Low-level laser therapy including laser acupuncture has been widely used for non-specific chronic low back pain in primary Korean medical clinics. However, there is no critically appraised data regarding which treatment conditions are most effective. A systematic review and meta-analysis was conducted to determine effective treatment conditions using 12 databases (PubMed, Ovid, CENTRAL, KoreaMed, KMBASE, KISS, NDSL, KISTI, OASIS, CNKI, CiNII, and J-STAGE). There were 1,019 studies retrieved and 13 studies included in this review. It was determined that when the power output was ≥ 50 mW, the beam size was increased to ≥ 1 cm², the energy dose was increased to ≥ 4 J per point, the treatment interval was increased to ≥ 3 times a week, and the number of treatment sessions was increased to ≥ 10 treatments, these conditions appeared to increased treatment effectiveness.

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ABSTRACT

Low-level laser therapy including laser acupuncture has been widely used for non-specific chronic low back pain in primary Korean medical clinics. However, there is no critically appraised data regarding which treatment conditions are most effective. A systematic review and meta-analysis was conducted to determine effective treatment conditions using 12 databases (PubMed, Ovid, CENTRAL, KoreaMed, KMBASE, KISS, NDSL, KISTI, OASIS, CNKI, CiNII, and J-STAGE). There were 1,019 studies retrieved and 13 studies included in this review. It was determined that when the power output was ≥ 50 mW, the beam size was increased to ≥ 1 cm², the energy dose was increased to ≥ 4 J per point, the treatment interval was increased to ≥ 3 times a week, and the number of treatment sessions was increased to ≥ 10 treatments, these conditions appeared to increased treatment effectiveness.

Introduction

Low back pain (LBP) is a common musculoskeletal disorder affecting 67% of the adult population at some point in their lives. It is estimated that 10% to 20% of affected adults develop symptoms of chronic low back pain (CLBP) that last more than 12 weeks [1]. A study conducted in 2012 looking at the burden of different diseases on Koreans determined that LBP ranked 2nd in men and 1st in women [2]. Non-specific chronic low back pain (NCLBP) occurs when the pain lasts over 12 weeks with no clear underlying etiology. NCLBP is not a life-threatening disease however, it affects the patient’s quality of life and therefore it is important manage and treat. Low-level laser therapy including laser acupuncture (LLLT/LA) also known as photobiomodulation, uses a laser configured to aid tissue repair, relieve pain, and stimulate acupuncture points [3-5]. One review in 2015 categorized 399 different studies on LLLT (which were published between 2003 and 2013) and observed that LLLT was most frequently used in dentistry, pain management, and musculoskeletal disorders like LBP [6].

The empirical effect of LLLT/LA for NCLBP is recognized, however, there are currently still no standardized guidelines for treatment methods. LLLT/LA has been conducted under a range of different conditions using different machine specifications. Furthermore, there are various treatment parameters related to laser irradiation that correlate with biostimulation. While the World Association of Laser Therapy (WALT) has published guidelines for LLLT dosage for certain diseases, previous randomized control trials (RCTs) have been conducted using different conditions and machine specifications.

A systematic review and meta-analysis suggested that LLLT/LA could be used as an alternative or add-on treatment for NCLBP [7]. Based on the results, a systematic review and meta-analysis of effective treatment conditions for chronic pain management was conducted addressing 5 core questions (1) power output; (2) beam size; (3) energy dose; (4) treatment intervals per week; and (5) total treatment sessions.

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Materials and Methods

Five core questions

Taking into account the results of existing studies, WALT guidelines, and the duration of general clinical treatment, 5 core categories (1) power output; (2) beam size; (3) energy dose; (4) treatment intervals per week; and (5) total treatment sessions have been addressed.

Database searched and study selection

There were 12 bibliographic databases searched from their inception to June 2019 [MEDLINE (PubMed), EMBASE (Ovid), the Cochrane Central Register of Controlled Trials (CENTRAL), Korean databases (KoreaMed, KBASE, KISS, NDSL, KISTI, OASIS), the China National Knowledge Infrastructure Database (CNKI), and Japanese databases (GINII, J-STAGE)].

The search terms were composed of 2 parts, LLLT/LA (e.g., laser, laser acupuncture, laserpuncture, laser needle, low-dose laser acupuncture, LLLT, low-level laser, laser therapy, laser treatment) and CLBP (e.g., low back pain, sciatica, radiculopathy, lumbarho, backache, back pain, lumbosacral). To increase the sensitivity of the search for NCLBP, the search was performed by also including conditions such as radiculopathy and sciatica. In some cases, the LLLT/LA parameters were classified however, in the case of the lower back area, it was difficult to avoid acupuncture points during treatment due to their high density. Moreover, laser treatments have an “alpha-phenomenon” effect that shows an indirect biostimulation on the surrounding tissues.

In this review, all RCTs using LLLT/LA were analyzed. Patients with NCLBP were included in the review and cases of CLBP (indicated by malignancy, infection, neoplasm, osteoporosis, fracture, inflammatory disorder, or neurological syndrome) were excluded. Only RCTs of LLLT/LA which were compared with sham laser therapy were included in the review. Observational, cohort, case reports, case series, non-RCTs, animal, and experimental studies were all excluded. Two reviewers independently screened the studies and after thorough 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 outcome values was extracted by 2 reviewers and checked for accuracy by a 3rd reviewer. The primary outcomes were: (1) Pain intensity measured on a visual analog scale or the numeric rating scale; and (2) Functional status/disability which was measured by the Oswestry disability index (ODI) or the Japanese orthopaedic association score. The secondary outcomes were the range of motion, the result of the Modified Schober test, global assessment of quality of life, and negative side effects.

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 95% confidence interval (CI). 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 a 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, 13 RCTs were selected according to the inclusion criteria [8-20]. The 13 RCTs were conducted in 8 countries and included a total of 773 participants (Fig. 1). The characteristics of each study and laser parameters are listed in Tables 1 and 2.

Intervention analysis

All 13 studies compared LLLT/LA with sham laser therapy [8-20] however, each RCT used different treatment parameters so, the differences between the RCTs were analyzed using the following core question to answer, “Does a condition (1-5) of treatment using LLLT/LA for CNLBP show a better improvement in the level of pain or function?”

1. A power output of ≥ 50 mW compared with < 50 mW
2. A beam size of ≥ 1 cm² compared with < 1 cm²
3. An energy dose of ≥ 4 J/point compared with < 4 J/point?
4. A treatment interval of ≥ 3/week compared with < 3/week?
5. A number of treatment sessions ≥ 10 times compared with < 10 times?
Table 1. Summary of the Included Studies Comparing LLLT/LA and Sham-LLLT/LA Therapy.

<table>
<thead>
<tr>
<th>First author (year)</th>
<th>Country</th>
<th>Intervention group (allocated Pt./analyzed Pt.)</th>
<th>Comparison group (allocated Pt./analyzed Pt.)</th>
<th>Main outcomes</th>
<th>Intergroup difference</th>
<th>Adverse event</th>
<th>Authors’ conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basford (1999) [8]</td>
<td>USA</td>
<td>LILI (30/27)</td>
<td>Sham LILI (29/29)</td>
<td>1) ODI</td>
<td>1) p = 0.001</td>
<td>No SAEs</td>
<td>Laser &gt; control (in pain and function). Benefits decreased with time.</td>
</tr>
<tr>
<td>Djavid (2007) [9]</td>
<td>Iran</td>
<td>LLLT (20/19)</td>
<td>Sham LLLT (19/18)</td>
<td>1) VAS</td>
<td>1) p = 0.03</td>
<td>No AEs</td>
<td>Laser &gt; control (in pain and function).</td>
</tr>
<tr>
<td>Heish (2013) [12]</td>
<td>Taiwan</td>
<td>Light therapy (35/33)</td>
<td>Sham Light therapy (35/27)</td>
<td>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</td>
<td>1-4) Not differ</td>
<td>5) p = 0.04 (physical) 6) p = 0.007 (work) 7) p = 0.021 8) Not differ</td>
<td>No AEs</td>
</tr>
<tr>
<td>Lin (2012)</td>
<td>Taiwan</td>
<td>LA (28/21)</td>
<td>Sham LA (29/21)</td>
<td>1) VAS, 2) Ryodoraku value</td>
<td>1) Not differ 2) changed back to almost original values in active group (reinforcing effect)</td>
<td>n.r.</td>
<td>Not different</td>
</tr>
<tr>
<td>Lin (2017)</td>
<td>Taiwan</td>
<td>LA (25/20)</td>
<td>Sham LA (23/20)</td>
<td>1) VAS, 2) Plasma cortisol levels</td>
<td>1) p = 0.005 2) p = 0.65</td>
<td>n.r.</td>
<td>laser &gt; control (in pain)</td>
</tr>
<tr>
<td>Shin (2015)</td>
<td>Republic of Korea</td>
<td>LA (28/28)</td>
<td>Sham LA (28/26)</td>
<td>1) VAS, 2) PGIC, 3) PPT, 4) EQ-SD</td>
<td>1-4) Not differ</td>
<td>No AEs and SAEs</td>
<td>Not different</td>
</tr>
<tr>
<td>Soriano (1998) [16]</td>
<td>Argentina</td>
<td>Laser Treatment (38)</td>
<td>Sham Laser Treatment (33)</td>
<td>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</td>
<td>1-3) n.r. 4) p &lt; 0.01 5) p &lt; 0.007</td>
<td>No AEs</td>
<td>Laser &gt; sham (in pain)</td>
</tr>
<tr>
<td>Vallone (2014) [17]</td>
<td>Italy</td>
<td>Diode Laser (50)</td>
<td>Sham Diode Laser (50)</td>
<td>1) VAS</td>
<td>1) p &lt; 0.001</td>
<td>No AEs</td>
<td>Laser &gt; sham (in pain and lumbar mobility)</td>
</tr>
<tr>
<td>Choi (2007)</td>
<td>Republic of Korea</td>
<td>LILI (8)</td>
<td>Sham LILI (8)</td>
<td>1) VAS, 2) Modified Schober test</td>
<td>1) p = 0.001 2) p = 0.010</td>
<td>n.r.</td>
<td>Laser &gt; sham (in pain and lumbar mobility)</td>
</tr>
<tr>
<td>Klein (1999) [19]</td>
<td>USA</td>
<td>LELT (10)</td>
<td>Sham LEVT (10)</td>
<td>1) VAS, 2) Disability score, 3) Lumbar flexion, 4) Lumbar rotation, 5) Lumbar side flexion, 6) Lumbar extension, 7) Isometric torque, 8) Isodynamic velocity</td>
<td>1) p = 0.493 2) p = 0.919 3-8) Not different</td>
<td>No AEs</td>
<td>Not different</td>
</tr>
<tr>
<td>Ruth (2010) [20]</td>
<td>Germany</td>
<td>LA (51/46)</td>
<td>Sham LA (51/47)</td>
<td>1) Chronic pain index, 2) Disability score, 3) FABQ</td>
<td>1-3) Not different</td>
<td>No AEs</td>
<td>Not different</td>
</tr>
</tbody>
</table>

LLL, low-intensity laser irradiation; LLLT, low-level laser therapy; LA, laser acupuncture; LILI, low-level laser irradiation; LELT, low-energy laser treatment; ODI, Oswestry disability index; VAS, visual analog scale; DASS, depression anxiety stress scale; PWI-A, personal wellbeing index-adult; 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-quality-of-life five dimensions; ROM, range of motion; n.r., not reported; AE, adverse event; SAE, serious adverse event.
## Table 2. LLLT/LA Methods of Included Studies Comparing LLLT/LA and Sham-LLLT/LA Therapy.

<table>
<thead>
<tr>
<th>First author (year)</th>
<th>Study design</th>
<th>Medium (model, manufacturer)</th>
<th>Wavelength (nm)/type</th>
<th>Power output (mW)/power density (mW/cm²)</th>
<th>Energy density (J/cm²)/dose/point (J/point)</th>
<th>Beam size/No. treatments/treatment time</th>
<th>Treatment sessions (interval)</th>
<th>Other interventions on both group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basford (1999) [8]</td>
<td>RCT</td>
<td>Nd:YAG (1.06 µm Nd:YAG continuous-wave laser)</td>
<td>1,060/continuous</td>
<td>2,660/542</td>
<td>48.78/239.3</td>
<td>2.5 cm (diameter)/8 points (along the L2-L3)/90 s x 8 = 720 s (12 min)</td>
<td>12× (3/wk, 4 wks)</td>
<td>None</td>
</tr>
<tr>
<td>Djavid (2007) [9]</td>
<td>RCT</td>
<td>GaAlAs (n.r.)</td>
<td>810/continuous</td>
<td>50/226.1</td>
<td>275/9697</td>
<td>0.2211 cm²/8 points in paravertebral region (L2 to S2-3)/20 min</td>
<td>12× (2/wk, 6 wks)</td>
<td>Exercise</td>
</tr>
<tr>
<td>Glazov (2009) [10]</td>
<td>RCT</td>
<td>GaAlAs (Acupak, Melbourne, Australia)</td>
<td>830/continuous</td>
<td>10/50</td>
<td>1/0.2</td>
<td>0.2 cm²/8 points (individualized acupoints)/20 s/points</td>
<td>5× 10× (1/wk, average of 9.1 weekly sessions)</td>
<td>Exercise</td>
</tr>
<tr>
<td>Glazov (2014) [11]</td>
<td>RCT</td>
<td>GaAlAs (Acupak, Melbourne, Australia)</td>
<td>830/continuous</td>
<td>20/100</td>
<td>1/0.2</td>
<td>0.2 cm²/9 points (individualized acupoints)/10 s/points</td>
<td>8× (1/wk, 8 wks)</td>
<td>None</td>
</tr>
<tr>
<td>Heish (2013) [12]</td>
<td>RCT</td>
<td>GaAlAs (Anodyne Therapy Professional System 480 (Anodyne, Tampa, FL, USA))</td>
<td>890/n.r.</td>
<td>780/34.7</td>
<td>83.28/1873.8</td>
<td>22.5 cm²/7 points (low back region)/40 min</td>
<td>6× (3/wk, 2 wks)</td>
<td>Hot-pack</td>
</tr>
<tr>
<td>Lin (2012) [13]</td>
<td>RCT</td>
<td>n.r. (LA400, United Integrated Services Co., Ltd., Taiwan)</td>
<td>808/pulse type (pulse rate 20Hz)</td>
<td>20 (40:50% duty cycle of pulse)/25</td>
<td>15/12</td>
<td>0.8 cm²/4 points (BL40, Ashi acupoints)/10 min</td>
<td>5× (5/wk, 1 wk)</td>
<td>Soft cupping</td>
</tr>
<tr>
<td>Lin (2017) [14]</td>
<td>RCT</td>
<td>n.r. (LA400, United Integrated Services Co., Ltd., Taiwan)</td>
<td>808/pulse type (pulse rate 20Hz)</td>
<td>20 (40:50% duty cycle of pulse)/25</td>
<td>15/12</td>
<td>0.8 cm²/4 points (BL40, Ashi acupoints)/10 min</td>
<td>5× (5/wk, 1 wk)</td>
<td>Chinese cupping</td>
</tr>
<tr>
<td>Shin (2015) [15]</td>
<td>RCT</td>
<td>n.r. (Solco-LF100, Solco Biomedical Co., Ltd., Pyeongtaek, Korea)</td>
<td>660/pulse type (pulse rate 200Hz)</td>
<td>25 (50:50% duty cycle of pulse)/625</td>
<td>112.5/4.5</td>
<td>0.04 cm²/13 acupoints (GV3, GV4, GV5, bilateral BL23, BL24, BL25, BL40, GB30)/3 min/point</td>
<td>3× (3/wk, 1 wk)</td>
<td>None</td>
</tr>
<tr>
<td>Soriano (1998) [16]</td>
<td>RCT</td>
<td>GaAs (n.r.)</td>
<td>904/pulse type (pulse rate 10,000Hz)</td>
<td>40 /26.7 × 10⁶</td>
<td>2.67 × 10⁷/4</td>
<td>1.5 × 10⁶ cm²/low back region/100 s</td>
<td>10× (5/wk, 2 wks)</td>
<td>None</td>
</tr>
<tr>
<td>Vallone (2014) [17]</td>
<td>RCT</td>
<td>GaAlAs (LEONARDO BIO DMT dental medical technologies, Lissone, Italy)</td>
<td>980/continuous</td>
<td>20 × 10⁶/625</td>
<td>37.5/1,200</td>
<td>32 cm²/6 points in paravertebral region (L2 to S2-3)/1 min/point</td>
<td>9× (3/wk, 3 wks)</td>
<td>Exercise</td>
</tr>
<tr>
<td>Choi (2007) [18]</td>
<td>RCT</td>
<td>GaAs (Combi500, Gymna, Belgium)</td>
<td>904/pulse type (pulse duration 155 ms)</td>
<td>14/n.a.</td>
<td>n.a./2.5</td>
<td>n.r./10 points in paravertebral region/3 min/point</td>
<td>10× (5/wk, 2 wks)</td>
<td>None</td>
</tr>
<tr>
<td>Klein (1990) [19]</td>
<td>RCT</td>
<td>GaAs (Omniprobe laser biostimulation unit)</td>
<td>904/pulse type (pulse rate 10,000Hz)</td>
<td>5.42/5.42</td>
<td>1.3/1.3</td>
<td>1 cm²/low back region (L4 to L5, L5 to S1)/4 min/point</td>
<td>12× (3/wk, 4 wks)</td>
<td>Exercise</td>
</tr>
<tr>
<td>Ruth (2010) [20]</td>
<td>RCT</td>
<td>n.r. (Laserneedle)</td>
<td>680/785/continuous</td>
<td>50 - 150/1-5</td>
<td>n.a./n.a.</td>
<td>n.r./8 points (BL 23,40,60, Ni3, GB-track, Ashi acupoints)/15 min</td>
<td>10× (2/wk, 5 wks)</td>
<td>Conventional therapy</td>
</tr>
</tbody>
</table>

Calculated parameters are displayed in bold.
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.

## Primary outcomes

Core Question 1. In LLLT/LA for CNLBP, does a power output of ≥ 50 mW show a better improvement in the level of pain and function compared with < 50 mW?

Concerning pain, 4 out of 13 studies were excluded. Three studies used ≥ 50 mW power output [8,9,17] and 6 studies used < 50 mW power output [10-12,15,16,20]. The 3 studies using ≥ 50 mW power output showed a significant effect on pain reduction compared with sham treatment (193 participants, SMD -0.85, 95% CI: -1.15 to -0.55; χ² = 1.61, I² = 0%). In the 6 studies using < 50 mW power output there was no significant effect on pain reduction.
compared with the sham treatment (302 participants, SMD -0.27, 95% CI: -0.69 to 0.15; $\chi^2 = 14.37, I^2 = 65%$; Fig. 2).

Concerning function/disability, 4 of the 13 studies evaluated outcomes using ODI values [8-11]. Of those 4 studies, 2 [8,9] used a power output of ≥ 50 mW, and 2 studies [10,11] used a power output of < 50 mW. In the 2 studies using a power output of ≥ 50 mW, there was a significant improvement in function after treatment (93 participants, MD -7.47, 95% CI: -10.27 to -4.67; $\chi^2 = 0.15, I^2 = 0%$). In the 2 studies using a power output of < 50 mW, dysfunction significantly worsened after treatment (184 participants, MD 2.55, 95% CI: 0.99 to 4.11; $\chi^2 = 0.37, I^2 = 0%$; Fig. 3).

Core Question 2. In LLLT/LA for CNLBP, does a beam size of ≥ 1 cm² show a greater improvement in pain and function compared with < 1 cm²?

Concerning pain, 8 studies disclosed their beam size parameter. In 3 studies [8,17,19], a beam size of ≥ 1 cm² was used, and in
the other 5 [9-11,13,14], a beam size of <1 cm² was used. In the 3 studies using a beam size of ≥ 1 cm², there was a significant improvement in the level of pain after treatment. (176 participants, SMD -0.71, 95% CI: -1.02 to -0.41; \(\chi^2 = 1.19, I^2 = 0\%\)) In the 5 studies using a beam size of < 1 cm², there was no significance in pain improvement after treatment. (303 participants, SMD -0.16, 95% CI: -0.39 to 0.07; \(\chi^2 = 18.57, I^2 = 78\%\); Fig. 4).

Concerning function/disability, 4 of the 13 studies evaluated outcomes using ODI values [8-11]. One study [8] had a beam size of ≥ 1 cm² (56 participants, MD -9.30, 95% CI: -18.89 to 0.29), and 3 [9-11] used a beam size of < 1 cm² (221 participants, MD 0.37, 95% CI: -1.01 to 1.74; \(\chi^2 = 34.35, I^2 = 94\%\)). None of them showed any significant improvement in function (Fig. 5).

Core Question 3. In LLLT/LA for CNLBP, does the energy dose of ≥ 4 J/point show a superior level of improvement in pain and function compared with < 4 J/point?

Concerning pain, 9 studies disclosed their energy dose
In 5 studies [8,9,13,14,17], an energy dose of ≥ 4 J/point was used, and in the other 4 [10,11,18,19] an energy dose of < 4 J/point was used. In the 5 studies that used an energy dose of ≥ 4 J/point, there was a significant effect on pain reduction (275 participants, SMD -0.73, 95% CI: -1.08 to -0.38; $\chi^2 = 7.47$, I$^2 = 46\%$). In the 4 studies using an energy dose of < 4 J/point, there was no significance in pain improvement after treatment (220 participants, SMD -0.14, 95% CI: -0.62 to 0.34; $\chi^2 = 7.33$, I$^2 = 59\%$; Fig. 6).

Concerning function/disability, 4 of the 13 studies evaluated outcomes using ODI values [8-11]. Of those 4 studies, 2 [8,9] used an energy dose of ≥ 4 J/point, and 2 [10,11] used an energy dose of < 4 J/point. In the 2 using an energy dose of ≥ 4 J/point, there was a significant effect on pain improvement after treatment (93 participants, MD -7.47, 95% CI: -10.27 to -4.67; $\chi^2 = 0.15$, I$^2 = 0\%$). In the other 2 using an energy dose of < 4 J/point, no significant improvement in function was noted (184 participants, MD 2.55, 95% CI: 0.99 to 4.11; $\chi^2 = 0.37$, I$^2 = 0\%$; Fig. 7).

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**Fig. 6.** The effectiveness of LLLT/LA method of energy dose on pain relief (high energy dose ≥ 4J/point versus low energy dose < 4J/point). LLLT, low-level laser therapy; LA, laser acupuncture; IV, information value; CI, confidence interval; Df, degree of freedom.

**Fig. 7.** The effectiveness of LLLT/LA method of energy dose on function and disability measured by ODI (high energy dose ≥ 4J/point versus low energy dose < 4J/point). LLLT, low-level laser therapy; LA, laser acupuncture; ODI, Oswestry disability index; IV, information value; CI, confidence interval; Df, degree of freedom.
Core Question 4. In LLLT/LA for CNLBP, does the treatment interval of ≥ 3/week show an enhanced level of improvement in the level of pain and function compared with < 3/week?

Concerning pain, 9 studies disclosed their treatment interval parameter. Of the 9 studies, 6 [8,13,14,17-19] had a treatment interval of ≥ 3/week, and 3 [9-11] had a treatment interval < 3/week. In the 6 studies with a treatment interval of ≥ 3/week, there was a significant effect on pain reduction after treatment (274 participants, SMD -0.67, 95% CI: -0.91 to -0.42; $\chi^2 = 7.61, I^2 = 34\%$). In the 3 studies with treatment intervals of < 3/week, no significance was noted in pain improvement after the treatment (221 participants, SMD -0.07, 95% CI: -0.34 to 0.20; $\chi^2 = 15.39, I^2 = 87\%$; Fig. 8).

Concerning function/disability, 4 of the 13 studies evaluated outcomes using ODI values [8-11]. In 1 study [8] a treatment interval of ≥ 3/week was used (56 participants, SMD -9.30, 95% CI: -18.89 to 0.29), and the other 3 [9-11] used a treatment interval of < 3/week (221 participants, SMD 5.17, 95% CI: -7.30 to 17.63; $\chi^2 = 130.98, I^2 = 98\%$). None of them showed any significant improvement on function (Fig. 9).

![Fig. 8. The effectiveness of LLLT/LA method of treatment interval on pain relief (treatment interval ≥ 3 times a week versus treatment interval < 3 times a week). LLLT, low-level laser therapy; LA, laser acupuncture; IV, information value; CI, confidence interval; Df, degree of freedom.](image)

![Fig. 9. The effectiveness of LLLT/LA method of treatment interval on function and disability measured by ODI (treatment interval ≥ 3 times a week versus treatment interval < 3 times a week). LLLT, low-level laser therapy; LA, laser acupuncture; ODI, Oswestry disability index; IV, information value; CI, confidence interval; Df, degree of freedom.](image)
Core Question 5. In LLLT/LA for CNLBP, do ≥ 10 treatment sessions show a better improvement in the level of pain and function compared with < 10 treatments?

Concerning pain, 9 of the 13 studies disclosed their treatment session parameter. Four of the studies [8,9,18,19] used ≥ 10 treatment sessions (109 participants, SMD -0.94, 95% CI: -1.34 to -0.54; \(\chi^2 = 2.35, I^2 = 15\%\)), and the other 5 [10,11,13,14,17] used < 10 treatment sessions (366 participants, SMD -0.24, 95% CI: -0.45 to -0.04; \(\chi^2 = 19.30, I^2 = 79\%\)). All of them showed significant improvements on pain relief after treatment (Fig. 10).

Concerning function/disability, 4 of the 13 studies evaluated outcomes using ODI values [8-11]. Of those 4 studies, 2 [8,9] had ≥ 10 treatment sessions, and 2 [10,11] had < 10 treatment sessions. In the 2 studies with ≥ 10 treatment sessions, a significant improvement on function was noted. (93 participants, SMD -7.47, 95% CI: -10.27 to -4.67; \(\chi^2 = 0.15, I^2 = 0\%\)) In the other 2 with < 10 treatment sessions, the dysfunction significantly worsened (182 participants, SMD 2.55, 95% CI: 0.99 to 4.11; \(\chi^2 = 0.36, I^2 = 0\%\); Fig. 11).

Fig. 10. The effectiveness of LLLT/LA method of treatment session on pain relief (treatment session ≥ 10 times versus treatment session < 10 times).
LLLT, low-level laser therapy; LA, laser acupuncture; IV, information value; CI, confidence interval; Df, degree of freedom.

![Fig. 10](image_url)

Fig. 11. The effectiveness of LLLT/LA method of treatment session on function and disability measured by ODI (treatment session ≥ 10 times versus treatment session < 10 times). LLLT, low-level laser therapy; LA, laser acupuncture; ODI, Oswestry disability index; IV, information value; CI, confidence interval; Df, degree of freedom.

![Fig. 11](image_url)
**Adverse reactions and side effects**

Nine RCTs reported on adverse/negative side effects. Of these, 8 observed no adverse reactions [9,11,12,15-17,19,20], and 1 observed a mild adverse reaction that was deemed negligible [8]. No adverse reactions were reported on in the other 4 studies [10,13,14,18].

**Risk of bias**

The risk of bias was assessed for 13 RCTs according to the Cochrane handbook (Fig. 12). The proportion of low-risk studies for each domain demonstrated in Fig. 13.

**Discussion**

LLLT/LA is a noninvasive treatment with negligible risk of pain or infection. It is widely used to manage chronic pain in primary Korean medical clinics and has high patient satisfaction. However, with many variable treatment parameters an appropriate treatment methodology has yet to be established. Therefore, this systematic review looked at 5 core questions involving (1) power output; (2) beam size; (3) energy dose; (4) treatment intervals; and (5) total treatment sessions, and based on existing study results, WALT guidelines, and general clinical treatment periods optimal conditions of treatment were determined.

The 13 studies included in this review were from 8 countries and included a total of 773 participants [8-20]. Answering the core question (1) regarding power, when the power output was ≥ 50 mW a significant effect on the level of pain and function were noted. However, when it was < 50 mW, no significant effect was noted for both the level of pain and function. Furthermore, when answering core question (2) regarding beam size, a beam size of ≥ 1 cm² showed significant improvement on pain relief but none on functional improvements. When the beam size was < 1 cm², there was no significant effect noted on both the level of pain and function. Moreover, when answering the core question (3) regarding energy, a dose of ≥ 4 J/point showed a significant improvement on both the level of pain and function, whereas when it was < 4 J/point, no significant improvement was noted for both level of pain and function. When answering core question (4) regarding frequency of treatment, a frequency of ≥ 3 times a week led to significant improvements in the level pain, but none in function. When the frequency of treatment was < 3 times a week, no significant improvement was noted for both level of pain and function. When answering core question (5) with regards to total number of treatments, ≥ 10 treatment sessions led to significant improvements in the level of pain, and improved function were noted.

However, this study is not without its limitation. Firstly, of the 13 RCTs, none reported on all 5 treatment conditions considered in this review (power, beam size, energy, frequency of treatment, and total number of sessions). Furthermore, in 6 of the studies, some of the calculations made for this current review could not be performed due to a lack of information. Secondly, other factors were not controlled for when analyzing the effect of different treatment conditions due to the varying laser treatment methods observed. Therefore, an indirect comparison was made rather than a direct comparison, and the heterogeneity in this review was high. Thirdly, the machine in each paper has a different treatment range, but only the values used in the study were mentioned, so the optimum range could not determine through this paper, and only the minimum standard was confirmed.

This study provides valuable data on which treatment conditions of LLLT/LA which are most effective for NCLBP which may prove useful to both KM doctors as they plan treatments, and researchers as in the design of future studies to establish more accurate treatment. Further detailed and rigorously designed studies should be conducted in the future.

**Conclusion**

This systematic review and meta-analysis were used to evaluate the most effective LLLT/LA treatment conditions for the treatment of NCLBP. Results showed that significant reductions in the
levels of pain and improvements in function were observed when conditions of treatment including a power output of ≥ 50 mW, a beam size of ≥ 1 cm², an energy dose of ≥ 4 J/point, treatment intervals of ≥ 3 times/week, and ≥ 10 treatment sessions were performed.

Conflicts of Interest

The authors have no conflicts of interest to declare.

References