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The Beneficial Effects of High-Intensity Laser Therapy and Co-Interventions on Musculoskeletal Pain Management: A Systematic Review

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Abstract

Introduction: High-intensity laser therapy (HILT) has been used more recently in the therapeutic protocols of pain managements. Adding therapeutic interventions to laser therapy is usual in clinical practice. This study aimed to evaluate the efficacy of HILT and beneficial effects of adding co-interventions to HILT in musculoskeletal pain management.

Methods: The following databases were searched up to August 2018: Medline, PubMed, EMBASE, Cochrane, Google Scholar, Springer and ISI. The keywords of pain, HILT, high power laser therapy, laser therapy, photobiomodulation, physical therapy and rehabilitation were searched. The quality of the articles was assessed using the PEDro scale. The primary measure was pain severity expected to be reported in all studies. Effect size was calculated as standardized mean differences divided by the standard deviation of either the treatment or other group.

Results: Initially 52 potential studies were found. Eighteen of these studies were excluded based on title and abstract. The full text of 34 remaining articles was screened and 15 of the studies were excluded. All included studies had high quality (PEDro ≥7). Approximately, 94% of included articles (n=18) revealed positive effects of HILT on pain. The effect sizes for HILT and placebo/comparator groups were 0.9-9.11 and 0.21-11.22 respectively. Also, the differences of effect size between two groups were between 0.03 to 5.85.

Conclusion: It is early to determine that HILT may be an effective non-invasive agent in the management of musculoskeletal pain, as few studies have shown its clinical efficacy. Adding related co-interventions to HILT may enhance the beneficial effects of laser therapy. The variability of the study methods and outcomes suggests that further long-term follow-up, randomized controlled clinical trials with appropriate methodological design are needed regarding the effectiveness of HILT on pain.

Keywords: Musculoskeletal pain; Laser therapy; Rehabilitation; Intervention.

Introduction

Laser photobiomodulation (PBM) therapy is a non-invasive and painless method of treatment in contemporary physiotherapy which may have both local and systemic effects on the patients.[1-4] The effect of PBM on tissues depends on such factors as wavelength, irradiation mode (continuous or pulse), pulse duration, pulse time interval, energy fluence, power output and irradiance.[1] PBM stimulates cells including pain receptors in peripheral tissues, the immune system and can cause vasodilation and analgesic effects. So it is widely used to reduce patients' pain.[1-3] Moreover, laser therapy can stimulate repairs to damaged tissues and peripheral nerves leading to neurological regeneration.[1,4,5]

Low-power laser (light) therapy (power ≤ 500 mW) can be used to decrease acute and chronic pain, induce recovery of damaged nerves, enhance peripheral circulation and metabolism, and reduce joint inflammation.[2,5,6] The effects of low-power laser therapy are photochemical not thermal. In a recent review, Cotler et al concluded that

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low-power laser therapy is a new cost-effective therapy for musculoskeletal pain, which improves the quality of life and reduces financial strains.[5]

High-intensity laser therapy (HILT) has been used more recently in the therapeutic protocols of physiotherapy.[1,2,6] The main difference between HILT and low-power laser therapy, is that the more powerful beams (power >500 mW) are irradiated to penetrate deeper, bringing a desired high amount of multi-directional energy to deep tissues in a short time.[2,6-10] Also, application techniques, the time of treatment and the cost of the device are different between these two generations of the laser therapy.[11-13] A recent systematic review indicated that HILT is effective in reducing musculoskeletal pain.[14] Adding therapeutic interventions to laser therapy is usual in clinical practice.[3, 15-19] Bjordal et al showed that the overall effects of low-power laser therapy and anti-inflammatory drugs co-interventions, were poorer than those studies without these co-interventions.[20] On the other hand, Santuzzi et al found that the combined treatment of low-level laser therapy and cyclooxygenase-2 may have better effects on wound closure and scar organization.[21]

As there are increasing data available regarding the effects of HILT in musculoskeletal injuries, this study was designed to evaluate the literature assessing the influence of adding interventions to HILT on musculoskeletal pain management.

Methods

Search Strategy and Study Selection

The following databases were searched up to august 2018: Medline, PubMed, EMBASE, Cochrane, google scholar, Springer and ISI Web of Science. The search keywords were pain, high-intensity laser therapy, high-power laser therapy, laser therapy, photobiomodulation, physical therapy and rehabilitation.

Two reviewers (KE, AH) independently identified titles and abstracts related to applying HILT to musculoskeletal pain. The inclusion criteria were: 1) randomized clinical trial study 2) reporting visual analogue scale before and after treatment 3) to have minimum two HILT group or HILT plus exercise group and other intervention group 4) language of article was English 5) PEDro scale was ≥ 7.

Quality Assessment

The quality of the articles was assessed using the PEDro scale. The 11-point PEDro scale is considered a reliable and valid assessment tool and is the one most often employed for physical treatments. A score of ≥ 7 is considered to be a study of high methodological quality, while a score of ≤ 5 is considered to be of low methodological quality.[14,22] The methodological assessment was performed by two independent reviewers (KE, AH) and the results were compared. If there was a disagreement, the reviewers discussed the quality of the articles until they reached a final consensus and if necessary, a third reviewer made the decision (RF).

Data Extraction

Two reviewers (KE, AH) completed data extraction and evaluated the characteristics of the study, including the intervention program, inclusion/exclusion criteria, initial data, and values for the pain outcome before and after treatment and follow-up. The primary measure was pain severity which should be reported in all studies.

Statistical Analysis

Because the pain score was continuous outcome data, means and standard deviations of either group were used to calculate the effect size (ES). ES was calculated as standardized mean differences, which is defined as the differences in pain between two groups divided by the SD of either the control group or treatment group.

$$ES = \frac{m_1 - m_2}{sd}$$

The difference of effect sizes was calculated via subtraction of ES of the each group to find the more effective interventions[5, 23, 24]:

Difference of effect sizes $=ES_1-ES_2$

Results

The selection process for including studies in this review is shown in Figure 1. Initially 52 potential studies were found. Eighteen of these studies were excluded based on title and abstract. The full text of 34 remaining articles was screened and 15 articles were excluded[1-3,6,7,9,10,23-30] because: the PEDro score of three studies was 6 [2,3,28]. Six articles didn't report pain by VAS; it was not possible to estimate ES in two studies[1,6,7,9,10,23,24,27]; two studies[29,30] were case reports; and two studies did not have at least one another group for comparison.[25,26]

Finally, 19 studies (HILT: 11, +other interventions: 8) were included for qualitative and quantitative assessment.[11-13,15-17,19,31-42] The characteristics of all studies in two groups are listed in Table 1.

Technical parameters of HILT are provided in Table 2. Although a maximum power of 8000 W was reported in two studies, the average power of the lasers used in the reviewed studies was between 0.6 to 25 W. The majority of the studies (68%) used pulsed laser PBM with energy density varying from 0.25 to 150 J/cm^2.

All included studies were of high quality (PEDro ≥7) (Table 3). Approximately 94% of the included articles (n=18) revealed positive effects of the HILT on pain.

The effect sizes of the included studies and the differences of the effect sizes are presented in Table 4. The effect sizes presented are calculated according to the pain outcome. The effect sizes for HILT and placebo/comparator groups were 0.9-9.11 and 0.21-11.22, respectively. The values of the effect size according to Cohen classification are: small (0.2–0.5), moderate (0.5–

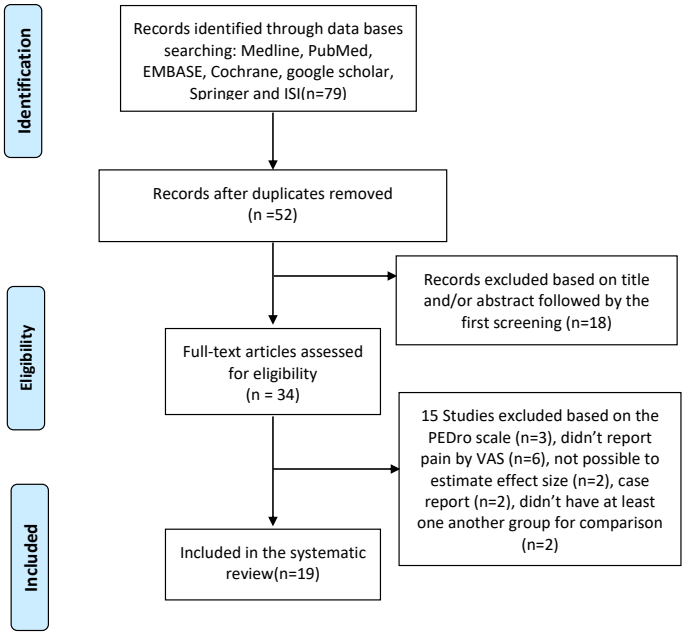

Figure 1. Chart of Screening and Search History.

0.8), and large (>0.8)[44-47] meaning that the more the ES, the more the impact of the intervention.[23,48] According to the present study, the difference in the ES for pain assessment was between 0.03 and 5.85. The difference of the ES in 3 numbers of comparisons were in favour of other groups rather than HILT group (see online Supplementary file 1, Table S1). The positive effect of HILT was shown as high ES difference in the 13 trials.

The results of the most to least efficacy of HILT in both groups are indicated in Table 4. However, in the HILT and exercise group the most effects of HILT were on osteopenia and the least on the Lateral epicondylitis. On the other hand, the most and least effects of HILT with co-interventions were on the chronic back pain and low back with unilateral leg pain respectively (Table 4).

Discussion

Musculoskeletal pain is the main cause of the chronic pain in adults.[5] The treatment options for reducing musculoskeletal pain are surgical and non-surgical interventions.[49] The results of this review showed that HILT is widely used in management of chronic pain recently but the laser dosage and power outputs are very different in the patients.

In the first group of classification (HILT and exercise) 4 studies[14,32,34,35] were about spinal pain which were matched to another group.[16-18,20] The average of the effect size differences was higher in the first group (1/08) for spinal pain patients. In contrast, the effect size in second group of studies was higher for knee pain patients. Other diseases in both groups were not the same e.g. the plantar fasciitis was surveyed in the first group[13] or the Juvenile rheumatoid arthritis was evaluated in second group only.[42] Also, the best effect in the first group was on plantar fascia[13] and osteopenia.[43] In the second group, the best outcomes have been shown in Juvenile rheumatoid arthritis[42] and chronic back pain patients.[16]

The studies that demonstrated positive effects of HILT on pain have some common features as follows: patients were monitored over a long period of time (up to 3 months); higher amounts of energy were used with the average power of 3 and 25 W; the patients most commonly did not use other interventions with laser therapy; and the PBM therapy pulsed for at least ten sessions.[39,42,43] HILT was more effective in the management of pain in patients with lumbar disc protrusion,[18] plantar fasciitis,[13]Children with Juvenile rheumatoid arthritis,[42] children with haemophilic arthropathy,[39] males with osteopenia orosteoporosis,[43] and low back pain.[32] Conversely, the studies which did not supporting a positive effect of HILT (low differences in ES) most commonly did not specify the amount of introduced energy or the simultaneous consumption of non-steroid anti-inflammatory drugs, so it was not possible to make a judgment on whether the energy parameters may have contributed to a sub-optimal outcome.[34,36,41] The consumption of non-steroid anti-inflammatory drugs may be a confounding factor in evaluating the effects of laser therapy, as identified in some studies[13,41] Some studies did not mention the effects of disease chronicity, despite the fact that this is a major factor in determining the amount of energy density and power output which is needed in the treatment protocol by laser therapy.[13,18,32-34,36, 38,41,42]

It seems that adding thermal and non-thermal agents to HILT may enhance the effects of laser therapy.[16,38-40,42] The Management of acute and chronic pain is based

Table 1. General Information of Included Studies

Groups	Author (Year)	Subjects N, Mean age (y)	Main Inclusion Criteria	Method	Result
HILT or HILT + Exercise	Santamato et al (2009)[31]	70, 54.1	Shoulder pain	G1: HILT G2: Ultrasound therapy (continuous, 1 MHZ, 2 W/cm^2, 10 min)	HILT (+)
	Fiore et al (2011)[32]	55, 51.2	Lumbar pain	G1: HILT G2: Ultrasound therapy (continuous, 1 MHZ, 2 W/cm^2, 10 min)	HILT (+)
	Casale et al (2013)[33]	N= 20 G1:57.3, G2:56.8	Carpal tunnel syndrome	G1: HILT G2: Transcutaneous electrical nerve stimulation (100 Hz, 80 ms width, 30 min, sensory level)	HILT (+)
	Kheshie et al (2014)[12]	53, 54.6	Osteoarthritic knee of grade 2–3	G1: HILT+ exercise (quadriceps muscle strengthening, self-stretching for the hamstring and calf muscles) G2: LPLT (830 nm, output power: 800 mW, energy density: 50 J/cm^2, frequency: 1 kHz, and duty cycle: 80%, time: 30 min, 12 sessions) + exercise G3: Placebo+ exercise	HILT (+)
	Dundar et al (2014)[34]	76, 20–60	Myofascial trigger point (upper trapezius)	G1: HILT+ exercise (isometric strengthening, active range of motion, and cervical stretching) G2: Sham laser+ exercise	HILT (+)
	Kim et al (2015)[41]	66, 41-71	Shoulder pain and limitation of passive movement	G1: HILT G2: Sham laser	HILT (+)
	Alayat et al (2016)[35]	60, 35.47	Unilateral or bilateral chronic neck pain	G1: HILT + exercise (Gentle stretching, apophyseal glides, strengthening and core stability training) G2: Placebo laser + exercise	HILT (+)
	Salli et al (2016)[36]	65, 46.5	Lateral epicondylitis	G1: HILT G2: Lateral epicondylitis bandage	HILT (+)
	Alayat et al (2017)[43]	100, >50	Osteopenia or osteoporosis ≤–1.5DEXA (Lower back and hip regions)	G1: HILT+ exercises (aerobic, weight-bearing, flexibility, strengthening and balance) G2: Placebo laser + exercises G3: HILT G4: Placebo laser	HILT(+)
	Ordahan et al (2018)[13]	75, 48.73 48.65	Plantar fascia	G1: HILT G2: LPLT (904 nm, output power: 240 mW, and frequency: 5000 Hz, total dose: 680.4 J)	HILT (+)
	Taradaj et al (2018)[14]	N=68 G1: 44.67(4.96), G2: 44.24(4.34), G3: 45.19(4.17), G4: 45.76(15.04)	Lumbar disc degenerative dysfunction	G1: HILT G2: Sham HILT G3: LPLT (of 785 nm, power output: 65 mW, energy density: 8 J/cm^2, duration: 8 min) G4: Sham LPLT	HILT (-)

Table 1. Continued

Groups	Author (Year)	Subjects N, Mean age (y)	Main Inclusion Criteria	Method	Result
HILT+ other interventions	Ebid et al (2015)[38]	61, 53.56	Breast cancer including axillary node dissection for stage II or III	G1: HPLT+ routine physical therapy G2: Placebo HPLT+ routine physical therapy	HPLT (+)
	Choi et al (2017)[16]	20 G1= 47.1, G2= 48.3	Chronic back pain	G1= hot pack,interferential current therapy and deep heat diathermy using ultrasonic waves G2=HLPT+ hot pack,interferential current therapy and deep heat diathermy using ultrasonic waves	HILT(+)
	El-Shamy et al (2016)[39]	30, 9-13 years	Bilateral knee haemarthrosis with mild to moderate haemophilia	G1: HILT + exercise (muscle stretching,strengthening exercises, proprioceptive training, balance and gait training, for three consecutive months (1 h/d, 3 d/wk)). G2:sham HILT + exercise	HILT (+)
	Ebid et al (2017)[40]	49, 15-50	The post-burn healing	G1= HILT+cetirizine 10 mg BD and 10 mg HS+ Massage G2= placebo laser + cetirizine 10 mg BD and 10 mg HS + massage	HILT (+)
	Haładaj et al (2017)[17]	174, 24–67	Pain and limited mobility of the cervical spine	G1= cervical axial traction G2=biostimulation + HILT	HILT (+)
	Chen et al (2017)[18]	63 G1=39.27, G2=43.00	Disc protrusion in lumbar	G1=HILT +SDS(spinal decompression system) G2=SDS	HILT (+)
	El-Shamy et al (2018)[42]	30, 8-12	Children with Juvenile rheumatoid arthritis	G1: HILT+ exercise (Acute: cold packs, passive range of motion, and isometric exercises. subacute: isometric and isotonic exercises. chronic: hot packs, proprioceptive training, flexibility exercises) G2: Placebo HILT+ exercise	HILT (+)
	Kolu et al (2018)[20]	54, 50.14	Low back with unilateral leg pain	G1=TENS+US+Hot pack G2=HILT +Hot pack	HILT (+)

G: Group, HILT: High Intensity laser therapy, LPLT: Low power laser therapy, (+): Significant, (-): Not-significant

Table 2. Technical Parameters of High Intensity Laser Therapy in Selected Studies

Groups	Authors	Wavelength (nm)	Energy Density (J/cm²)	Power Average (W)	Continouos/ Pulse	Frequency (Hz)	Time Per Point (s)	Location of Irradiation	Number of Treatments
HILT or HILT + Execcise	Santamato et al (2009)[31]	1064	0.510, 0.610, 0.710	6	Pulse	-	0.150	Upper trapezius, deltoid and pectoralis minor	10
	Fiore et al (2011)[32]	1064	0.76	6	Pulse	-	30	On lumbar, dorsal muscles	On trigger point until the pain was 70-80% reduction
	Casale et al (2013)[33]	830, 1034	0.250	25	-	-	100	The skin over median nerve to wrist	21
	Kheshie et al (2014)[12]	1064	Point 1=0.710-0.810, Point 2=0.610	-	Pulse	-	14	All aspects of the knee joint. The joint line between the tibial and femoral epicondyles	12
	Dundar et al (2014)[34]	1064	0.360–1.780	3	Pulse	10–40	Point 1: 30 Point 2:6 Point 3:60	On trigger point	15
	Kim et al (2015)[41]	1064	-	-	Pulse	30 Hz 20-25	30 5	Anterior and posterior joint line of the shoulder	9
	Alayat et al (2016)[35]	1064	0.510–0.1780	3000	Pulse	10–40	14	Trapezius and sternocleidomastoid muscles, and posterior and lateral shoulder areas	-
	Salli et al (2016)[36]	-	Phase 1: 6 Phase 2: 100-150	4 6	-	-		Painful areas in circular motion from the center to the outside	10
	Alayat et al (2017)[43]	1,064	0.510–1.780	10.5	Pulse	10–30	-	Lower back, proximal thigh	36
	Ordahan et al (2018)[13]	1064	Phase 1: 6 Phase 2: 0.120 -0.150	8 6	-	-	75 30	Plantar fascia area	9
	Taradaj et al (2018)[14]	1,064	60	10	-	-	480	Area 3 cm lateral to L5-S1 on the lower back.	15
HILT+ other interventions	Ebid et al (2015)[38]	1064 nm	0.510–1.780	3000	Pulse	10–40	14	Total 16 points (6 points in the breast, 5 points in the axilla, and 5 points in the arm)	12
	El-Shamy et al (2016)[39]	-	0.610_0.810	-	Pulse	-	14	The knee joint line between the tibial and femoral epicondyles, in the anterior, medial, and lateral, 10 points	36
	Choi et al (2017)[16]		1.378	-	-	-	-	L1–L5 and S1	12
	Ebid et al (2017)[40]	1064	0.510–1.780	3000	Pulse	10–40	14	16 points of the forearm and hand	18
	Haładaj et al (2017)[17]	980	5	0.6	Pulse	25	-	C4 to T4	10
	Chen et al (2017)[18]	1064	0.150	12	Continuous	-	10	Pain points between rib inferior margin and posterior superior iliac spine	10
	El-Shamy et al (2018)[42]	1064	0.510–1.780	10.5	Pulse	10–30	14	All aspects of the knee joint, the joint line between the tibial and femoral epicondyles	12
	Kolu et al (2018)[19]	-	12	10	Pulse	25 Hz	6	Lumbar region	10

(-): Not reported.

Table 3. Quality Assessment: PEDro Scores of the Included Trials

Groups	No. of article	Cri1	Cri2	Cri3	Cri4	Cri5	Cri6	Cri7	Cri8	Cri9	Cri10	Cri11	Total Score
HILT or HILT + Execcise	Santamato et al (2009) [31]	1	1	0	1	0	0	0	1	1	1	1	7
	Fiore et al (2011)[32]	1	1	0	1	0	0	1	1	1	1	1	8
	Casale et al (2013)[33]	1	1	0	1	1	0	0	1	1	1	1	8
	Kheshie et al (2014)[12]	1	1	0	1	1	0	0	1	1	1	1	8
	Dundar et al (2014)[34]	1	1	0	1	1	1	1	1	1	1	1	10
	Kim et al (2015)[41]	1	1	1	1	1	1	1	1	1	1	1	11
	Alayat et al (2016)[35]	1	1	0	1	1	1	0	1	1	1	1	9
	Salli et al (2016)[36]	1	1	0	1	0	0	0	1	1	1	1	7
	Alayat et al (2017)[43]	1	1	1	1	0	1	1	1	1	1	1	10
	Haładaj et al (2017)[17]	1	1	0	1	0	0	0	1	1	1	1	7
	Ordahan et al (2018)[13]	1	1	1	1	0	1	1	1	1	1	1	10
	Taradaj et al (2018)[14]	1	0	1	1	1	0	1	1	1	1	1	9
HILT+ other interventions	Ebid et al (2015)[38]	1	1	0	1	1	1	1	0	1	1	1	9
	El-Shamy et al(2016) [39]	1	1	0	1	0	0	0	1	1	1	1	7
	Choi et al (2017)[17]	1	1	0	1	0	0	0	1	1	1	1	7
	Ebid et al (2017)[40]	1	1	1	1	1	1	1	1	1	1	1	11
	Haładaj(2017)[17]	1	1	0	1	0	0	0	1	1	1	1	7
	Chen (2017)[19]	1	1	0	1	0	0	0	1	1	1	1	7
	El-Shamy et al (2018)[42]	1	1	0	1	1	1	0	1	1	1	1	9
	Kolu et al (2018)[20]	1	1	0	1	0	0	0	1	1	1	1	7

Table 4. The Function of the Laser Beam (Most Effect to Less Effect) on the Diseases

Groups	Author (Year)	Disease
HILT or HILT + Execcise	Alayat et al (2017)[43]	Osteopenia or osteoporosis (Lower back and hip regions)
	Ordahan et al (2018)[13]	Plantar fascia
	Kheshie et al (2014)[12]	Osteoarthritic knee of grade 2–3
	Alayat et al (2016)[35]	Unilateral or bilateral chronic neck pain
	Casale et al (2013)[33]	Carpal tunnel syndrome
	Dundar et al (2014)[34]	Myofascial trigger point (upper trapezius)
	Fiore et al (2011) [32]	Lumbar pain
	Santamato et al (2009)[31]	Shoulder pain
	Kim et al (2015) [41]	Shoulder pain and limitation of passive movement
	Taradaj et al (2018)[14]	Lumbar disc degenerative dysfunction
	Salli et al (2016)[36]	Lateral epicondylitis
HILT+ other interventions	Choi et al (2017)[16]	Chronic back pain
	El-Shamy et al (2018)[42]	Children with Juvenile rheumatoid arthritis
	El-Shamy et al (2016)[39]	Bilateral knee haemarthrosis with mild to moderate haemophilia
	Ebid et al (2017)[40]	The post-burn healing
	Ebid et al (2015)[38]	Breast cancer including axillary node dissection for stage II or III
	Chen et al (2017)[18]	Disc protrusion in lumbar
	Haładaj et al (2017)[17]	Pain and limited mobility of the cervical spine
	Kolu et al (2018)[20]	Low back with unilateral leg pain

on different mechanisms and it seems that we should apply more irradiance of laser therapy in chronic pain conditions.[50,51] The treatment area of the scanner lasers is a major contributor to laser efficacy, indicated by some studies.[13,18,36,39] Others just mentioned the probe size which is not as important as the treatment area. The etiology and diagnosis of the disease are important when using a laser. As an example, laser therapy cannot resolve the main sources of pain resulting from myofascial pain syndrome as the pain in these patients is caused by the development of the taut bands in the muscles.[34]

The limitation of this study is related to the fact that musculoskeletal disorders are wide-range disorders and thus it is better to limit this systematic review to some topics such as low back pain, shoulder pain or knee osteoarthritis in future studies.

Conclusion

Our results suggest that it is still early to determine if HILT may be an effective non-invasive agent in the management of musculoskeletal pain although there are indications that it may have benefits in some conditions depending on the treatment parameters. Adding related co-interventions to HILT may enhance the beneficial effects of laser therapy. It is clear from our findings that long-term, randomized controlled trials with an appropriate methodological design are needed to determine the effect of HILT on pain in a range of musculoskeletal conditions not covered by this review, or in some conditions that methodological matters made it difficult to evaluate the outcomes.

Ethical Considerations

Not applicable.

Conflict of Interests

The authors declare no conflict of interest.

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Supplementary Materials

Supplementary file 1 contains Table S1.

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