectional area increased in the electrical stimulation and combined groups. All groups presented similar improvements in torque, electrical activity and health status	p<0.05	Absence of control group, all females, small sample size

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de Paula Gomes et al. [27]	60 (20 each)	5 / 55	65.5	Knee osteoarthritis	Group 1: Ex Group 2: Ex + Phototherapy	nine-diode cluster device: one 905 nm super-pulsed diode laser, four 875 nm LED and four 640 nm LED	2 times a week for 5 weeks	Group 3: Ex + Placebo phototherapy	Group 2 was better than Group 1 and 3 only with regard to the NRPS	p<0.05	Small sample size, mostly female
de Paula Gomes et al. [28]	100 (20 each)	8 / 92	67	Knee osteoarthritis	Group 1: Ex Group 3: Ex + ICT Group 4: Ex + SDT Group 5: Ex + PHOTO	laserpulse device (Ibramed, Amparo, SP, Brazil)(904nm wavelenght, 70 W)	3 times a week for 8 weeks	Group 2: Ex + placebo	In all groups, there was a significant improvement in all variables (WOMAC, NRPS, PPT, STST) over time, except pressure pain threshold.	p<0.05	Therapists not blinded, no follow-up, only two physiotherapists for evaluations, no control over painkillers
Ekici and Ordahan [29]	60 (30 vs 30)	-	-	Knee osteoarthritis	Group 1: Hotpack, (TENS), exercise Group 2: HILT	10 W	9 sessions, 3 days a week for 3 weeks	Group 3: Sham laser	Decrease in VAC, an increase in flexion range of motion, WOMAC, and femoral cartilage thickness in groups 1 & 2. Increase in the average peak torque flexion muscle strength measurements post treatment and at 3rd month in groups 1 & 2	(p < 0.005) (p<0.05)	-
Elboim-Gabyzom et al. [30]	40 (20 vs 20)	12 / 28	62.85	Knee osteoarthritis	Group 1: LLLT Group 2: PEMFT	-	6 sessions 3 weeks	-	Pain and physical function improved in both groups but PEMFT was more effective in reducing pain at rest, when standing from a sitting position, and when climbing the stairs, and in improving both WOMAC scores and TUG results	(p ≤ 0.0001) (p ≤ 0.0003)	No control over medication use, results not applicable for KOA <2 or >4, no true control

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Fang et al. [31]	86 (43 vs 43)	-	-	Knee osteoarthritis	Group 1: TM Group 2: LM	-	3 times a week for 4 weeks	-	Both LM and TM significantly decreased the WOMAC (pain, function and stiffness) score, VAS score and the 15-m walking time at the end of the trial.	p<0.05	No true control
Gur et al. [32]	90 (30 vs 30 vs 30)	18 / 72	59.43 ± 7.36	Knee osteoarthritis	Group 1: actual LPLT Group 2: actual LPLT + Ex	Ga-As infrared laser, class III b Laser Product, (Frank Line IR 30, Fysiomed Belgium)(904 nm wavelenght, 20W)	10 sessions over 14 weeks	Group 3: placebo laser group + Ex	All parameters improved in Group 1 and 2.	Compared to placebo: All parameters Group 1 (p<0.01) WOMAC Group 2 (p<0.05)	-
Haladaj et al. [33]	150 (75 vs 75)	81 / 69	45.5	Cervical spine OA	Group 1: Saunders method Group 2: HILT	-	-	-	The results obtained by Saunders method remained significantly higher than those obtained when HILT laser therapy	p<0.05	-
Hegedus et al. [34]	27	5 / 22	49.48	Knee osteoarthritis	active LLLT	diode laser (830nm wavelenght, 50mW)	2 times a week for 4 weeks	placebo LLLT	With active LLLT, improvement was found in VAS, circumference, pressure sensitivity, and flexion.	p<0.05	Small sample size, more females
Helianthi et al. [35]	59 (30 vs 29)	34 / 25	69	Knee osteoarthritis	active laser acupuncture	Single-probe gallium aluminum arsenide laser device (Handylaser Trion RJ-Laser®, Waldkirch, Germany) (785nm wavelength, 50mW)	2 times a week for 5 weeks	placebo laser acupuncture	VAS scores were significantly improved in the active laser acupuncture group compared to the placebo group.	VAS improved after 4, 9 sessions and 2 weeks (p<0.0001) Lequesne index improved after 4, 9 sessions and 2 weeks (p<0.0001)	Short follow up
Hinman et al. [36]	282 (71 vs 70 vs 71 vs 70)	143 / 139	63.55	Knee osteoarthritis	Group 1:Needle Group 2: Laser	Standard Class 3B laser (10mW)	12 weeks	Group 3: Sham Laser Group 4: No acupuncture	Compared with control, needle and laser acupuncture resulted in modest improvements in pain at 12 weeks, but not at 1 year.	p<0.05	19% of patients dropping out

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Huang et al. [37]	70 (30 vs 40)	-	73	Knee osteoarthritis	ALLLT	-	-	Sham LLLT	The experimental group displayed better joint flexion and less stiffness on days 2 and 3 than did the control group	p<0.05	-
Ip and Fu [38]	70	1: 2.5	75	Knee osteoarthritis	Group 1: LLLT + Hyaluronic acid injection	GaAlAs semiconductor (810nm wavelength, 20mW)	3 sessions per week for 6 weeks	Group 2: Sham laser + Normal saline injection	1 patient needed knee replacement in Group 1, while 15 needed surgery in Group 2	p<0.05	-
Ip et al. [39]	100	1:1.5	65	Knee osteoarthritis	Group 1: LLLT + Ex + Electrical stimulation + Diathermy	GaAlAs semiconductor (810nm wavelength, 20mW)	3 sessions per week for 12 weeks	Group 2: Ex + Electrical stimulation + Diathermy	1 patient needed knee replacement in Group 1, while 9 needed surgery in Group 2	p<0.05	-
Jankaew et al. [40]	48	10 / 38	68	Knee osteoarthritis	Group1: 808nm laser Group 2: 660nm laser	Laser 808nm wavelenght, 300mW Laser 660nm wavelength, 300mW	3 days per week for 8 weeks	Group 3: Sham laser	Muscle strenght and functional performance was improved in both intervention groups.	Knee extensor strength was more improved in the 808 nm group (p < 0.001) . Knee flexor strenght was improved in the 808 nm (p = 0.009) and sham control groups (p< 0.001). The number of 30 sit-to-stand was increased only in the 660 nm group (p = 0.006).	Small sample size, no combined therapy, short follow up.
Kalo et al. [41]	18	4 / 14	51.8 ± 7.3	Knee osteoarthritis	Neuromuscular exercise	Laser ACUbeam, Laser Acumed GmbH, Beverungen, Germany		placebo laser acupuncture	The MPF pre-post differences of the exercise intervention were higher compared to the MPF pre-post differences of the placebo treatment	p<0.05	Individual effort difference, technical issues with equipment
Langella et al. [42]	18 (8 vs 9)	55.5 / 44.4%	69 ± 5.6	Hip osteoarthritis	Photobiomodulation therapy (LLLT + LEDT)	Superpulsed laser of (905 nm, 2.7mW), Four infrared LEDs of (875 nm, 15mW) and Four red LEDs (640 nm, 17mW)		Placebo	VAS, TNF-α and IL-8 serum levels decreased in the active PBMt group compared to placebo-control group	p<0.05	Lack of assessment of cytokines before surgery

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Lin et al. [43]	163 (88 vs 55)	58 / 105	62.5	Knee osteoarthritis	Moxibustion + Infrared CO2 Laser	SX10-C1 infrared laser moxibustion instrument (10.6 µm wavelenght, 160-180 mW)	3 sessions per week for 12 weeks	Moxibustion + Sham laser	Benefit associated with laser moxibustion compared with traditional moxibustion in physical function at the follow-up of 4 weeks	(P=0.006)	No proper random assignment, treatment protocols different from both RCTs
Madani et al. [44]	20 (10 vs 10)	1 / 19		TMJ osteoarthritis	LLLT	Mustang 2000z (810 nmwavelength, 50mW)	3 sessions per week for 4 weeks	Placebo	LLLT no more effective than the placebo treatment for reducing pain and improving mouth opening in patients with TMJ osteoarthritis	Some change in VAS for body of masseter and TMJ; otherwise no significant difference (p>0.05)	-
Marini et al. [45]	99 (39 vs 30 vs 30)	25 / 74	41.93±11.51 versus 36.23±11.30	TMJ osteoarthritis	Group 1: SLLLT Group 2: Ibuprofen	gallium-arsenide diode superpulsed laser (910 nm wavelenght, 400mW)	10 sessions over 2 weeks	Group 3: sham laser	Mandibular function improved in all SLLLT patients	Mean VAS in SLLLT group was significantly lower than in nonsteroidal anti-inflammatory drug group and control group (P=0.0001)	-
Melo et al. [46]	45	All female		Knee osteoarthritis	Group 1: Electrical stimulation Group 2: Laser group Group 3: Combined		4 week control followed by 8 week intervention		Low-level laser therapy did not improve the effects of electrical stimulation on the evaluated parameters.		
Mostafa et al. [47]	40 (20 vs 20)		40.12 ± 9.45 vs 46.62 ± 8.68	Knee osteoarthritis	ESWT		3 sessions a week for 4 weeks	HILT	HILT showed a superior effect compared with ESWT on pain, physical function, and disability in chronic KOA patients.	p<0.05	
Muhammad et al. [48]	40 (20 vs 20)	6 / 34		Knee osteoarthritis	Laser acupuncture	Soft-laser 202 (808nm wavelenght, 90 mW) Galuim Aluminum Arsenide	12 sessions	Sham laser	Laser acupuncture is a safe and cheap tool for management of grade 2 knee osteoarthritis	improvement in VAS, increase in serum beta-endorphin and a decrease in substance P (p<0.05)	-

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Nazari et al. [49]	90 (30 vs 30 vs 30)	41 / 49	62	Knee osteoarthritis	Group 1: HILT Group 2: CET Group 3: ET	E20780 - laser YAG HT (1064nm wavelenght, 5 W)	3 sessions a week for 4 weeks		HILT was significantly more effective than the other groups in decreasing the VAS, increasing FROM and improving the scores of WOMAC both after treatment and after 12 weeks.	p<0.05	Patient had no control over exercise, no sonographic assessment, short follow up
Ozdemir et al. [50]	60	10 / 50	40.13 ± 10.31 and 40 ± 11.23	Cervical osteoarthritis	LPL	Endolaser 476 (830nm wavelenght, 50mW)	10 sessions	Placebo	Pain, paravertebral muscle spasm, lordosis angle, the range of neck motion and function were observed to improve significantly in the LPL group	p<0.05	
Yan et al. [51]	392 (201 vs 191)	98 / 294	62.5	Knee osteoarthritis	Laser moxibustion	10.6 μm wavelength, 160 to 180 mW	3 times a week for 4 weeks.	Sham laser	Laser moxibustion is effective for pain reduction and functional improvement in the treatment of KOA with KL grades 2 and 3	Patients with KL grades 2 and 3 had improvement scores in pain, function, and total scores. Patients with KL grade 2 had significantly higher improvement scores in stiffness. (p<0.05)	Small sample size, lack of measurement of specialized psychiatric depression-related scales and posttreatment imaging of the patients
Yurtkuran et al. [52]	55 (28 vs 27)	2 / 53	52.6	Knee osteoarthritis	LLLT	Infrared 27 GaAs diode laser instrument, 4 mW	5 days per week (total 10 days)	placebo laser therapy	Laser acupuncture was found to be effective only in reducing periarticular swelling	Improvement was observed in PVAS, 50 foot, and KC in group 1. In Group II, improvement was observed in PVAS, 50 foot, and WOMAC. The improvement observed in KC was superior in Group I at the 2nd week (p = 0.005)	Applied doses may be less than the doses recommended by World Association with Laser Therapy (WALT) for musculoskeletal diseases.

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Zhao et al. [53]	40 (20 vs 20)	5 / 35	60	Knee osteoarthritis	Laser acupuncture	Semiconducter (650 nm wavelenght, 36mW)	3 sessions a week for 4 weeks	Sham laser	Combined 10.6-mum-650-nm laser acupuncture-moxibustion on acupoint ST35 is safe to use and was effective after 2-wk treatment, but not at the 4-wk assessment	Improvement in the WOMAC pain score of the acupoint group was significantly greater than that of the control group (p<0.05)	1. Higher dropout rate. 2. lack of a longer follow-up period made it impossible to assess the long-term effects of this treatment. 3. the operator of the laser treatment was not blinded to the treatment assigned.
Zhao et al. [54]	392 (201 vs 191)	98 /294	63.1	Knee osteoarthritis	Laser moxibustion	SX10-C1 (Shanghai Wonderful Opto-Electrics Tech. Co., Ltd) (10.6 μm wavelength 160–180 mW)	3 sessions a week for 4 weeks	Sham laser	Laser moxibustion resulted in pain reduction and function improvement following a 4-week treatment	The median WOMAC pain score decreased and the physical component of the QoL improvedat Week 4 in the active group (P < 0.01). At Week 24, active laser treatment resulted in significant pain reduction and function improvement (P < 0.01).	Moxibustion has limitations due to smoke
Zou et al. [55]	104	26 / 78	66.3 ± 6.6 vs 64.8 ± 7.4	Knee osteoarthritis	Laser	BTL-6000, Laser Therapy Device, UK	2 times a week for 4 weeks	No laser	Decreased synovial fluid ghrelin levels are related to disease severity in patients with primary osteoarthritis and are increased following laser therapy	Synovial fluid ghrelin concentrations were negatively correlated with K-L grading (P<0.001).. Attenuated synovial fluid ghrelin levels were also related to clinical severity determined by Lequesne index (P=0.025), VAS scores (P<0.001) and Lysholm scores (P=0.005). Ghrelin levels were also negatively associated with TNF-α (P=0.002) and IL-6 concentrations (P=0.002).	Single center trial, only ghrelin levels measured

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Discussion

This review primarily aimed to assess the efficacy of laser therapy for osteoarthritis, focusing on local studies conducted in Saudi Arabia (SA) while also taking a snapshot of the findings from global research. The studies from SA were limited in number; as such, they provided minimal insights into treatment outcomes. Statistical analysis revealed no significant results due to the small dataset; however, based on the qualitative evaluation, certain trends were appreciated. Primarily, low-level laser therapy (LLLT) and high-level laser therapy (HLLT), when combined with exercise, offered a greater benefit to patients with knee osteoarthritis than placebo. But this is the extent to which inferences can be made. Although it is acknowledged that knee osteoarthritis remains the more prevalent and comparatively more morbid condition [56], which explains why all local studies focused on it as the exclusive indication, It is unknown how laser therapy can affect patients with osteoarthritis of different joints within this same demographic. Overall, while the outcomes slightly differ from those of global studies, the latter reports the sufficiency of LLLT to bring about significant outcomes. Nonetheless, it is not enough to warrant the inclusion of therapy into regular clinical practice. The disproportionate representation of local studies compared to global ones underscores the need for more extensive and methodologically robust research.

In comparison, the global studies reviewed in this paper offer valuable insights into the efficacy of laser therapy in osteoarthritis management. Several noteworthy patterns were appreciated. Firstly, the majority of studies reported LLLT as superior to placebo, though improvements in VAS and WOMAC were more substantial when LLLT was combined with another modality like exercise. It should be noted that this conclusion on the superiority of LLLT is not made on the merit of the changes seen in VAS and WOMAC as compared to HLLLT but rather due to the fact that the majority of studies only studied LLLT against a placebo. This may be due to LLLT being more accessible or cheaper. Conversely, it can be recognized as a limitation since there were few direct one-to-one comparisons between LLLT and HLLT. Nevertheless, the significant outcomes in patient symptoms still lend credence to LLLT as a treatment modality. However, a review paper by Ahmed et al. [57], which acknowledged how laser therapy is effective but only when used as an adjunct to rehabilitative exercise, found that HLLT was more efficacious with regards to symptom improvement, at least as far as knee osteoarthritis was concerned. The authors Wu et al. [58] go as far as reporting how high-intensity laser therapy is even better than conventional modalities. However, after reviewing the literature, exercise should be given the spotlight as it is mentioned as a tried and tested method of non-invasive treatment according to multiple review papers [2,5]. So, while it is understood how laser therapy has yet to establish itself as a dependable treatment option, it does beg the question of whether the positive outcomes obtained from the majority of studies were mostly, if not entirely, due to the effects of exercise instead of the laser.

Amongst the significant statistical findings, a strong relationship was observed between condition and mean age ($p = 0.046$). This is explainable, as the finding is consistent with demographic trends; for example, knee osteoarthritis is more prevalent among elderly populations due to degenerative changes, whereas hand osteoarthritis may affect younger, active individuals who engage in repetitive manual tasks. It is interesting to note that, according to a report by Peat et al. [59], in the English population, hand osteoarthritis is actually more common than knee osteoarthritis among females. This may partially explain why we did not see this subtype within the current review, as most global studies have a greater percentage of male participants. Similarly, a significant association was noted between condition and sessions per week ($p = 0.046$), and this may reflect the differences in therapeutic requirements among various joint types. Larger, weight-bearing joints such as the knee might demand more frequent therapy sessions compared to smaller joints like the hand, which could benefit from fewer sessions. However, without further evidence, all of this remains speculative since none of the studies specifically focused on these parameters.

The collected studies had a number of limitations. First and foremost was the lack of standardization. Multiple studies lacked protocols for inclusion, exclusion criteria, laser dosages, duration, application methods, etc. This led to a lack of true homogeneity that made comparisons across studies difficult and made it impossible to conduct a more robust statistical analysis. Additionally, there was heterogeneity in the comparators, with some studies making a comparison with a sham laser while others made a direct comparison between two lasers. Furthermore, there were also a couple of studies that had limited participants, so this added to the reduced statistical power and the generalizability of findings. Coupled with some studies reporting a high dropout rate, a few not blinding participants, and the fact the majority of osteoarthritis subtypes were knee-related, this introduced a significant bias in the reported results.

The second most important limitation was that of gender imbalance; most studies were male-dominated, and this was also reflected in the statistical analysis. Due to this, we cannot comment on whether laser therapy is as efficacious for female patients with osteoarthritis. Regarding other data items, the majority of studies also only provided short-term outcomes (no more than 12 months), and thus, we can't comment on how effective or safe laser therapy is for long-term management. Also, while most studies mentioned no significant side-effect of laser therapy, there was no systematic documentation or reporting of this. This leaves a gap in the

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risk-benefit assessment, and thus, we cannot make concrete recommendations that can be utilized by clinical guidelines.

Thirdly, there was a dearth of local studies; since the prime focus of this review was to determine the effects of laser therapy on osteoarthritic patients from SA, we are left with little insight specific to this regional population. Moreover, a lot of the studies combined laser therapy with other modalities. This concurrent use of exercise, kinesiology tape, or other modalities makes it difficult to isolate the effects of laser therapy. This is why our recommendation is to employ a combination of laser therapy with other modalities until further understanding is achieved through prospective research.

Conclusions

Generally, low-power laser therapy is a valid non-invasive treatment option for osteoarthritis, particularly in alleviating pain and improving joint function, but only if used in combination with other modalities, with exercise being preferable. While tailoring the laser parameters such as wavelength, dosage, and duration to the specific needs of patients may have a role in influencing outcomes, more studies are needed to explicitly specify the values; for now, the wavelength and duration associated with low-power laser therapy remain safe and effective. It is stressed that future studies need greater standardization in treatment protocols to enhance comparability and reproducibility across studies. Until then, the integration of laser therapy as part of management into clinical practice should be put on hold, or at least the treatment should be offered to those patients not willing to try other options or who have exhausted all other forms of treatment. Further high-quality evidence is essential to establish optimal treatment guidelines.

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