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Review Article

Low-Level Laser Therapy including Laser Acupuncture for Non-Specific Chronic Low Back Pain: Systematic Review and Meta-Analysis

Hyewon Yeum, Yejin Hong, Dongwoo Nam*

Department of Acupuncture and Moxibustion Medicine, Kyung Hee University Korean Medicine Hospital, Seoul, Korea

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ABSTRACT

Low-level laser therapy including laser acupuncture (LLLT/LA) has been widely used for non-specific chronic low back pain (NCLBP). However, there is no critically appraised evidence of its potential benefits. This study aimed to evaluate the effectiveness of LLLT/LA for NCLBP. There were 12 databases (MEDLINE, CENTRAL, EMBASE, KoreaMed, KMBASE, KISS, NDSL, KISTI, OASIS, CNKI, CiNII, J-stage) searched for randomized controlled trials using LLLT/LA for NCLBP up until June 2019. The primary outcome was pain intensity and functional status/disability due to NCLBP. A random-effects meta-analysis was conducted on 20 studies involving 1,323 participants. LLLT/LA showed a significant positive effect on pain relief scores compared with sham treatments (SMD -0.51, 95% CI: -0.88 to -0.13; χ^2 = 31.12, I^2 = 74%). Alone, the therapy showed a significant positive effect on function/disability scores (30 participants, MD -11.90, 95% CI: -17.37 to -6.43). As an add-on treatment, it showed a significant positive effect on pain relief (80 participants, MD -5.10, 95% CI: -9.31 to -0.88; χ^2 = 28.99, I^2 = 97%) and improved function/disability scores (120 participants, MD 5.44, 95% CI: 2.19 to 8.68; χ^2 = 4.07, I^2 = 75%). Among 20 studies, 9 studies reported no adverse events and 1 study reported mild adverse events. LLLT/LA may be an alternative or add-on treatment for NCLBP.

Introduction

Low back pain (LBP) is a common musculoskeletal disorder affecting 80% of people at some point in their lives. It is estimated that 10% to 20% of affected adults develop symptoms of chronic LBP (CLBP) lasting over 12 weeks [1]. A survey on the use of Korean Medical Institutions and consumption of Korean Herbal Medicine, conducted by the Korean Ministry of Health and Welfare in 2011 and 2017, reported that patients with LBP accessed Korean medical institutions the most, and accounted for 12.89% in 2011 and 52.7% in 2017 [2,3]. Non-specific chronic low back pain (NCLBP) is defined as pain lasting over 12 weeks with no clear underlying etiology. Aging is associated with lower recovery rates and higher levels or chronicity and severity [4]. According to the bio-psychosocial model, chronic pain is associated with biological, psychological, and social factors such as distress (depression, anxiety, and fear), self-efficacy, smoking, drinking, and working life [5]. Therefore, while NCLBP is not life-threatening, it reduces a patient's quality of life.

Low-level laser therapy including laser acupuncture (LLLT/LA) induces a photochemical reaction in cells (biostimulation or photobiomodulation) to aid tissue repair and relieve pain [6]. In 2017, the American College of Physicians developed guidelines to provide clinical recommendations for non-invasive treatment of LBP, and strongly recommended that non-pharmacological treatments including LLLT should be considered for patients with CLBP [7-9].

To date, there have been no studies about LLLT/LA for NCLBP that incorporated data collected in Korea, China, and Japan; this study addressed this and critically evaluated the efficacy of LLLT/LA for NCLBP.

Materials and Methods

This systematic review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses

*Corresponding author. Nam Dongwoo
Department of Acupuncture and Moxibustion, College of Korean Medicine, Kyung Hee University, 26 Kyungheedae-ro, Dongdaemun-gu, Seoul, 02447, Korea
E-mail: hanisanam@khu.ac.kr
ORCID: Yeum Hyewon https://orcid.org/0000-0002-2859-5195, Hong Ye Jin https://orcid.org/0000-0002-8817-136X, Nam Dong Woo https://orcid.org/0000-0002-7957-3121

(PRISMA) [10]. The protocol for this systematic review was prospectively registered on PORSPERO CRD42019140419.

Database search and study selection

There were 12 bibliographic databases searched up until June 2019: MEDLINE (PubMed), EMBASE (Ovid), the Cochrane Central Register of Controlled Trials (CENTRAL), Korean database (KoreaMed, KMBASE, KISS, NDSL, KISTI, OASIS), the China National Knowledge Infrastructure Database (CNKI), and Japanese databases (CiNII, J-STAGE).

The search strategy followed the study protocol. The search terms comprised of 2 parts, LLLT/LA (e.g., laser, laser acupuncture, laser puncture, laser needle, low-dose laser acupuncture, LLLT, low-level laser, laser therapy, laser treatment) and CLBP (e.g., lower back pain, sciatica, radiculopathy, lumbago, backache, back pain, lumbo-sacral, NCLBP). To increase the sensitivity of the search for NCLBP, concepts such as radiculopathy and sciatica were included. In some cases, the LLLT/LA parameters were classified, however, in the case of the lower back, it was difficult to avoid using acupuncture points during treatment due to their high density of use. Moreover, laser treatments have an "Alpha-phenomenon" effect that shows an indirect biostimulation effect on the surrounding tissues. In this review, all randomized controlled trials (RCTs) where LLLT/LA was performed were analyzed. Observational, cohort, case reports, case series, non-RCT, animal and experimental studies were excluded from this review.

Two reviewers independently screened the studies and after analysis made the final decision of which studies to include.

Data extraction and assessment of risk bias

Study data including the intervention description, baseline, demographics, and values for outcomes was extracted by 2 reviewers and checked for accuracy by a third reviewer. The primary outcomes were: (1) Pain intensity measured on a visual analog scale (VAS) or the numeric rating scale (NRS) and (2) Functional status/disability measured by the Oswestry disability index (ODI) or Japanese orthopaedic association (JOA) scale. The secondary outcomes included range of motion (ROM), results from the Modified Schober test, global assessment of quality of life, and negative side effects.

The study quality was assessed according to the criteria described in the Cochrane Handbook for Systematic Review of Intervention, and RCTs were assessed using the Cochrane Bias Risk tool.

Statistical analysis

The Review Manager (e.g., Cochrane Collaboration Software, RevMan version 5.3.5) was used for data management and statistical analysis. For continuous data, treatment effects were expressed as a mean difference (MD) or standardized mean difference (SMD) with a 95% confidence interval (CI) level. Meta-analysis was used to combine the results of trials using a random-effects model. Data was presented as a forest plot. Heterogeneity was evaluated using heterogeneity test (I^2 statistic).

Results

Description of the included studies

A total of 1,019 studies were retrieved from 12 online databases. After screening the articles and removing duplicates, 20 studies (RCTs) were selected according to the inclusion criteria [8,9,11-28], and were conducted in 11 countries with a combined total of 1,323 patients (Fig. 1).

Intervention analysis

The 20 studies consisted of 13 RCTs comparing LLLT/LA with sham laser therapy [8,9,11-21], 2 trials comparing LLLT/LA with no treatment [24,26], 4 trials comparing LLLT/LA used as add-on therapy with a control group [24,25,27,28], and 1 study which compared the effects of 2 laser treatment methods on different conditions [23].

Of these 20 studies, 2 trials were 3-arm RCTs, 1 compared low-dose laser treatment with high-dose laser treatment, and sham laser treatment [13], 1 compared LLLT and exercise in combination with ultrasound and exercise in combination, and to exercise alone [24]. Three of the studies could not be included in the analysis because the laser treatment methods varied between individual groups [13,22,23]. The characteristics of the included studies are listed (Tables 1-4).

Furthermore, LLLT/LA is a treatment method that uses a laser device, therefore, the following laser parameters and treatment characteristics were recorded: wavelength, power, energy density, beam size, number of treatments, treatment time, treatment sessions and treatment intervals. Where particular laser parameters were not reported, values were calculated from formulas using the reported parameters. The characteristics of the laser parameters are listed (Tables 5-8).

Primary outcomes

Comparing LLLT/LA with sham-LLLT/LA therapy

With regards to pain, 4 of the 13 studies were excluded. Three studies evaluated pain relief by the amount of change in the

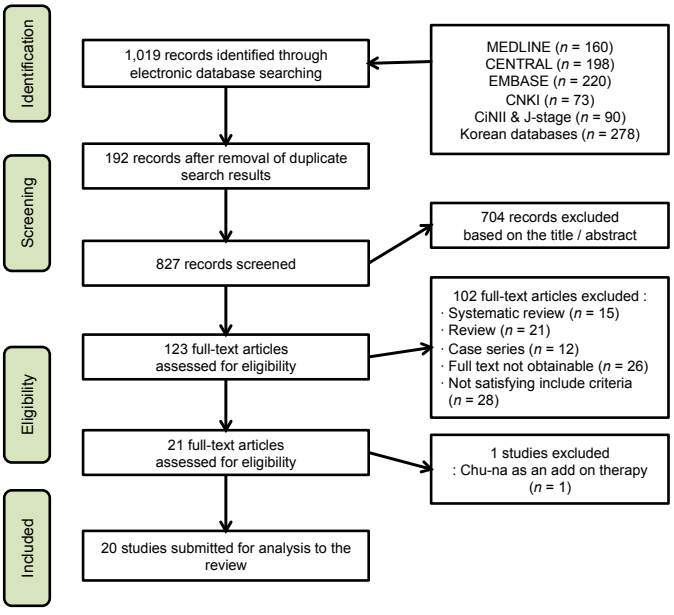

Fig. 1. A PRISMA flow diagram of the literature screening and selection processes. MEDLINE, PubMed; CENTRAL, the Cochrane Central Register of Controlled Trials; EMBASE, Ovid; CNKI, the China National Knowledge Infrastructure Database; CiNII, Scholarly and Academic Information Navigator, pronounced like "sigh-knee"; J-STAGE, Science and Technology Agency Electronic journal platform; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analyses.

Table 1. Summary of the Included Studies Comparing LLLT / LA and Sham-LLLT/LA Therapy.

First author, year	Nation	Intervention group (allocated Pt./analyzed Pt.)	Comparison group (allocated Pt./analyzed Pt.)	Main outcomes	Intergroup difference	Adverse event	Authors conclusion
Basford 1999 [8]	USA	LILI (30/27)	Sham LILI (29/29)	1) ODI 2) Modified Schober test 3) VAS	1) $p = 0.001$ 2) $p = 0.949$ 3) $p = 0.007$	No SAEs	Laser > control (in pain and function), benefits decreased with time.
Djavid 2007 [11]	Iran	LLLT (20/19)	Sham LLLT (19/18)	1) VAS 2) Schober test 3) Lumber flexion 4) Lumbar extension 5) Right lateral flexion 6) Left lateral flexion 7) ODI	1) $p = 0.03$ 2) $p < 0.01$ 3) $p < 0.01$ 4)-6) Not different 7) $p = 0.03$	No AEs	Laser > control (in pain and function)
Glazov 2009 [12]	Australia	LA (50/45)	Sham LA (50/45)	1) VAS 2) ODI 3) Global assessment of effectiveness of treatment 4) DASS-21 5) PWI-A 6) SWH	1)-7) Not different	n.r.	No difference
Glazov 2014 [13]	Australia	LA (48/48)	Sham LA (48/46)	1) NRS 2) ODI 3) NLARS	1)-2) Not different	No AEs	No difference
Heish 2013 [14]	Taiwan	Light therapy (35/33)	Sham Light therapy (35/27)	1) L-spine ROM 2) VAS 3) MFI 4) Biodex Stability System 5) FABQ 6) FAI 7) ODI 8) 5 repeated chair-rising time, Osteoarthritis quality of life	1)-4) Not different 5) $p = 0.04$ (physical) $p = 0.007$ (work) 7) $p = 0.021$ 6),8) Not different	No AEs	Laser > control (in the severity of disability and fear avoidance beliefs)
Lin 2012 [15]	Taiwan	LA (28/21)	Sham LA (29/21)	1) VAS 2) Ryodoraku value	1) Not different 2) changed back to almost original values in active group (reinforcing effect)	n.r.	No difference
Lin 2017 [16]	Taiwan	LA (25/20)	Sham LA (23/20)	1) VAS 2) Plasma cortisol levels	1) $p = 0.005$ 2) $p = 0.65$	n.r.	Laser > control (in pain)
Shin 2015 [17]	Republic of Korea	LA (28/28)	Sham LA (28/26)	1) VAS 2) PGIC 3) PPT 4) EQ-5D	1)-4) Not different	No AEs and SAEs	No difference
Soriano 1998 [9]	Argentina	Laser Treatment (38)	Sham Laser Treatment (33)	1) VAS (0-29% relief, poor) 2) VAS (30-59% relief, regular) 3) VAS (60-89% relief, good) 4) VAS (90-100% relief, excellent) 5) Therapeutic efficacy	1)-3) n.r 4) $p < 0.01$ 5) $p < 0.007$	No AEs	Laser > sham (in pain)
Vallone 2014 [18]	Italy	Diod Laser (50)	Sham Diod Laser (50)	1) VAS	1) $p < 0.001$	No AEs	Laser > sham (in pain)
Choi 2007 [19]	Republic of Korea	LLLI (8)	Sham LLLI (8)	1) VAS 2) Modified Schober test	1) $p = 0.001$ 2) $p = 0.010$	n.r.	Laser > sham (in pain and lumbar mobility)
Klein 1990 [20]	USA	LELT (10)	Sham LELT (10)	1) VAS 2) Disability score 3) Lumbar flexion 4) Lumbar rotation 5) Lumbar side flexion 6) Lumbar extension 7) isometric torque 8) isodynamic velocity	1) $p = 0.493$ 2) $p = 0.919$ 3)-8) Not different	No AEs	No difference
Ruth 2010 [21]	Germany	LA (51/46)	Sham LA (51/47)	1) Chronic pain Index 2) Disability score 3) FABQ	1)-3) Not different	No AEs	No difference

LILI, low-intensity laser irradiation; LLLT, low-level laser therapy; LA, laser acupuncture; LLLI, low-level laser irradiation; LELT, low-energy laser treatment; ODI, Oswestry disability index; VAS, visual analog scale; DASS, depression anxiety stress scale; PWI, personal wellbeing index; SWH, satisfaction with health; NRS, numerical rating scale; NLARS, numerical rating scale of limitation of activities; MFI, multi-fatigue inventory; FABQ, fear-avoidance behavior questionnaire; FAI, Frenchay activities index; PGIC, patient global impression of change; PPT, pressure pain threshold; EQ-5D, Euro-Wuality-of-Life Five Dimensions; n.r., not reported; AE, adverse event; SAE , serious adverse event; allocated Pt., number of allocated patients; analyzed Pt., number of analyzed patients.

Table 2. Summary of the Included Studies Comparing LLLT/ LA as Alone with Other Therapies.

First author, year	Nation	Intervention group (allocated Pt./ analyzed Pt.)	Comparison group (allocated Pt./ analyzed Pt.)	Main outcomes	Intergroup difference	Adverse event	Authors conclusion
Tantawy 2019 [24]	Kingdom of Bahrain	LP (15/15)	US (15/15)	1) Modified ODI 2) VAS 3) PDI 4) 6 MWT 5) Flexion ROM 6) Extension ROM	1) $p = 0.001$ 2) $p = 0.03$ 3) $p = 0.01$ 4) $p = 0.04$ 5) $p = 0.03$ 6) $p = 0.04$	n.r.	LP > US (in pain, disability, mobility)
Liu 2017 [26]	China	LI (53)	Manipulation (53)	1) VAS 2) ICF	1)-2) $p > 0.05$	n.r.	No difference

LP, laser photomodulaton; US, ultrasound therapy; LI, linear-polarized near- infared light; ODI, Oswestry disability index; VAS, visual analog scale; PDI, pain disability index; 6 MWT, 6-minute walk test; ROM, range of motion; ICF, international classification of functioning, disability and health; Preferred Reporting Items for Systematic Reviews and Meta-analyses.

Table 3. Summary of the Included Studies Comparing LLLT/ LA as Add-on Treatment.

First author, year	Nation	Intervention group (allocated Pt./analyzed Pt.)	Comparison group (allocated Pt./ analyzed Pt.)	Main outcomes	Intergroup difference	Adverse event	Authors conclusion
Tantawy 2019 [24]	Kingdom of Bahrain	(1) LP+ (2) Ex (15/15)	(2) Ex (15/15)	1) Modified ODI 2) VAS 3) PDI 4) 6 MWT 5) Flexion ROM 6) Extension ROM	1)-6) $p < 0.05$	n.r.	LP+Ex. > Ex. (in pain, disability, mobility)
Guo 2010 [25]	China	(1) Diode Laser+ (2) Maitland technique (30)	(2) Maitland technique (30)	1) JOA	1) $p < 0.01$	n.r.	Laser (1) + (2) > (2) (in disability)
Qin 2010 [27]	China	(1) Laser diode radiation + (2) Massage (30)	(2) Massage (30)	1) JOA	1) $p < 0.01$	n.r.	Laser (1) + (2) > (2) (in disability)
Gur 2003 [28]	Turky	(1) LPLT + (2) Ex. (25)	(2) Ex. (25)	1) VAS 2) Roland disability questionnaire 3) Modifide ODI 4) Schober test 5) Antero-posterior flexion 6) lateral flexion (right) 7) lateral extension (left)	1)-5) $p > 0.05$	n.r.	No difference

LP, laser photomodulaton; Ex., exercise; LPLT, low power laser therapy; ODI, Oswestry disability index; VAS, visual analog scale; PDI, pain disability index; 6 MWT, 6-minute walk test; ROM, range of motion; JOA, Japanese orthopaedic association; n.r., not reported; allocated Pt., number of allocated patients; analyzed Pt., number of analyzed patients.

Table 4. Summary of the Included Studies Comparing Two Methods of LLLT/ LA.

First author, year	Nation	Intervention group (allocated Pt./ analyzed Pt.)	Comparison group (allocated Pt./ analyzed Pt.)	Main outcomes	Intergroup difference	Adverse event	Authors conclusion
Ammar 2015 [22]	Egypt	MIPE (39/35)	LLLT (37/35)	1) FRI 2) VAS 3) Flexion ROM 4) Extension ROM	1) $p = 0.21$ 2) $p = 0.41$ 3) $p = 0.81$ 4) $p = 0.16$	n.r.	No difference
Dogan 2017 [23]	Turky	LLLT 1 (20)	LLLT 2 (29)	1) VAS 2) Patient's global assessment 3) Physician's global assessment 4) Modified Schober test 5) Right lateral flexion 6) Left lateral flexion 7) Modifide ODI	1) $p = 0.901$ 2) $p = 0.569$ 3) $p = 0.925$ 4) $p = 0.061$ 5)-7) $p < 0.01$	No AEs	No difference
Glazov 2014 [13]	Australia	LA1 (48/48)	LA2 (48/47)	1) NRS 2) ODI 3) NLARS	1)-2) Not different	No AEs	No difference

MIPE, monochromic infrared photo energy; LLLT, low-level laser therapy; LA, laser acupuncture; LLLI, low-level laser irradiation; LELT, low-energy laser treatment; FRI, functional rating index; VAS, visual analog scale; ROM, range of motion; ODI, Oswestry disability index; NRS, numerical rating scale; NLARS, numerical rating scale of limitation of activities; n.r., not reported; AE, adverse event; allocated Pt., number of allocated patients; analyzed Pt., number of analyzed patients.

Table 5. LLLT/LA Methods of Included Studies Comparing LLLT/ LA and Sham-LLLT/ LA Therapy.

First author, year	Study design	Medium (model, manufacturer)	Wavelength (nm)/type	Power output (mW)/ power density (mW/ cm^2)	Energy density (J/cm2) / dose/ point (J/ point)	Beam size/ number of treatment/treatment time	Treatment session & interval	Other interventions on both group
Basford 1999 [8]	RCT	Nd:YAG (1.06 μm Nd:YAG continuous-wave laser™)	1,060 / continuous	2,660*/ 542	48.78 / 239.3*	2.5 cm (diameter) / 8 points (along the L2-L3)/ 90 s*8 = 720 s (12 min)	12 times, 3 times a week, 4 weeks	None
Djavid 2007 [11]	RCT	GaAlAs (n.r.)	810 / continuous	50 / 226.1*	27 / 5.9697*	0.2211 cm^2 / 8 points in paravertebral region (L2 to S2-3) / 20 min	12 times, 2 times a week, 6 weeks	Exercise
Glazov 2009 [12]	RCT	GaAlAs (Acupak, Melbourne, Australia)	830 / continuous	10 / 50	1* / 0.2	0.2 cm^2 / 8 points (individualized acupoints) / 20 s/points	5~10 times, once a week, average of 9.1 weekly sessions	Exercise
Glazov 2014 [13]	RCT	GaAlAs (Acupak, Melbourne, Australia)	830 / continuous	20 / 100	1* / 0.2	0.2 cm^2 / 9 points (individualized acupoints) / 10 s/points	8 times, once a week, 8 weeks	None
Heish 2013 [14]	RCT	GaAlAs (Anodyne Therapy Professional System 480 (Anodyne, Tampa, FL, USA)	890 / n.r.	780 / 34.7	83.28 / 1,873.8*	22.5 cm^2 / 8 points (Low back region) / 40 min	6 times, 3 times a week, 2 weeks	Hot-pack
Lin 2012 [15]	RCT	n.r. (LA400, United Integrated Services Co., Ltd., Taiwan)	808 / pulse type (pulse rate 20Hz)	20 (40;50% duty cycle of pulse) / 25	15 / 12*	0.8 cm^2/ 4 points (BL40, Ashi acupoints) / 10 min	5 times, 5 times a week, one week	Soft cupping
Lin 2017 [16]	RCT	n.r. (LA400, United Integrated Services Co., Ltd., Taiwan)	808 / pulse type (pulse rate 20Hz)	20 (40;50% duty cycle of pulse) / 25	15 / 12*	0.8 cm^2/ 4 points (BL40, Ashi acupoints) / 10 min	5 times, 5 times a week, one week	Chinese cupping
Shin 2015 [17]	RCT	n.r. (Solco-LF100, Solco Biomedical Co., Ltd., Pyeongtaek, Korea)	660 / pulse type (pulse rate 200 Hz)	25 (50;50% duty cycle of pulse) / 625*	112.5 / 4.5*	0.04 cm^2/ 13 acupoints (GV3, GV4, GV5, bilateral BL23, BL24, BL25, BL40, GB30) / 3 min/point	3 times, 3 times a week, one week	None
Soriano 1998 [9]	RCT	GaAs (n.r.)	904 / pulse type (pulse rate 10,000 Hz)	40 /26.7 x 106*	2.67 x 106 / 4*	1.5*10-6 cm^2/ Low back region / 100 s	10 times, 5 times a week, 2 weeks	None
Vallone 2014 [18]	RCT	GaAlAs (LEONARDO BIO DMT dental medical technologies, Lissone, Italy)	980 / continuous	20 x 103 / 625*	37.5 / 1,200	32 cm^2/ 6 points in paravertebral region (L2 to S2-S3) / 1 min/point	9 times, 3 times a week, 3 weeks	Exercise
Choi 2007 [19]	RCT	GaAs (Combi500, Gymna, Belgium)	904 / pulse type (pulse duration 155 ns)	14 / n.a.	n.a. /2.5	n.r. / 10 points in paravertebral region / 3 min/point	10 times, 5 times a week, 2 weeks	None
Klein 1990 [20]	RCT	GaAs (Omniprobe™ laser biostimulation unit)	904 / pulse type (pulse rate 10,000 Hz)	5.42 / 5.42*	1.3 / 1.3	1 cm2/ Low back region (L4 toL5, L5 to S1) / 4 min/point	12 times, 3 times a week, 4 weeks	Exercise
Ruth 2010 [21]	RCT	n.r. (Laserneedle™)	680, 785/ continuous	50-150 / 1-5	n.a./n.a.	n.r./ 8 points (BL 23, 40, 60, Ni3, GB-track, Ashi acupoints) / 15 min	10 times, 2 times a week, 5 weeks	Conventional therapy

*Calculated parameters.
RCT, randomized controlled trial; Nd YAG, Neodymium yttrium-aluminum-garnet; GaAlAs, gallium-aluminum-arsenide; GaAs, gallium arsenide; n.r., not reported; n.a., not available.

Table 6. LLLT/LA Methods of Included Studies Comparing LLLT/ LA as Alone with Other Therapies.

First author, year	Study design	Medium (model, manufacturer)	Wavelength (nm)/type	Power output (mW)/power density (mW/cm^2)	Energy density (J/cm^2) /dose/point (J/ point)	Beam size/number of treatment/treatment time	Treatment session & interval	Other interventions on both group
Tantawy 2019 [24]	RCT	(1) LP GaAlAs (FISIOLASERSCAN HP4, CHINESPORT, Udine, Italy)	808 / continuous	25* / 113.6	17.05 / 3.75	0.22 cm^2 / 8 points (L2-S3) / 150 s/point	16 times, twice a week, 8 weeks	Exercise
		(2) US (Chattanooga, 278 w/Ultrasound, New York, USA)	Frequency: 1 MHz /Continuous wave /Intensity: 1 W/cm^2			5 cm^2 / Lumbar vertebral region / 10 min		
Liu 2017 [26]	RCT	(1) LI n.r. (Super Lazer HA-2200)	n.r.	n.a.	n.a.	n.r / Acu points in lumbar region / 7 min/points	20 times, every day, 20 days	None
		(2) Manipulation	1) Patient in prone position with abdominal pad with soft pillow and Rolling method to make a large massage on the waist and hips. Gradually roll from around to the center of the pain point, repeated several times from slight to heavy. 2) Take a finger manipulation method to take BL23, BL25, BL52, and BL40, and push each point for about 1 minute. 3) Then, along the sides of the waist, along the BL-track is scrolled up and down. Finally, take passive traction of the lower back muscles, fascia and ligaments.					

*Calculated parameters.
RCT, randomized controlled trial; LP, laser photomodulaton; US, ultrasound therapy; LI, linear-polarized near-infared light; n.r., not reported; n.a., not available.

Table 7. LLLT Including LA Methods of Included Studies Comparing LLLT/ LA as Add-on Treatment.

First author, year	Study design	Medium (model, manufacturer)	Wavelength (nm)/type	Power output (mW)/power density (mW/cm^2)	Energy density (J/cm^2) /dose/point (J/point)	Beam size/ number of treatment/ Treatment time	Treatment session & interval	Other interventions on both group
Tantawy 2019 [24]	RCT	(1) LP GaAlAs (FISIOLASERSCAN HP4, CHINESPORT, Udine, Italy)	808 / continuous	25* / 113.6	17.05 / 3.75	0.22 cm^2 / 8 points (L2-S3) / 150 s/point	16 times, twice a week, 8 weeks	None
		(2) Exercise	Active strengthening, stretching, mobilization, coordination, and maintaining stabilization of back.				15 times, 3 times a week, 8 weeks	
Guo 2010 [25]	RCT	(1) Diode laser GaAlAs (MDC1000-31BP, Shanghai)	830 / n.r.	300-500/n.a.	n.r. / n.a.	n.r./ n.r. / 5 min/ point	10-20 times, n.r.	None
		(2) Maitland technique	Manipulation method including traction, stretching, massage in lumbar spine.					
Qin 2010 [25]	RCT	(1) Laser diode radiation GaAlAs GaAlAs (MDC1000-31BP, Shanghai)	830 / n.r.	300-500/n.a.	n.r. / n.a.	n.r./ n.r. / 5-10 min/ point	10-20 times, n.r.	None
		(2) massage	Manipulation method including rolling, finger pressure, traction etc.					
Gur 2003 [28]	RCT	(1) Laser GaAs (n.r.)	904 / pulse type (pulse rate 2.1 kHz)	42.42* /4.2	1 / 10.1	10.1 cm^2 / Pain points (L4-5, L5-S1) / 4 min	20 times/ 5 times a week / 4 weeks	None
		(2) Exercise	Lumbar flexion and extension, knee flexion, hip adduction exercise and strength exercises of extremity muscle group.				40 times/ 2 times a day / 4 weeks	

*Calculated parameters.
RCT, randomized controlled trial; LP, laser photomodulaton; GaAlAs, gallium-aluminum-arsenide; GaAs, gallium arsenide; n.r., not reported; n.a., not available.

Table 8. LLLT/LA Methods of Included Studies Comparing 2 Methods of LLLT/LA.

First author, year	Study design	Medium (model, manufacturer)	Wavelength (nm)/type	Power output (mW) /power density (mW/cm^2)	Energy density (J/cm^2) /dose/point (J/point)	Beam size/number of treatment/ treatment time	Treatment session & interval	Other interventions on both group
Ammar 2015 [22]	RCT	GaAlAs Anodyne™ Therapy System,model 480 (Anodyne Therapy, LLC, Tampa, Florida)	890 / pulse type (pulse rate 292Hz)	267 / 11.85*	2.13* / 48	22.5 cm^2/ 8 points (either side in lumbar spine) / 30 min	12 times, 2 times a week, 6 weeks	Exercise
		GaAlAs (Chattanooga group, USA)	850 / continuous type	100 / 12.7 x 103*	1,143 / 9	1 mm (diameter)/ 8 points along the lumbosacral spine (T12-S3) / 90 s/point		
Dogan 2017 [23]	RCT	GaAlAs (Chattanooga group, USA)	850 / continuous type	100 / 1,428*	342.7 / 24*	0.07 cm^2/ 4 point (L4-L5, L5-S1) / 4 min	15 times, 5 times a week, 3 weeks	hot-pack
		HeNe + GaAlAs (n.r.)	HeNe 680mm 10 diodes (1) + GaAlAs 785nm 3 diodes (2) + GaAlAs 980nm 4 diodes (3) / continuous	(1) 7 mW/ n.a. (2) 50 mW/ n.a. (3) 10 mW/ n.a.	3 / n.a.	112 cm^2/ 17 point (L4-L5, L5-S1) / 20 min		
Glazov 2014 [13]	RCT	GaAlAs (Acupak, Melbourne, Australia)	830 / continuous	20 / 100	1* / 0.2	0.2 cm^2/ 9 points (individualized acupoints) / 10 s/ points	8 times, once a week, 8 weeks	none
		GaAlAs (Acupak, Melbourne, Australia)	830 / continuous	20 / 100	4* / 0.8	0.2 cm^2/ 9 points (individualized acupoints) / 40 s/ points		

*Calculated parameters.
RCT, randomized controlled trial; GaAlAs, gallium-aluminum-arsenide; He-Ne, helyum-neon; n.r., not reported; n.a., not available.

VAS score without reporting exact values [9,14,17], and 1 study described the results by the degree of change in the chronic pain index [21]. In 9 studies involving 495 participants, the VAS and NRS were used to evaluate the degree of pain relief, and LLLT/LA significantly reduced pain compared with sham treatment (SMD -0.51, 95% CI: -0.88 to -0.13; $\chi^2 = 31.12$, $I^2 = 74\%$; Fig. 2).

With regards to function/disability, 4 out of 13 studies evaluated outcomes using ODI values [8,11-13]. In 4 studies (277 participants), LLLTs with LA had no significant effect compared with sham treatment (MD -2.68, 95% CI: -9.15 to 3.79; $\chi^2 = 38.40$, $I^2 = 92\%$; Fig. 3).

Comparing LLLT/LA as alone with other therapies

With regards to pain, 2 studies applied LLLT/LA alone; 1 study compared LLLT/LA with ultrasound treatment [24], and 1 study compared LLLT/LA with chu-na therapy [26]. There was significant pain relief in the study where LLLT/LA alone was compared with ultrasound therapy alone (30 participants, MD -1.12, 95% CI: -2.09 to -0.15). In the study comparing LLLT/LA with chu-na therapy, there was no significant effect on pain relief (106 participants, MD 0.03, 95% CI: -0.31 to 0.37; Fig. 4).

With regards to function/disability, 1 study showed a significant positive effect on the ODI between LLLT/LA alone and ultrasound therapy alone [26] (30 participants, MD -11.90, 95% CI: -17.37 to -6.43; Fig. 5).

Comparing LLLT/LA as add-on treatment

With regards to pain, 2 studies where LLLT/LA was applied as add-on treatment showed a significant positive effect on pain relief [24,28] (80 participants, MD -5.10, 95% CI: -9.31 to -0.88; $\chi^2 = 28.99$, $I^2 = 97\%$; Fig. 6).

With regards to function/disability, 2 studies used the JOA scale to evaluate outcomes [25,27], and a further 2 used the ODI [24,28]. A higher JOA scale score and a lower ODI score post-treatment indicated increased effectiveness at improving dysfunction. As an add-on treatment, LLLT/LA significantly improved function and disability in the studies evaluated using the JOA scale (120 participants, MD 5.44, 95% CI: 2.19 to 8.68; $\chi^2 = 4.07$, $I^2 = 75\%$). In the studies using the ODI, there was no significance noted (80 participants, SMD -0.81, 95% CI: -2.74 to 1.13; $\chi^2 = 14.05$, $I^2 = 93\%$; Figs. 7 and 8).

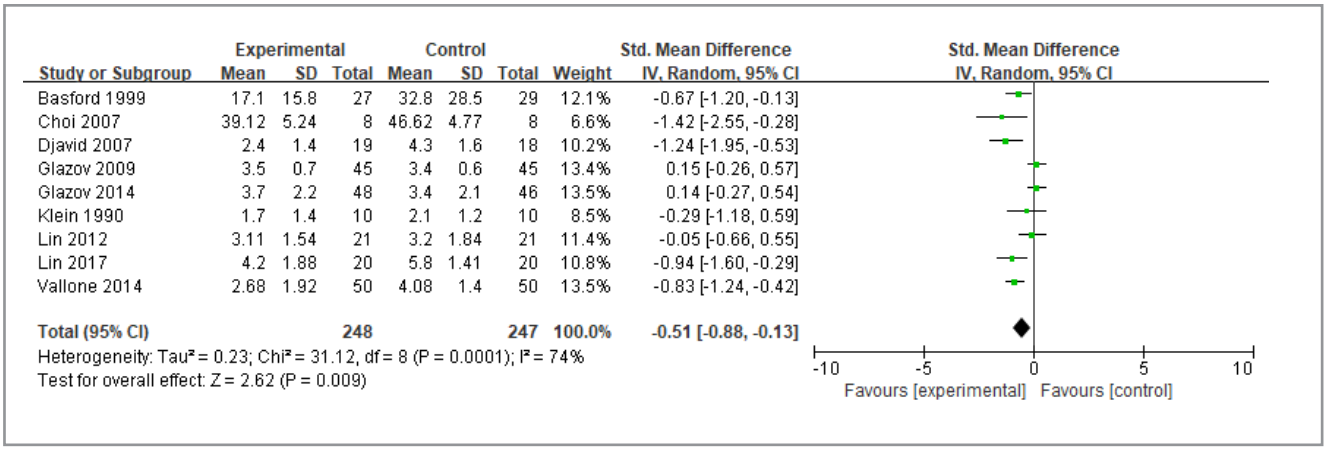

Fig. 2. The effectiveness of LLLT/LA versus sham LLLT including LA on pain relief
CI, confidence interval; Df, degree of freedom; IV, information value; LA, laser acupuncture; LLLT, low-level laser therapy.

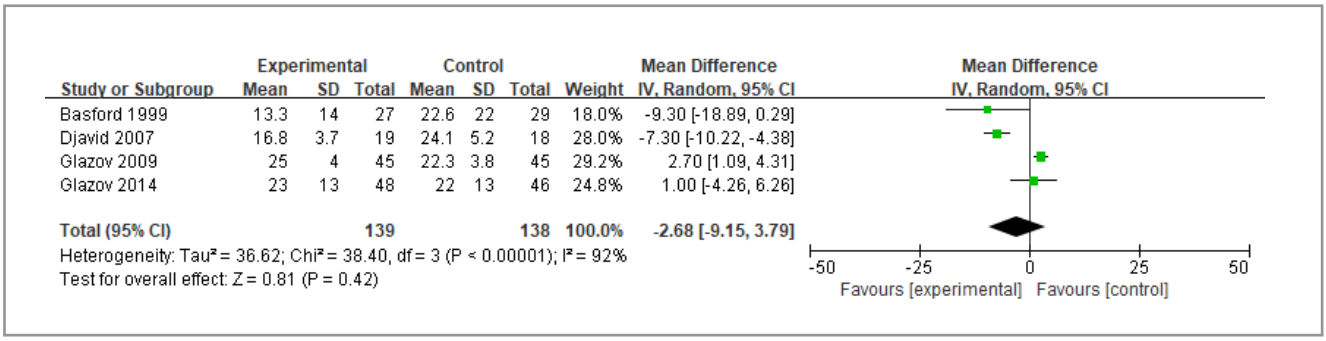

Fig. 3. The effectiveness of LLLT/LA versus sham LLLT/LA on function and disability measured by ODI.
CI, confidence interval; Df, degree of freedom; IV, information value; LA, laser acupuncture; LLLT, low-level laser therapy; ODI, Oswestry disability index.

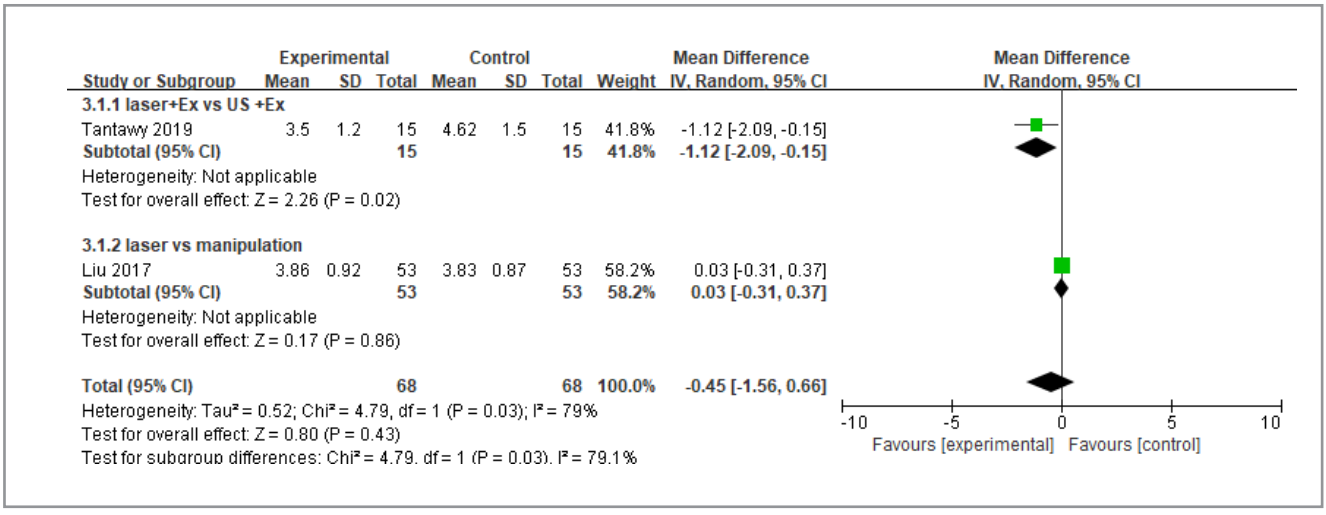

Fig. 4. The effectiveness of LLLT/LA as alone on pain relief
CI, confidence interval; Df, degree of freedom; LA, laser acupuncture; LLLT, low-level laser therapy; IV, information value.

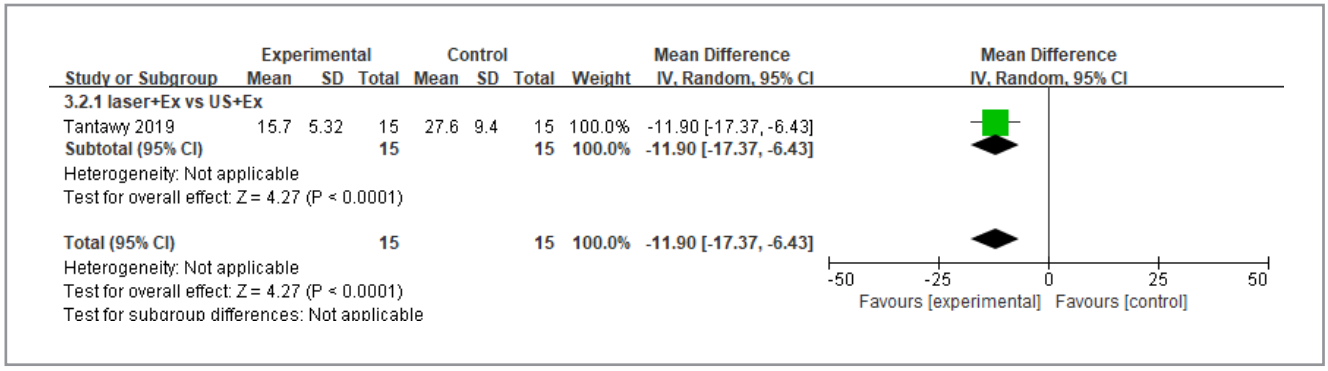

Fig. 5. The effectiveness of LLLT/ LA as alone on function and disability measured by ODI
CI, confidence interval; Df, degree of freedom; IV, information value; LA, laser acupuncture; LLLT, low-level laser therapy; ODI, Oswestry disability index.

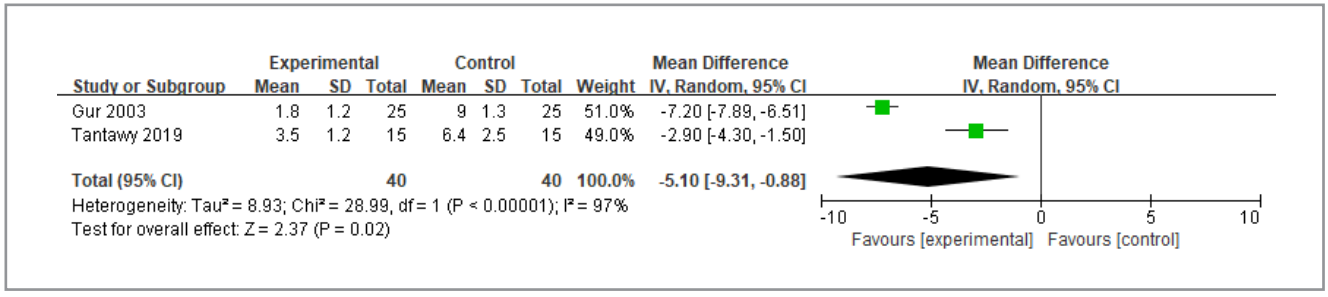

Fig. 6. The effectiveness of LLLT/LA as add-on treatment of pain relief
CI, confidence interval; Df, degree of freedom; LA, laser acupuncture; LLLT, low-level laser therapy; IV, information value.

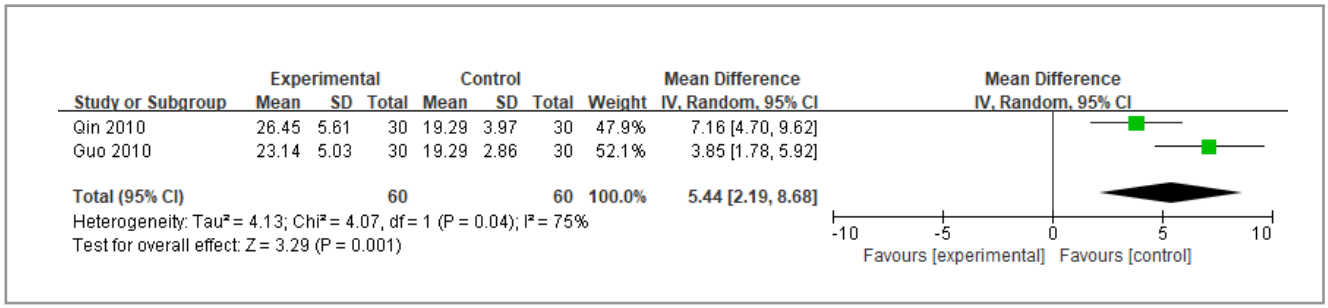

Fig. 7. The effectiveness of LLLT/LA as add-on treatment on function and disability measured by JOA
CI, confidence interval; Df, degree of freedom; IV, information value; JOA, Japanese orthopaedic association; LA, laser acupuncture; LLLT, low-level laser therapy.

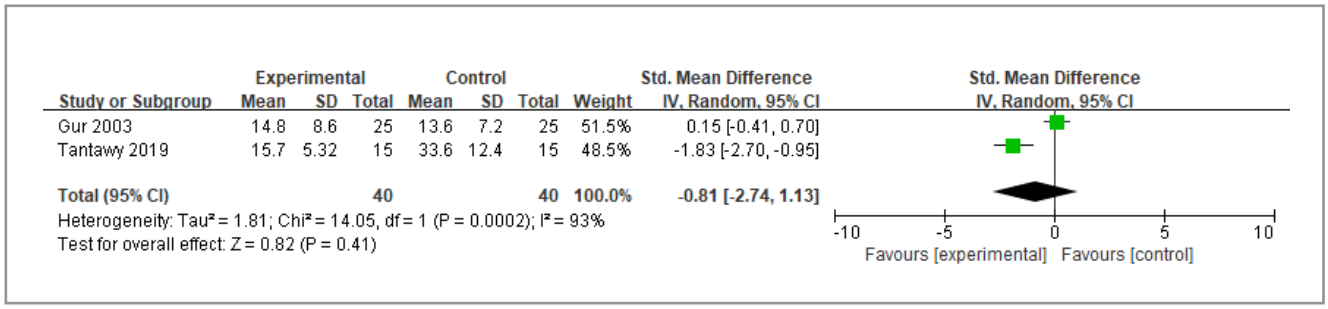

Fig. 8. The effectiveness of LLLT/LA as add-on treatment on function and disability measured by ODI
CI, confidence interval; Df, degree of freedom; IV, information value; LA, laser acupuncture; LLLT, low-level laser therapy; ODI, Oswestry disability index.

Adverse reactions and side effects

Ten RCTs reported adverse reactions/negative side effects. Of these, 9 reported no adverse reactions [9,11,13,14,17,18,20,21,23], and in 1 RCT, adverse reactions were reported as mild "warmth" which occurred more often during treatment in the active group [8]. No adverse reactions were noted in the other 10 studies [12,15,16,19,22,24-28].

Risk of bias

The risk of bias was assessed for the 20 RCTs according to the Cochrane handbook (Figs. 9 and 10).

Random sequence generation

Low risk was observed in 12 studies [8,11-14,17,18,20,22-24]. The other 8 studies were evaluated as unclear risk [9,15,19,21,25-28].

Allocation concealment

Low risk was observed in 12 studies [8,11-14,17,18,20,22-24]. The other 8 studies were evaluated as unclear risk [9,15,19,21,25-28].

Blinding of participants and personnel

Two studies were evaluated as high risk, which clearly stated that blinding of the study was not possible for the therapist [14,23]. Eight studies were deemed low risk as they reported that therapist was independently blinded to the study [8,9,11-13,16,17,20]. The other 10 studies were evaluated as unclear risk [15,18,19,21,22,24-28].

Blinding of outcome assessment

Low risk was observed in 10 studies that mentioned independent researcher and evaluators [11-14,16,17,20,23,24,28]. The other 10 studies were classified as unclear risk [8,9,15,18,19,21,22,25-27].

Incomplete outcome data

Low risk was observed in 17 studies that had no dropouts or similar occurrence of missing values between groups. The other 3 studies were evaluated as unclear risk [17,21,22].

Selective reporting

Five studies that reported results according to the previous protocols were classified low risk [12,13,17,18,24]. Two studies reported an incomplete result and was evaluated as high risk [9,21]. There were 13 studies that did not report the protocol and were classified as unclear risk [8,11,14-16,19,20,22,23,25-28].

Other bias

None of the 20 studies reported all the laser parameters. Six of the studies were evaluated as high risk because some important parameters could not be calculated [11,21,23,25-27].

Discussion

The US Bureau of Statistics published "An Aging World: 2015" which predicted that from 2025 to 2050, the older population is projected to almost double to 1.6 billion globally, whereas the total population will grow by just 34% over the same period [29]. When life expectancy is increasing and aging is rapidly progressing, pain is 1 of the main indicators of quality of life. Chronic pain not only limits daily life at work/home, it also impairs mental health and negatively affects the economy. Several South Korean surveys (the Survey on the Elderly, the National Health and Nutrition Survey, and the Aging Research Panel Survey) reported that 90% of pain in men and women over 60 years of age occurred in the musculoskeletal area, with lower back pain, and knee pain being

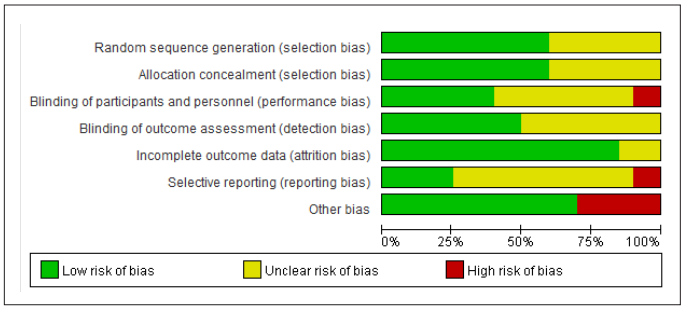

Fig. 9. Risk of bias graph

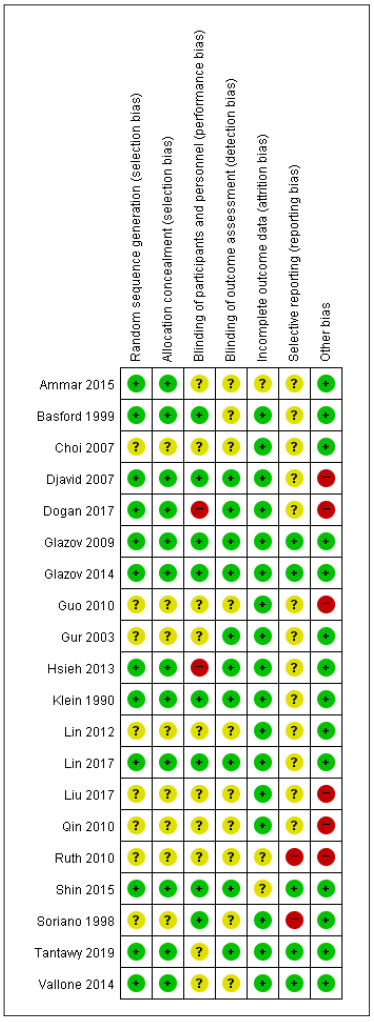

Fig. 10. Risk of bias summary.

the most prevalent [30].

NCLBP is a condition where non-pharmaceutical treatment is recommended over pharmaceutical therapy. Non-steroidal anti-inflammatory analgesics and/or muscle relaxants are used to alleviate symptoms. However, these forms of pharmaceutical therapy require a risk-benefit assessment due to potential side effects (increased risk of renal failure, gastric ulcers, and cardiovascular disease) [31].

LLLT/LA is a non-invasive treatment without the risk of pain or infection. It has been used to manage chronic pain in Korean medical clinics and has high patient satisfaction. However, it is difficult to prove its efficacy because each RCT is conducted under different conditions using different laser machine specifications. In this systematic review, as many databases as possible were used from the USA, Europe, Korea, China, and Japan. The efficacy of LLLT/LA on NCLBP was investigated under 3 conditions: comparison with a control group, comparison with other treatments, and efficacy as an add-on treatment.

The 20 studies that were selected covered 11 countries and included a total of 1,323 patients. Among the 13 studies comparing LLLT/LA with sham treatment, 7 mentioned a positive effect on pain reduction in the experimental group compared with the control group. As a result of VAS score analysis of the 9 studies that could be analyzed, a significant positive effect on pain relief was confirmed. In the 4 studies that could not be analyzed concerning the improvement of function/disability, the result of the ODI analysis showed no significance. There was a significant positive effect on pain relief and function/disability in the study where LLLT/LA group was compared with ultrasound treatment. When compared with chu-na treatment, there was no significant improvement in pain relief between the 2 groups. However, each group did show significant pain improvement after treatment. Further study is required to fully assess these outcomes. LLLT/LA as an add-on treatment showed a significant positive effect on pain relief. With regards to the improvements in function/disability, the 2 studies using the JOA scale showed a significant positive effect and the 2 studies using the ODI scale showed no significant positive effect. As a result, LLLT/LA showed a significant positive effect on pain relief and function/disability improvement during a short period.

This study is not without its limitations. Firstly, with increasing age came a higher association of LBP with the underlying disease, therefore the number of studies on NCLBP was small compared with the total number of studies retrieved. All Japanese studies had to be excluded due to inclusion of LBP associated with the underlying disease. Secondly, chronic pain is correlated to quality of life. However, the treatment and evaluation periods in most studies were too short to evaluate any long-term biopsychosocial outcomes. Therefore, this should be considered when designing future studies to evaluate the possibility of LLLT/LA as a therapy for chronic pain management in an aging era. Finally, many of the studies presented were not of high quality.

This study determined that LLLT/LA may be an effective and safe intervention for NCLBP. However, there were no studies conducted under the same treatment conditions, therefore further well-designed studies are required to determine which treatment condition is most effective. Therefore, moving forward, establishing a more accurate treatment method will require well-designed studies.

Conclusion

This systematic review and meta-analysis suggest that LLLT/LA may be considered as an alternative or add-on treatment for NCLBP. LLLT/LA has a significant positive effect on reducing pain and improving the function/disability and has rare serious adverse events.

Conflicts of Interest

The authors have no conflicts of interest to declare.

References

[1] Deyo RA, Weinstein JN. Low back pain. N Engl J Med 2001;344:363-370.
[2] Korean Ministry of Health and Welfare, Korea Institute for Health and Social Affairs. Survey on the use of Korean Medical Institutions and consumption of Korean Herbal Medicine in 2011. Sejong (Korea): Korean Ministry of Health and Welfare; 2011. 554 p. [in Korean].
[3] Korean Ministry of Health and Welfare, Korea Institute for Health and Social Affairs. Survey on the use of Korean Medical Institutions and consumption of Korean Herbal Medicine in 2011. Sejong (Korea): Korean Ministry of Health and Welfare; 2017. 304 p. [in Korean].
[4] Nascimento PRCD, Costa LOP, Araujo AC, Poitras S, Bilodeau M. Effectiveness of interventions for non-specific low back pain in older adults: A systematic review and meta-analysis. Physiotherapy 2019;105:147-162.
[5] Schiphorst Preuper HR, Reneman MF, Boonstra AM, Dijkstra PU, Versteegen GJ, Geertzen JHB et al. Relationship between psychological factors and performance-based and self-reported disability in chronic low back pain. Eur Spine J 2008;17:1448-1456.
[6] Kim HH, Nam DW, Lee SH, Fundamentals and Research Trend of Laser Acupuncture. J Korean Acupunct Moxib Soc 2009;26:21-30. [in Korean].
[7] Qaseem A, Wilt TJ, McLean RM, Forciea MA, Clinical Guidelines Committee of the American College of Physicians. Noninvasive Treatments for Acute, Subacute, and Chronic Low Back Pain: A Clinical Practice Guideline from the American College of Physicians. Ann Intern Med 2017;166:514-530.
[8] Basford JR, Sheffield CG, Harmsen WS. Laser therapy: A randomized, controlled trial of the effects of low-intensity Nd:YAG laser irradiation on musculoskeletal back pain. Arch Phys Med Rehabil 1999;80:647-652.
[9] Soriano F, Roxana R. Gallium Arsenide Laser Treatment of Chronic Low Back Pain: A Prospective, Randomized and Double-Blind Study. Laser Ther 1998;10:175-180.
[10] Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, loannidis JP et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: Explanation and elaboration. BMJ 2009;339:b2700.
[11] Djavid GE, Mehrdad R, Ghasemi M, Hasan-Zadeh H, Sotoodeh-Manesh A, Pouryaghoub G. In chronic low back pain, low level laser therapy combined with exercise is more beneficial than exercise alone in the long term: A randomized trial. Aust J Physiother 2007;53:155-160.
[12] Glazov G, Schattner P, Lopez D, Shandley K. Laser acupuncture for chronic non-specific low back pain: a controlled clinical trial. Acupunct Med 2009;27:94-100.
[13] Glazov G, Yelland M, Emery J. Low-dose laser acupuncture for non-specific chronic low back pain: A double-blind randomized controlled trial. Acupunct Med 2014;32:116-123.
[14] Hsieh RL, Lee WC. Short-term therapeutic effects of 890-nanometer light therapy for chronic low back pain: A double-blind randomized placebo-controlled study. Lasers Med Sci 2014;29:671-679.
[15] Lin ML, Wu HC, Hsieh YH, Su CT, Shih YS, Lin CW et al. Evaluation of the effect of laser acupuncture and cupping with ryodoraku and visual analog scale on low back pain. Evid Based Complement Alternat Med 2012;2012:521612.
[16] Lin ML, Wu JH, Lin CW, Su CT, Wu HC, Shih YS et al. Clinical Effects of Laser Acupuncture plus Chinese Cupping on the Pain and Plasma Cortisol Levels in Patients with Chronic Nonspecific Lower Back Pain: A Randomized Controlled Trial. Evid Based Complement Alternat Med 2017;2017:3140403.
[17] Shin JY, Ku B, Kim JU, Lee YJ, Kang JH, Heo H et al. Short-Term Effect of Laser Acupuncture on Lower Back Pain: A Randomized, Placebo-Controlled, Double-Blind Trial. Evid Based Complement Alternat Med 2015;2015:808425.
[18] Vallone F, Benedicenti S, Sorrenti E, Schiavetti I, Angiero F. Effect of diode laser in the treatment of patients with nonspecific chronic low back pain: A randomized controlled trial. Photomed Laser Surg 2014;32:490-494.

[19] Choi JH. Effects of Low-Level Laser Irradiation for Low Back Pain. J of Korea Sport Res 2007;18:469-478. [in Korean].
[20] Klein RG, Eek BC. Low-energy laser treatment and exercise for chronic low back pain: double-blind controlled trial. Arch Phys Med Rehabil 1990;71:34-37.
[21] Ruth M, Weber M, Zenz M. Laser acupuncture for chronic back pain: A double-blind clinical study. Schmerz 2010;24:485-493. [in German].
[22] Ammar TA. Monochromatic Infrared Photo Energy Versus Low Level Laser Therapy in Chronic Low Back Pain. J Lasers Med Sci 2015;6:157-161.
[23] Dogan SK, Ay S, Evcik D. The effects of two different low level laser therapies in the treatment of patients with chronic low back pain: A double-blinded randomized clinical trial. J Back Musculoskelet Rehabil 2017;30:235-240.
[24] Tantawy SA, Abdelbasset WK, Kamel DM, Alrawaili SM, Alsubaie SF. Laser photobiomodulation is more effective than ultrasound therapy in patients with chronic nonspecific low back pain: a comparative study. Lasers Med Sci 2019;34:793-800.
[25] Guo JH, Qin Y. Diode Laser Radiation with Maitland Technique in Treatment of Nonspecific Low Back Pain. Chin J Laser Med Surg 2010;19:251-253. [in Chinese].
[26] Liu X, Ling X, Lin J, Qi H. The effect of linear polarized near-infrared light on chronic nonspecific low back pain in the elderly. Chin J Convalescent Med 2017;26:1011-1014. [in Chinese].
[27] Qin Yin. Clinical analysis of semiconductor laser combined with lumbar massage in the treatment of chronic low back pain. Chin J Bone Tumor Bone Dis 2010;9:333-335. [in Chinese].
[28] Gur A, Karakoc M, Cevik R, Nas K, Sarac AJ, Karakoc M. Efficacy of low power laser therapy and exercise on pain and functions in chronic low back pain. Lasers Surg Med 2003;32:233-238.
[29] Wan H, Daniel G, Paul K [Internet]. An Aging World. 2015. U.S.: Department of Commerce and U.S. Department of Human Services: 2016. 175 p. Available from: https://cdn.cnsnews.com/attachments/census_bureau-an_aging_world-2015.pdf.
[30] Choi KH, Park JY, Kim NS, Park HY. Status of Chronic Pain Prevalence in Korean Adults. Public Health Weekly Rep KCDC 2015;8:728-734. [in Korean].
[31] Michèle B, Nandini D, Benjamin R, Lyne N, Arja HS, Edeltraut G et al. Risk of acute myocardial infarction with NSAIDs in real world use: Bayesian meta-analysis of individual patient data. BMJ 2017;357:j1909.