The effectiveness of laser therapy on the management of chronic low back pain (Review)

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Abstract

Background/Aim: Chronic low back pain (CLBP) is a global musculoskeletal challenge, resulting in pain and disability on individuals. Laser therapy can be used to treat CLBP. This review evaluates the effectiveness of laser therapy including high level laser therapy (HLLT) and low level laser therapy (LLLT) on CLBP in relation to pain or functional disability.

Methods: The authors conducted a systematic review of randomised controlled trials (RCTs) and searched the Cochrane Library, MEDLINE, CINAHL, AMED and PEDro from their start to June 2015. All studies that met predetermined inclusion and exclusion criteria were appraised with The Cochrane Collaboration's tool for assessing risk of bias and Critical Appraisal Skills Programme Tools in June, 2015.

Findings: Six RCTs met the inclusion criteria: two RCTs reported significant improvement in pain and functional disability with the use of HLLT but with small sample size (n=103); one RCTs (n=61) reported significant improvement and three RCTs (n=215) reported insignificant improvement in pain and functional disability with the use of LLLT.

Conclusion: On the strength of the evidence available HLLT and LLLT are not currently recommended to be replaced or be offered in addition to conventional treatment. Further rigorous research is required to confirm the potential use of laser therapy on individuals presenting with CLBP.

Background

Low back pain (LBP) is a common musculoskeletal problem in adult (Diamound and Borenstein, 2006), where Hoy et al. (2012) stated a lifetime prevalence up to 85%, a mean estimated point prevalence is approximately 11.9% and recurrence rate at 1 year ranges from 24% to 80%. Walker (2000) estimated 65% of those who recur will eventually develop chronic low back pain (CLBP).

The National Institute for Health and Care Excellence (NICE, 2009) recommended physiotherapy intervention is effective in the early management of persistent non-specific LBP; however, clinically there is no standardised approach due to patients' differences and therapists' background and preferences. NICE (2009) recommends exercise therapy, acupuncture and manual therapy as primary treatment for early management of persistent non-specific LBP; however, all electrotherapy modalities including laser therapy are excluded from the recommendation list; this is due to a lack of rigorous evidence.

The European guidelines for the management of chronic non-specific low back pain (Airaksinen et al., 2004) also did not recommend laser therapy for the management of chronic low back pain due to conflicting evidences and limited evidence that showed there was no difference in effectiveness between laser therapy, laser therapy and exercise, and exercise. Likewise, the American College of Physicians and the American Pain Society clinical guideline for diagnosis and treatment for low back pain (Chou et al., 2007)

concluded that there was insufficient evidence to recommend to LLLT, as the evidence was poor and therefore it was unable to estimate to net benefit.

The latest systemic review (Yousefi-Nooraie et al. 2008) investigated the effectiveness of low-level laser therapy (LLLT) on pain relief and functional disability in LBP patients and also concluded that due to the heterogeneity of data, there were insufficient data to draw firm conclusions on the positive clinical effects of LLLT for LBP.

Nevertheless, the evidence from Timimi et al. (2010) has not been taken into account in any systematic review or clinical guideline yet where the effectiveness of high-level laser therapy (HLLT) on CLBP management has not been reviewed. This review aims to evaluate the effectiveness of laser therapy including both HLLT and LLLT on CLBP in relation to pain relief and improving functional disability.

Laser therapy

Laser or “Light Amplification by Stimulated Emission of Radiation” therapy is a medical treatment that uses concentrated light beam. Laser characterised by the properties of monochrome, coherence and collimation. Under the U.S Food and Drug Administration laser classification system, laser therapy is categorised into LLLT and HLLT. HLLT is referred to Class IV laser with a limited average power more than 500mw and up to 7500mW, where LLLT is usually referred to Class III laser with a limited average power up to 500mW (Conforti and Fachinetti, 2013). Both LLLT and HLLT have a wavelength range of about 600nm – 1000nm, depending on which type of laser it is.

Although the popularity of HLLT is increasing, there is no recommended dosage by any clinical guideline or association yet; while World Association of Laser Therapy (2010) recommends LLLT dosage as below:

1. 4 points of laser head;
2. minimum 1J per point;
3. peak pulse output is higher than 1W,
4. mean output is higher than 5mW;
5. power density is higher than 5mW/cm^2;
6. irradiation times should range between 30 seconds and 600 seconds;
7. and the frequency of receiving treatment is daily treatment for 2 weeks or having treatment every other day for 3 to 4 weeks.

The effectiveness of HLLT and LLLT remains controversial with conflicting evidences. However, Huang et al. (2011) reported both in vivo and in vitro trials indicated positive results of LLLT and suggested there is a biphasic dose response in LLLT, which suggests HLLT theoretically may exceed the optimal therapeutic dosage; however, this phenomenon was not reported in any clinical trials (Huang et al., 2011) and two RCTs (Conforti and Fachinetti, 2013; Kheshie et al., 2014) reported a significant pain reduction effect with the use of HLLT on musculoskeletal problems.

The mechanism of laser therapy was hypothesised to be directly link to the absorption of monochromatic visible and near infrared radiation by components of the cellular respiratory chain (Kaur 1989). Application of LLLT

induces photobiological process and during this process, it increases proton electrochemical potential (Huang et al., 2011) and stabilises cellular membrane (Lubart et al., 2000; Karu et al., 2001), increased ATP synthesis and production (Passarella et al. 1994; Ferraresi et al., 2014) and increased mitochondrial membrane potential (Huang et al., 2011), increased RNA and protein synthesis (Greco et al. 1989), achieve local vasodilation induced by the nitrogen oxide that is dissociated from intracellular store (Shiva and Gladwin, 2009), enhances lymphocyte response (Stadler et al., 2000), blocks depolarisation of C-fiber afferent nerves (Tsuchiya K et al, 1993). In overall, these physiological and cellular responses can ultimately reduce inflammation, pain and healing time and therefore in theory, laser therapy can reduce pain and improve functional disability on the management of CLBP.

Biphasic dose response in LLLT in cell cultures was reported (Huang et al., 2011),

Methodology

Criteria for consideration of studies for this review

See: PICOS (table 1)

----------insert table 1----------

Type of studies

Published reports of completed RCTs were included. There were no restrictions on date of trial but had to be English-language studies.

Type of participants

Included

Trials that included male or female subjects with non-specific CLBP who aged 18 years old or above but less than 60 years old were included, where CLBP is defined as pain localised between the rib cage and the folds of buttocks, with or without referred symptoms to the legs that lasts more than 6 weeks (NICE, 2009).

Excluded

Trials that included subjects with CLBP caused by extraspinal source such as rheumatological conditions, fractures, osteoporosis, infection, metastatic diseases, dysvascularity, neoplasms, gastrointestinal causes, psychological disorder, or other auto-immune disease were excluded as Yousefi-Nooraie et al. (2007) and NICE (2009) suggested.

Type of Intervention

Laser therapy can be subdivided into HLLT and LLLT. The difference between them is the amount of energy delivered to achieve therapeutic effects. This review included reports of studies which investigated the effects of all form of HLLT and LLLT, including all wavelengths, all irradiance and all source of laser, in comparison to any other treatment modalities. This comparison could be no treatment, sham procedures (Basford et al., 1999; Djavid et al., 2007; Ay et al., 2010), any form of laser therapy with other therapeutic intervention (Gur et al., 2003; Djavid et al., 2007; Ay et al., 2010; Alayat et al., 2014) or the use of other therapeutic interventions alone (Fiore et al., 2011).

Type of outcome measures

The selected patient reported outcome measures were either conducted through verbal questioning or by filling in a questionnaire. They were:

1. CLBP intensity measured by visual analogue scale (VAS) (Ogon et al., 1996), numerical rating scale (NRS) (Ferreira-Valente et al., 2011) or other validated outcome measures.
2. CLBP-related disability measured by the Oswestry disability index (ODI) (Fairbank and Pynsent, 2000), Roland-Morris Disability Questionnaire (RMDQ) (Roland and Fairbank, 2000), or any modified version and validated outcome measures.

To be included in this review, studies had to have measured at least one of these outcomes at baseline and during follow-up.

Search methods for identification of studies

This review was done by the two authors and they searched 5 databases: 1. AMED (1998 to June 2015); 2. CINAHL (1992 to June 2015); 3. Cochrane Library (to June 2015); 4. MEDLINES (1979 to June 2015); and 5. PEDro (to June 2015) with specific search term (appendix 1), then articles were screened by inclusion and exclusion criteria (appendix 2). See PRISMA flowchart for details (figure 1).

Data Extraction and Analysis

The authors extracted the information about the data on study design,

participants, intervention and outcomes, the type of laser therapy equipment, its setting, the method and frequency of its use of placement of laser, where recalculation was done for laser characteristics and dosage based on the data published on each study. The calculation aimed to obtain data of irradiance (mW/cm2) and dose (J) for each study if not provided, or presented in different unit, see appendix 3 for calculation formula. During the process of data extraction, authors were not blind to the aims of the study.

----------insert figure 1----------

Analysis

Meta-analysis was not possible due to the clinical heterogeneity of study design and intervention protocols, where clinical heterogeneity was considered by table 2.

----------insert table 2----------

Due to insufficient amount of published data available, statistical heterogeneity was not tested, therefore a narrative synthesis was conducted. The authors critically appraised each article matching all inclusion and exclusion criteria by using Critical Appraisal Skills Programme Tools (CASP UK, 2013) and The Cochrane Collaboration's tool for assessing risk of bias (Furlan et al., 2015)

For the review purpose, the authors selected 15mm change in pain on a 100mm pain scale as an absolute cut-off as Ostelo et al. (2008) suggested and approximately 6-point change in ODI (Fritz and Irrgang, 2001), as minimal clinically important difference (MCID).

Results

Description of Studies

See: Characteristics of included studies (appendix 4a); Characteristics of excluded studies (appendix 4b)

Throughout the literature search (figure 1), one hundred and seventy-one studies were identified. Among these studies, seven of them met the inclusion and exclusion criteria but only six studies (n=379) are included for data synthesis in this review, as one study (n=80) (Timimi et al., 2010) was excluded due to poor methodology. A summary of baseline characteristics of participants in each study is presented in table 3. Among these six studies, two of them (Fiore et al., 2011; Alayat et al., 2014) investigated the effect of HLLT while four of them (Basford et al., 1999; Gur et al., 2003; Djavid et al., 2007; Ay et al., 2010) investigated the effect of LLLT. The population included in the trials had a diagnosis of CLBP but differed in distribution in age and in gender, duration of pain, initial intensity of pain and initial functional disability.

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Risk of bias

The Cochrane Collaboration's tool for assessing risk of bias (Furlan et al., 2015) was adapted in this review and a summary of risk of bias for included studies is presented in table 4. Critical Appraisal Skills Programme Tools

(CASP UK, 2013) is also used to evaluate studies' quality.

----------insert table 4----------

All RCTs included scored at least 8 out of 13 in the scoring system for assessing risk of bias, where the scores ranged from 6 to 9. For selection bias, all RCTs have low risk in random sequence generation; three RCTs (Alayat et al., 2014; Ay et al., 2010; Gur et al., 2003) have high risk in allocation concealment. For performance and detection bias, three RCTs (Gur et al., 2003; Djavid et al., 2007; Fiore et al., 2011) have high risk in blinding subjects and only one RCT (Alayat et al., 2014) has high risk in blinding assessors, while only one RCT (Basford et al., 1999) has low risk in blinding providers. For attrition bias, two RCTs (Gur et al., 2003; Alayat et al., 2014) did not report drop-outs; and only two RCTs (Djavid et al., 2007; Fiore et al., 2011) used an intention-to-treat analysis. All included RCTs have low risk in suggestion of selective outcome reporting. For similarity of baseline characteristics, avoiding co-interventions or having similar interventions, acceptable compliance, all RCTs have low risk in these domains. All RCTs have low risk in having similar timing of outcome assessment with the exception of one RCT (Basford et al., 1999); all RCTs have low risk in having other risks of bias. A summary of result and limitation of each included study is also presented on table 5.

----------insert table 5----------

The effect of intervention – HLLT

Among the included studies, two studies investigated the effect of HLLT on pain relief and improving functional disability (Fiore et al., 2011; Alayat et al., 2014). Currently, there is no recommendation for HLLT dosage, as this

intervention is recently introduced. The Fiore et al (2011) study (n=30) compared the short-term effects of HLLT to ultrasound therapy (US) in the treatment of CLBP, while Alayat et al. (2014) study (n=72) looked at the long-term effect of HLLT, alone or combined with exercise in the treatment of CLBP.

Pain intensity

Both studies (Fiore et al., 2011; Alayat et al., 2014) used VAS as outcome measure for pain and found clinically and statistically significant improvement in VAS in HLLT and HLLT with exercise groups (all $p<0.001$). In Fiore et al. (2011) study reported their HLLT group had a significant greater reduction in pain (VAS) compared with their US group ($p<0.005$) after 3-week of treatment (5 sessions a week); in the Alayat et al. (2014), study although there was no significant difference between placebo laser with exercise group and HLLT alone group in VAS, the HLLT with exercise group had a larger significant improvement in VAS compared with the placebo laser with exercise group and the HLLT alone group (all $p=<0.001$) after 4-week treatment and further 8 weeks without any intervention. Their result also showed a significant incline in VAS after that 8 weeks without any intervention but the overall improvement in VAS was still significantly better when compared to baseline.

Functional disability

Fiore et al. (2011) study used ODI (Fairbank and Pynsent, 2000) to evaluate the effect of HLLT on functional disability and the findings showed both

clinically and statistically significant reduction when compared to their US group at the end of the treatment (3-week) ($p < 0.005$). Alayat et al. (2014) used ODI (Fairbank and Pynsent, 2000) and RMDQ (Roland and Fairbank, 2000) to review the effect of HLLT on function disability, where the result showed no statistically significant difference between placebo with exercise group and HLLT group at week 4 and 12. However, their HLLT with exercise group showed clinically and statistically significant improvement when compared to other groups at week 4 and 12 (RMDQ: all $p=0.0001$; ODI: week 4: $p=0.002$, week 12: $p = 0.0001$)

The effect of intervention – LLLT

In 2010, the World Association of Laser Therapy (WALT) revised the recommended dosage of LLLT for LBP. Among the included studies, four RCTs (Basford et al., 1999; Gur et al., 2003; Djavid et al., 2007; Ay et al., 2010) (n=277) investigated the effect of LLLT on pain relief and improving functional disability, where three RCTs (Gur et al., 2003; Djavid et al., 2007; Ay et al., 2010) matched with the WALT (2010) recommendation and although one RCTs (Basford et al., 1999) did not use pulsed waveform as recommended, their findings showed positive result in both pain relief and improving functional disability.

Basford et al. (1999) (n=61) study compared the effect between LLLT group and placebo laser group on CLBP; Gur et al. (2003) (n=75) investigated the efficacy of LLLT and exercise on pain and function on CLBP with a trial design of three groups: LLLT with exercise group, LLLT alone group and

exercise alone group; Djavid et al. (2007) (n=61) did a similar trial as Gur et al (2003) but the exercise alone group was replaced with a placebo laser with exercise group. Ay et al. (2010) (n=80) study included four arms of trial for acute and chronic lumbar herniation (two arms each); however, this review only included their results from the chronic lumbar disc herniation groups (n=40) which were sub-divided into hot pack and LLLT, and hot pack and placebo laser group. Although the population had a diagnosis of lumbar disc herniation, current recommended low back pain referral pathway (The Royal College of Surgeons of England, 2013) does not refer patients for radiographical investigation unless patients present with severe and/or progressive neurological deficits or unsettling pain after primary care (at 4-6 weeks with treatment). Thus, the diagnosis of lumber disc herniation is not yet confirmed by radiographical investigation when they receive physiotherapy in primary care. Since Ay et al. (2010) also excluded patients with any neurological deficits; therefore their result is still included into this review.

Pain intensity

All included LLLT RCTs (Basford et al., 1999; Gur et al., 2003; Djavid et al., 2007; Ay et al., 2010) used VAS (Ogon et al., 1996) as outcome measure for pain intensity.

Basford et al. (1999) study's finding showed clinically and statistically significant difference in maximal pain in the last 24 hours between active and placebo LLLT groups at week 5 ($p = 0.007$, differences in mean = -15.7; 95%

CI = -14.0, -4.0) and at 1-month follow up (p = 0.012; differences in mean = -16.0, 95% CI = -28.4, -3.7), suggesting an analgesic effect can be achieved by LLLT.

In the Djavid et al. (2007) study, there was no statistically significant difference between LLLT alone group, LLLT with exercise group, placebo laser with exercise group in pain relief effect immediately after 6-week intervention and after another further 6-week of no intervention (both p > 0.05); however, in LLLT with exercise group achieved a 18mm more in reduction of VAS than placebo laser with exercise group (p= 0.03, 95%CI = -0.2, -1.8) after another further 6-week of no intervention. This suggested LLLT combined with exercise may be more beneficial than LLLT or exercise therapy alone as it reached the selected MCID (15mm) in this review.

In the Gur et al. (2003) study, all treatment groups showed clinically and statistically significant decrease in pain intensity after therapy (p<0.05). Although there was no significant between-group difference, they reported pain levels in LLLT with exercise and LLLT alone groups decreased more than the exercise alone group in their trial (no data provided). Therefore, LLLT can be an effective method in reducing pain for CLBP.

Ay et al. (2010) findings showed clinically and statistically significant improvement in VAS in all CLBP groups: hot pack with laser therapy and with placebo lasers group (p<0.001); however no significant difference was detected in this RCT between groups (p=0.405).

Functional disability

All of the LLLT RCTs (Basford et al., 1999; Gur et al., 2003; Djavid et al., 2007; Ay et al., 2010) used ODI (Fairbank and Pynsent, 2000) as functional disability outcome measure, while Ay et al (2014) used ODI and RMDQ (Roland and Fairbank, 2000).

Basford et al. (1999) (n=56) reported that there was clinically and statistically significant reduction in ODI in LLLT group when compared to baseline (all $p<0.05$), and between LLLT and placebo laser group at 5-week follow-up and 1-month follow-up (after 5-week treatment: $p=0.001$, difference in mean = -9.3, 95%CI = -14.7, -4.0) (at 1-month follow-up: $p=0.004$, difference in mean = -8.2, 95%CI = -13.6, -2.8). An insignificant increase of about 1 point in ODI at LLLT group was noted when compared the result of after 5-week treatment and at 1-month follow-up. These findings suggested LLLT can improve functional disability with CLBP; however, the effect could be limited and lost over time.

Djavid et al. (2007) study (n=61) reported that LLLT alone, LLLT with exercise and placebo laser with exercise group all showed clinically and statistically significant improvement in individual groups between week 0, week 6 and week 12 (all $p<0.05$). There was no between-group difference for functional disability immediately after 6-week treatment and after a further 6 week of no intervention. However, LLLT with exercise group reduced 9.4 point more ($p=0.03$, 95%CI = -0.1, -3.3) in ODI than in the placebo laser with exercise

group after another 6 weeks of no intervention. Their result suggested LLLT with exercise is more effective in improving disability in the long term.

Conversely, another two studies (Gur et al, 2003; Ay et al, 2010) (n=115) did not support Basford et al. (1999) and Djavid et al. (2007) findings (n=117). In the Gur et al (2003) study (n=75), all treatment groups showed clinically and statistically significant improvement in ODI in individual group when compared to their baseline ($p<0.05$); however, there was no between–group difference ($p>0.05$). Similarly, in Ay et al. (2010) study (n=40), all treatment groups achieved clinically and statistically significant improvement in ODI ($p<0.001$) and RMDQ ($p=0.001$) in all individual groups but no statistically significant difference was found between groups ($p>0.05$).

Discussion

This review has found that HLLT has a significant positive analgesic effect on CLBP and improve functional disability on CLBP after 4-week treatment and another 8 weeks without any intervention (Fiore et al., 2011; Alayat et al., 2014); the therapeutic effect may decrease with time but there is still significant improvement at week 12 when compared to baseline. It might be more effective when combined with personalised exercise programme. However, the total sample from their studies is too small (n=103) for a conclusion to be drawn. This review has also found that LLLT (n=277) (Basford et al., 1999; Gur et al., 2003; Djavid et al., 2007; Ay et al., 2010) with exercise may be superior to LLLT alone or exercise alone group in pain relief effect and improving functional disability; however, the difference was not

always statistically significant. HLLT and LLLT are not currently to be replaced or be offered in addition to conventional treatment. Further rigorous research is required to confirm the potential use of laser therapy on individuals presenting with CLBP.

Among all RCTs included, there was only one RCT (Basford et al., 1999) specifically described how pain intensity was measured by VAS, for example: pain at rest or maximal pain in 24 hours, whereas other included studies did not. Standardising the measurement of VAS in CLBP patients would allow more rigorous comparison between trials.

The findings from this review also suggest that a significant reduction in pain in CLBP patients who received laser therapy does not necessarily lead to a significant increase in function. This matches with the findings from Kovacs et al. (2004) (n=195) who reported that ODI has a weak correlation with VAS in CLBP population (r = 0.103), where RMDQ correlated better with VAS (r = 0.570). This could be explained by the findings from Thomas et al. (2010) (n=50): psychosocial factors are strongly associated with disability and altered quality of life in chronic low back pain patients, whereas ODI focuses more on activity while RMDQ has more psychosocial aspect.

Yousefi-Nooraie et al. (2007) conducted a systematic review and concluded there were insufficient data to either support or refute the effectiveness of LLLT for the treatment of both acute and chronic LBP; however, they did not evaluate the effectiveness of HLLT. There are other systematic reviews that

investigated the effectiveness of laser therapy. Kadhim-Saleh et al. (2013) concluded the effectiveness of LLLT on relieving neck pain is inconclusive because of heterogeneity and potential risk of bias. Another systematic review (Brosseau et al., 2005) evaluated the effectiveness of LLLT on rheumatoid arthritis LLLT can relief pain and stiffness in short-term but there is need to further investigate the parameters of LLLT to maximise its effectiveness. Jang and Lee (2012) conducted a meta-analysis on pain relief effects by laser irradiation on joint areas and they found applying LLLT on the joint can reduce pain in patients. Chow et al (2009) conducted a systematic review and meta-analysis of randomised placebo or active-treatment controlled trials on efficacy of LLLT in the management of neck pain and concluded that LLLT reduced pain immediately after treatment in acute neck pain, and up to 22 weeks after completion of treatment, in patients with chronic neck pain. To conclude, LLLT can reduce pain caused by musculoskeletal problems but its benefits in improving functional disability are still inconclusive; no review has evaluated the effectiveness of HLLT.

HLLT versus LLLT

The use of LLLT has been over decades (Moshkovska and Mayberry, 2005) while the trend of laser therapy has been to increase dosage and the use of HLLT was introduced 9 years ago (Wartz, 2006).Theoretically, a biphasic response in LLLT was observed in both in vivo and in vitro studies (Huang et al., 2011); therefore the dose of HLLT would be too high and may cause damage on the target tissue rather than healing it.

A preliminary literature search on different databases revealed there is only one RCT (Kheshie et al., 2014) that compared the effectiveness of HLLT and LLLT in patients with osteoarthritis of the knee. Kheshie et al., (2014) reported HLLT is more effective than LLLT in pain relief and improvement in functional disability in treating patients with osteoarthritis of the knee. Further research is required to compare the effectiveness between LLLT and HLLT.

Conclusion

Implication for practice

Based on this review's findings, HLLT is more beneficial for pain relief and improving functional disability in patients with CLBP when compared to placebo treatment and ultrasound therapy; however, due to the small total sample size (n=103), HLLT with and without exercise is not recommended to replace conventional treatment. Current findings from four RCTs (n=277) suggest LLLT achieves better pain relief effect and greater improvement in functional disability, despite the effect is not always statistically significant when compared to other treatment groups. Therefore, LLLT with and without exercise is also not recommended to replace conventional treatment either.

Implication for research

More research with rigorous methodology is required to further investigate the effect of HLLT and LLLT in the management of CLBP. Comparison between HLLT and LLLT is recommended.

Key messages:

1. HLLT is not recommended to replace conventional therapy because although current evidence indicates a statistically significant improvement on the selected patient reported outcome measures, the total sample size of this review for HLLT was small.
2. LLLT is not recommended to replace conventional therapy as current evidence does not show statistically significant improvement on the selected patient reported outcome measures.
3. More rigorous research is required to investigate the effect of HLLT and LLLT on the management of CLBP; comparison between HLLT and LLLT is also recommended.

References

Alayat, M. S., Atya, A. M., Ali, M. M. and Shosha, T. M. (2014) Long-term effect of high-intensity laser therapy in the treatment of patients with chronic low back pain: a randomized blinded placebo-controlled trial. Lasers Med Sci, 29 (3), pp.1065-1073

Airaksinen, O., Brox, J.I., Cedtraschi, C., Hidebrandt, J., Klaber-Moffett, J., Kovacs, F., Mannion, A.F., Reis, S., Staal, J.B., Ursin, H., Zanoli, G. (2004) European guidelines for the mangagement of chronic non-specific low back pain. COST ACTION B13 Low back pain

Ay, S., Dogan, S. K. and Evcik, D. (2010) Is low-level laser therapy effective in acute or chronic low back pain? Clin Rheumatol, 29 (8), pp.905-910

Basford, J. R., Sheffield, C. G. and Harmsen, W. S. (1999) Laser therapy: a randomized, controlled trial of the effects of low-intensity Nd:YAG laser irradiation on musculoskeletal back pain. Arch Phys Med Rehabil, 80 (6), pp.647-652

Brosseau, L., Robinson, V., Wells, G., Debie, R., Gam, A., Harman, K., Morin, M., Shea, B. and Tugwell, P. (2005) Low level laser therapy (Classes I, II and III) for treating rheumatoid arthritis. Cochrane Database Syst Rev (4), pp.Cd002049

Chou, R., Qaseem, A., Snow, V., Casey, D., Cross Jr, T., Shekelle, P., and Owens, D.K. (2007) Clinical guidelines - Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicans and the American Pain Society. Ann Intern Med, 147, pp.478-491

Chow, R.T., Johnson, M.I., Lopes-Martins, R.A. and Bjordal, J.M. (2009) Efficacy of low-level laser therapy in the management of neck pain: a systematic review and meta-analysis of randomised placebo or active-treatment controlled trials. Lancet, 374(9705), pp.1897-1908

Conforti, M. and Fachinetti, G.P. (2013) High power laser therapy treatment compared to simple segmental physical rehabilitation in whiplash injuries (1° and 2° grade of the Quebec Task Force classification)

involving muscles and ligaments. Muscles Ligaments Tendons J., 3(2), pp. 106-111

Critical Apprisal Skills Programme UK (CASP UK). (2013) CASP Checklists [Online] Available at: http://www.casp-uk.net/#!casp-tools-checklists/c18f8 [Accessed 25th Feburary 2015]

Diamound, S. and Borenstein, D. (2006) Chronic low back pain in a working-age adult. 20 (4), pp.707–720

Djavid, G. E., Mehrdad, R., Ghasemi, M., Hasan-Zadeh, H., Sotoodeh-Manesh, A. and Pouryaghoub, G. (2007) In chronic low back pain, low level laser therapy combined with exercise is more beneficial than exercise alone in the long term: a randomised trial. Aust J Physiother, 53 (3), pp.155-160

Fairbank, J. C. and Pynsent, P. B. (2000) The Oswestry Disability Index. Spine (Phila Pa 1976), 25 (22), pp.2940-2952; discussion 2952

Ferraresi, C., Kaippert, B., Avci, P., Huang, Y., de Sousa, M.V.P., Bagnato, V.S., Parizotto, N.A. and Hamblin, M.R. (2014) Low-level laser (light) therapy increases mitchondrial membrane potential and ATP synthesis in C2C12 myotuves with a peak reponse. Photochemistry and

Photobiology, 91(2), pp.411-416

Ferreira-Valente, M. A., Pais-Ribeiro, J. L. and Jensen, M. P. (2011) Validity of four pain intensity rating scales. Pain, 152 (10), pp.2399-2404

Fiore, P., Panza, F., Cassatella, G., Russo, A., Frisardi, V., Solfrizzi, V., Ranieri, M., Di Teo, L. and Santamato, A. (2011) Short-term effects of high-intensity laser therapy versus ultrasound therapy in the treatment of low back pain: a randomized controlled trial. Eur J Phys Rehabil Med, 47 (3), pp.367-373

Fritz, J. M. and Irrgang, J. J. (2001) A comparison of a modified Oswestry Low Back Pain Disability Questionnaire and the Quebec Back Pain Disability Scale. Phys Ther, 81 (2), pp.776-788

Furlan, A.D., Malmivaara, A., Chou, R., Maher, C.G., Deyo, R.A., Schoene, M., Bronfort, G. and van Tulder, M.W. (2015) Updated Method Guideline for Systematic Reviews in the Cochrane Back and Neck Group. Spine, 40(21), pp.1660-1673

Greco, M., Guida, G., Perlino, E., Marra, E. and Quagliariello, E. (1989) Increase in RNA and protein synthesis by mitochondria irradiated with helium-neon laser. Biochem Biophys Res Commun,163(3), pp.1428-1434

Gur, A., Karakoc, M., Cevik, R., Nas, K. and Sarac, A. J. (2003) Efficacy of low power laser therapy and exercise on pain and functions in chronic low back pain. Lasers Surg Med, 32 (3), pp.233-238

Hoy, D., Bain, C., Williams, G., March, L., Brooks, P., Blyth, F., Woolf, A., Vos, T. and Buchbinder, R. (2012) A systematic review of the global prevalence of low back pain. Arthritis Rheum, 64 (6), pp.2028-2037

Huang, Y. Y.,Sharma, S.K., Carroll, J. D. and Hamblin, M. R. (2011) Biphasic Dose Response in Low Level Light Therapy – An Update : Dose Response., 9(4)pp.602-618

Karu, T., Afanasteva, N.I., Kolyakov, S.F., Pyatibrat, L.V. and Welser, L. (2001) Changes in absorbance on monolayer of living cells induced by laser irradiation. IEEE Journal of Selected Topics in Quantum Electronics, 7(6), pp.982.

Kaur, T.I. (1989) Laser biostimulation: a photobiological phenomenon. J Photochem Photobiol B, 3(4), pp.638-640

Lubart, R., Friedman, H., and Lavie, R. (2000) Photobiostimulation as a function of different wavelengths. bone regeneration. The Journal of Laser Therapy, 12

Jang, H. and Lee, H. (2012) Meta-analysis of pain relief effects by laser

irradiation on joint areas. Photomed Laser Surg, 30 (8), pp.405-417

Kadhim-Saleh, A., Maganti, H., Ghert, M., Singh, S. and Farrokhyar, F. (2013) Is low-level laser therapy in relieving neck pain effective? Systematic review and meta-analysis. Rheumatol Int, 33 (10), pp.2493-2501

Kheshie, A. R., Alayat, M. S. and Ali, M. M. (2014) High-intensity versus low-level laser therapy in the treatment of patients with knee osteoarthritis: a randomized controlled trial. Lasers Med Sci, 29 (4), pp.1371-1376

Kovacs, F. M., Abraira, V., Zamora, J., Teresa Gil del Real, M., Llobera, J., Fernandez, C., Bauza, J. R., Bauza, K., Coll, J., Cuadri, M., Duro, E., Gili, J., Gestoso, M., Gomez, M., Gonzalez, J., Ibanez, P., Jover, A., Lazaro, P., Llinas, M., Mateu, C., Mufraggi, N., Muriel, A., Nicolau, C., Olivera, M. A., Pascual, P., Perello, L., Pozo, F., Revuelta, T., Reyes, V., Ribot, S., Ripoll, J. and Rodriguez, E. (2004) Correlation between pain, disability, and quality of life in patients with common low back pain. Spine, 29(2), pp.206-210

Moshkovska, T. and Mayberry, J.(2005) It is time to test low level laser therapy in Great Britain. Postgrad Med J, 81, pp.436-441

NICE (2009) Low back pain - Early management of persistent non-specific low back pain. UK

Ogon, M., Krismer, M., Sollner, W., Kantner-Rumplmair, W. and Lampe, A. (1996) Chronic low back pain measurement with visual analogue scales in different settings. Pain, 64 (3), pp.425-428

Ostelo, R.W.J.G., Deyo, R A., Stratford, P., Waddell, G., Croft, P., Von Korff, M., Bouter, L. M. and de Vet, H .C. (2008) Interpreting change scores for pain and functional status in low back pain. Spine, 33 (1), pp. 90-94

Passarella, S., Casamassima, E., Molinari, S., Pastore, D., Quagliariello, E., Catalano, I.M. and Cingolani, A. (1984) Increase of proton electrochemical potential and ATP synthesis in rat liver mitochondria irradiated in vitro by helium-neon laser. FEBS Lett 175(1), pp.95-99

Roland, M. and Fairbank, J. (2000) The Roland-Morris Disability Questionnaire and the Oswestry Disability Questionnaire. Spine (Phila Pa 1976), 25 (24), pp.3115-3124

Royal College of Surgeons for England (RCS), British Orthopaedic Assoicaiton, Charted Society of Physiotherapy. (2013) Commission Guide 2013: Low back pain; board principles of the patient pathway

Shiva, S. and Gladwin, M.T. (2009) Shining a light on tissue NO stores: near infrared release of NO from nitrite and nitrosylated hemes. J Mol Cell Cardiol,46(1), pp.1-3.

Stadler, I., Evans, R., Kolb, B., Naim, J.O., Narayan, V., Buehner, N. and Lanazafame R.J. (2000) In vitro effects of low level laser irradiation at 660 nm on peripheral blood lymphocytes. Lasers Surg Med, 27(3), pp.255-61

Thomas, E. N., Pers, Y. M., Mercier, G., Cambiere, J. P., Frasson, N., Ster, F., Herisson, C. and Blotman, F. (2010) The importance of fear, beliefs, catastrophizing and kinesiophobia in chronic low back pain rehabilitation. Ann Phys Rehabil Med, 53 (1), pp.3-14

Timimi, Z. A., Jaafar, M. S. and Jafri, M. Z. A. (2010) Comparison between low level laser therapy and exercise for treatment of chronic low back pain. Indian Journal of Physiotherapy and Occupational Therapy, 4 (3), pp.102-104

Tsuchiya, K., Kawatani, M., Takeshiqe, C., Sato, T. and Matsumoto, I. (1993) Diode laser irradiation selectively diminishes slow component of

axonal volleys to dorsal roots from the saphenous nerve. Neuroscience Letters, 161, pp.65-68.

Walker, B. F. (2000) The prevalence of low back pain: a systematic review of the litereature from 1966 to 1998. J Spinal Disord, 13 (3), pp.205-217

Wartz, R.L. (2006) Class IV "High-Power" Laser Therapy in Chiropractic and Rehabilitation. Dynamic Chiropractic, 24(3)

World Association of Laser Therapy (WALT) (2010) Recommended treatment doses for low level laser therapy 904 nm GaAs Lasers [Online] Available at: < http://waltza.co.za/wp-content/uploads/2012/08/Dose_table_904nm_for_Low_Level_Laser_Therapy_WALT-2010.pdf > Accessed [13th January 2015]

Yousefi-Nooraie, R., Schonstein, E., Heidari, K., Rashidian, A., Pennick, V., Akbari-Kamrani, M., Irani, S., Shakiba, B., Mortaz Hejri, S., Jonaidi, A. R. and Mortaz-Hedjri, S. (2008) Low level laser therapy for low-back pain. Cochrane Database of Systematic Revews, 2

Appendix 1 - Search Strategy for databases

MH “Low back pain”

1. MH “back pain”
2. “lower back pain”
3. “Lumbar back pain”
4. 1 OR 2 OR 3 OR 4
5. MH “Laser therapy”
6. MH “laser therapy, low-level”
7. “cold laser therapy”
8. “Infrared laser therapy”
9. “ near-infrared laser therapy”
10. “high level laser therapy”
11. “high power laser therapy”
12. “high intensity laser therapy
13. “non infrared laser therapy”
14. 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14
15. 4 AND 14

Key:

“MH” = Medical Subject Heading

“OR” = or

“AND” = and

*further screening was then done manually, please refers to PRISMA flowchart (figure 1)

Appendix 2 – Inclusion and exclusion criteria

Inclusion criteria

1. Randomized controlled trials (RCTs)
2. English language available
3. Available at AMED; CINAHL; Cochrane Library; MEDLINES; and PEDRO all from the start of each database to November 2014.
4. Full text available
5. Match the search terms (appendix 1)
6. Has at least one validated patient reported outcome measure to investigate pain intensity and/or functional disability
7. Population aged more than 17 years old but less than 60 years old
8. Studies that included laser intervention with or without other intervention either as a co-intervention or stand alone

Exclusion criteria

1. Non-RCTs
2. using laser acupuncture as primary intervention
3. total sample size is smaller than 20 or equal to 20
4. scored less than 8 out of 13 in The Cochrane Collaboration' s tool for assessing risk of bias (2015 Updated)
5. acute low back pain or equivalent
6. pain is considered to be originated from an extraspinal source

Appendix 3 - Laser therapy dosage calculation

Glossary:

Fluency (H): it is equivalent to the energy density (joules/cm^2), at a point of a surface, the radiant energy incident on an element of the surface, divided by the area of the surface.

Irradiance (E): At a point of a surface, the radiant energy flux (or power) incident on an element of the surface, divided by the area of the surface.

Total energy (J^T): The total energy delivered throughout the treatment

Time (s): Time or duration

Equations:

Fluency (j/cm^2) = total amount of energy (j) / area (cm^2)

Total energy (j) = average power (W) x Time (s), when it is continuous waveform

Irradiance (W/cm^2) = $Q = \int_{t^0}^{t^P} P(t)\,dt$ when it is pulsed waveform, where $t^P - t^0$ = pulse duration

Appendix 4 - Characteristics of Studies

Appendix 4a – Characteristics of Included Studies

Methods	Alayat et al, 2014	Ay et al, 2010	Basford et al, 1999	Djavid et al, 2007	Fiore et al, 2011	Gur et al, 2003
Study Design	RCT	RCT	RCT	RCT	RCT	RCT
Unit of Allocation	Patients	Patients	Patients	Patients	Patients	Patients
Method of randomisation	Using Graphpad program	By numbered envelopes method	By computer-generated schedule	Using block randomisation with a manual schedule	Not stated	Not stated
Allocation concealment	No	No	Yes	Yes	Yes	No
Blindedness	Single blinded (patient)	Single blinded (patient and assessor)	Double blinded	Single blinded (assessor blinded)	Single blinded (assessor blinded)	Single blinded (assessor blinded)

Appendix 4a – Characteristics of Included Studies

Participants	Alayat et al, 2014	Ay et al, 2010	Basford et al, 1999	Djavid et al, 2007	Fiore et al, 2011	Gur et al, 2003
Number	Randomised = 72; Analysed = 72	Randomised = 80 Analysed = 80	Randomised = 63 Analysed = 56	Randomised = 61 Analysed = 53	Randomised = 30 Analysed = 30	Randomised = 75 Analysed = 75
Recruitment of patients	From the male section of the rehabilitation of their hospital	Not stated	Recruited with announcements in their institutional newspaper and local newspaper and by referral from local physicians and chiropractors	Referred by local physicians to the clinic of an Occupational Medicine Department	Consecutive outpatients attending the Department of Physical medicine and Rehabilitation, University of Foggia	Patients admitted to Dicle University, Faculty of Medicine, Physical Medicine and Rehabilitation Department
Enrolment dates	Not stated	Not stated	Not stated	Not stated	From June 2009 to January 2011	From May 1999 to March 2000
Age	Between the age of 20 and 50	Not stated	Between the age of 18 and 70	Between the age of 20 and 60	Between the age of 20 and 60	Between the age of 20 and 50
Sex	Male	Male and female	Male and female	Male and female	Male and female	Male and female
Ethnicity	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated
Work status	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated
Diagnosis of LBP	Based on history and physical examination	Lumbar disc herniation, based on clinical examination	Non-radiating musculoskeletal low back pain, based on clinical examination	Based on clinical examination from referrers	The presence of lumbar pain at rest, or pain during movement of the lumbar spine, absence of sciatica	Clinically and radiologically diagnosed as CLBP

Appendix 4a – Characteristics of Included Studies

Appendix 4a – Characteristics of Included Studies

Participants	Alayat et al, 2014	Ay et al, 2010	Basford et al, 1999	Djavid et al, 2007	Fiore et al, 2011	Gur et al, 2003
Duration of Pain	At least 1 year history of LBP	Not stated	At least 1 month history of LBP	At least 12 week history of LBP	At least 3 week history of LBP	At least 12 month history of LBP
Previous treatment	Not stated	Excluded those had surgery	Excluded those had treatment of this problem in the previous 30 days or had spinal surgery	Not stated	No other physiotherapy intervention in the 4 weeks prior to the study	Not stated
Exclusion criteria	Any history of spinal surgery, any degenerative disc disease, any disc herniation, spine fracture, spondylosis, spinal stenosis, neurological deficits, abnormal laboratory findings, and systemic and psychiatric illnesses were excluded	Any history of spinal surgery, any degenerative disc disease, any neurological deficit, any spondylosis, any spinal stenosis, any spondyloisthesis, any pregnancy and any inflammatory, infectious, or malignant disease, and history of spinal surgery were excluded	Any radicular pain, any neurological deficits, any litigation or workman's compensation was pending, any intake of corticosteroid in the previous 30 days	Any history of spinal surgery, any degenerative disc disease, any disc herniation, spine fracture, spondylosis, spinal stenosis, neurological deficits, abnormal laboratory findings, and systemic, psychiatric illnesses and pregnancy were excluded	Any patients, with anaesthetic or corticosteroid injection within 4 weeks of study enrolment, radicular pain, osteoporosis, surgery or previous fracture of spine, spinal stenosis, a history of acute trauma, known osteoarthritis, myofascial pain syndrome, inflammatory rheumatic disease, systemic lupus erythematosus, diabetes mellitus type 1 or 2, thyroid dysfunction, obesity, pace-maker, neurological pathologies and anxious-depressive syndromes were excluded	Patients with pregnancy, any neurological deficits, any abnormal laboratory findings and systemic and psychiatric illness were excluded

Appendix 4a – Characteristics of Included Studies

Interventions		Alayat et al, 2014	Ay et al, 2010	Basford et al, 1999	Djavid et al, 2007	Fiore et al, 2011	Gur et al, 2003
Interventions		**Alayat et al, 2014**	**Ay et al, 2010**	**Basford et al, 1999**	**Djavid et al, 2007**	**Fiore et al, 2011**	**Gur et al, 2003**
Groups		HLLT with exercise (n=28); HLLT only (n=24); placebo laser with exercise (n=24)	Acute lumbar disc herniation with hot-pack + LLLT (n=20); Acute lumbar disc herniation with hot-pack + placebo laser (n=20); chronic lumbar disc herniation with hot-pack + LLLT (n=20); chronic lumbar disc herniation with hot-pack + placebo laser (n=20);	LLLT group (n=27); Placebo laser group (n=29)	LLLT group (n=16); LLLT with exercise group (n=19); placebo laser with exercise group (n=18)	HLLT group (n=15); ultrasound (US) group (n=15)	LLLT with exercise group (n=25); LLLT alone group (n=25); exercise alone group (n=25)
Laser setting	Sessions	3 sessions per week for 4 weeks	5 sessions per week for 3 weeks	3 sessions per week over 4 weeks	2 sessions a week over 6 weeks	5 sessions a week over 3 weeks	5 sessions a week over 4 weeks
	Laser Medium	Neodymium YAG(Nd: YAG) laser	Gallium-Aluminium-Arsenide (GaAIAs) laser	Neodymium YAG(Nd: YAG) laser	Gallium-Aluminium-Arsenide (GaAIAs) laser	Neodymium YAG(Nd: YAG) laser	Gallium-Aluminium-Arsenide (GaAIAs) laser
	Laser model	HIRO 3 device (ASA laser)	Infrared diode laser device (Chattanooga group USA)	Not stated	Not stated	HIRO1.0 (ASA laser)	Frank Line IR 30(Fysiomed, Belgium)
	Wavelength	1064 nm	850 nm	1060 nm	810 nm	1064 nm	Not stated
	Laser mode	Pulsed	Continuous	Continuous	Continuous	Pulsed	Pulsed

Appendix 4a – Characteristics of Included Studies

Interventions		Alayat et al, 2014	Ay et al, 2010	Basford et al, 1999	Djavid et al, 2007	Fiore et al, 2011	Gur et al, 2003
Laser setting	Pulse frequency	10-40 Hz	16 Hz (for acute); 155 Hz (for chronic)	Not stated	Not stated	Not stated	2100 Hz
	Pulse duration	120-150 µs	Not stated	Not stated	Not stated	Less than 15000 µs	Not stated
	Peak power	3000 W	Not stated	Not stated	Not stated	1000 W	Not stated
	Average power	3.33 W	0.1 W	0.11 W	0.11 W	6W	0.0042 W
	Average irradiance	54W/cm^2	Not stated	0.542 W/cm^2	Not stated	Not stated	Not stated and not enough data to calculate
	Fluency	0.510 – 1.780 J/cm^2	40 J/cm^2	Not stated and not enough data to calculate	27 J/cm^2	0.760 J/ cm^2	1 J/cm^2
	Laser class	Not stated	Not stated	Not stated	Not stated	Not stated	IIIb
	Spot area	0.2 cm^2	0.07 cm^2	4.01 cm^2	0.22 cm^2	0.2 cm^2	1.0 cm^2
	Application time	15 mins	4 mins per point	90 sec per two points	About 20 mins	About 10 mins	About 30 mins

		Appendix 4a – Characteristics of Included Studies					
		Alayat et al, 2014	**Ay et al, 2010**	**Basford et**	**Djavid et al, 2007**	**Fiore et al, 2011**	**Gur et al, 2003**
Laser setting	Anatomical location	Lower back area of L1-L5 and S1	2 – 4 points over both sides of the paraspinal tissues of the disk spaces	Irradiating two points simultaneously at each of four equally spaced level; two sites at each of four equally spaced levels along the L2 to S3 paraspinal tissues	A series of standardised fields designed to include the L4 to L5 and L5 to S2 apophyseal capsules, dorsolumbar fascia, and interspinous ligaments, as well as the gluteal fascia, posterior sacroiliac ligaments, hamstrings, and gastro-soleus muscles of which pain points were palpated form the low back to the foot.	Stage 1: fast manual scanning on the zones of muscular contractures, particularly on the lumbar and dorsal muscles, latissimus dorsi, external oblique abdominis and gluteus maximus; Stage 2: on the trigger point found until a pain reduction of 70-80% achieved; stage 3: same as stage 1 but slow manual scanning.	A series of standardised fields designed to include the L4 to L5 and L5 to S2 apophyseal capsules, dorsolumbar fascia, and interspinous ligaments, as well as the gluteal fascia, posterior sacroiliac ligaments, hamstrings, and gastro-soleus muscles of which pain points were palpated from the low back to the foot

Interventions						
			al, 1999			
Other combined treatment	Exercises included strengthening, stretching, mobilising, coordinating and stabilising the abdominal, back and pelvic muscle but they were personalised for each patient's clinical finings	Hot-pack: 20 mins per session	Not applicable	Home exercise program that might include strengthening, stretching, mobilising, coordination and the stabilising of the abdominal, back, pelvic, and lower limb muscles, depending on the clinical findings	Ultrasound (US) group (n=15): 5 times a week over 3 weeks; US model: SONOPLUS 492 (Enraf-Nonius BV); US frequency = 1MHz; US intensity = 2W/cm^2 with a duty cycle of 100%; transducer head area = 5.8cm^2; effective radiating area = 4.6cm^2; anatomical location: over the lumbar and dorsal muscles, latissimus dorsi , external oblique adbominis and gluteus maxius, covering about 150cm^2	Exercise: lumbar flexion and extension, knee flexion, hip adduction exercises and strength exercises on extremity muscle group were give two sessions a day (total 40 session over 4 weeks), where the first exercise session was conducted with a physiotherapist and continued at home by patients themselves
Placebo treatment or other single treatment	Placebo irradiation with deactivated laser radiation. Received before applying exercises	Same as experimental group but applied without turning on the device	Same protocol as LLLT but using inactive device	Same protocol as LLLT but using inactive device and carrying out exercise with the same protocol as LLLT with exercise group	Not applicable	LLLT alone group: same protocol as LLLT with exercise group but without exercise Exercise alone group: same protocol as LLLT with exercise group but without LLLT

Outcomes	Alayat et al, 2014	Ay et al, 2010	Basford et al, 1999	Djavid et al, 2007	Fiore et al, 2011	Gur et al, 2003
Measurement by	Not stated	Not stated	Physicians	Physicians	Not stated	Physicians
Measured variables	Pain (VAS), lumbar range of movement, functional disability (RDQ and ODS)	Pain (VAS), lumbar range of movement and modified Schöber test, functional disability (RMDQ and ODI)	Pain (VAS), lumbar range of movement, patient perception of benefits, functional disability (ODI)	Pain (VAS), lumbar range of movement and Schöber test, functional disability (ODI)	Pain (VAS), lumbar range of movement and Scholber test, functional disability (ODS)	Pain (VAS), lumbar range of movement (flexion and lateral flexion) and Scholber test, functional disability (ODI)
Follow-up session	8 week after 4-week treatment	No follow-up after completion of treatment	1 month after 4-week treatment	6 weeks after 6-week treatment	3 week mark (after the whole course of treatment)	1 month after 4-week treatment
Intention-to-treat analysis	No	No	No	Yes	Yes	No

Appendix 4a – Characteristics of Included Studies

Notes	Alayat et al, 2014	Ay et al, 2010	Basford et al, 1999	Djavid et al, 2007	Fiore et al, 2011	Gur et al, 2003
Total score	8 / 13	10 / 13	11 / 13	11 / 13	11 / 13	8 / 13
Limitation	All participants were male; the exercise program for individual was personalized and monitored by participant's family members, therefore the exercise intensity could be varied	Hot-pack was used in each group, leading to potential mask effect; unknown peak output of laser therapy; unknown optimum irradiance; short follow-up duration; no placebo group alone; participants were not blinded	Unknown optimal treatment parameters	Small sample size to detect change in some outcomes; no power calculation prior to the trial; no data provided to compare the effectiveness between low-intensity laser therapy group and low-intensity laser therapy plus exercises group	Relatively small sample size: n = 30(15/15); demographic information was not clearly presented; participants were not blinded; no control group; time effect may contribute into the result; lack of follow-up post-3-week period	No concealed allocation; participants and therapists were not blinded; no intention-to-treatment analysis; inadequate follow-up; unknown optimum irradiance

Appendix 4a – Characteristics of Included Studies

	Alayat et al, 2014		Ay et al, 2010		Basford et al, 1999		Djavid et al, 2007		Fiore et al, 2011		Gur et al, 2003	
Risk of bias	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*
Adequate sequence generation ?	Low risk		Low risk		Low risk		Low risk		Low risk		Low risk	
Allocation concealment?	High risk		High risk		Low risk		Low risk		Low risk		High risk	
Blinding? All outcomes – patients?	Low risk		Low risk		Low risk		High risk	The laser therapy alone group was not blinded	Low risk		High risk	

Appendix 4a – Characteristics of Included Studies

	Alayat et al, 2014		Ay et al, 2010		Basford et al, 1999		Djavid et al, 2007		Fiore et al, 2011		Gur et al, 2003	
Risk of bias	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*
Blinding? All outcomes – providers?	High risk		High risk		Low risk		High risk	Authors do not think wearing googles can achieve blinding	Low risk		High risk	
Blinding? All outcomes – outcome assessors?	High risk		Low risk		Low risk		Low risk		Low risk		Low risk	
Incomplete outcome data addressed? All outcomes – drop-outs?	Unknown risk	Not stated in text	Low risk		Low risk	Drop-out number and reasons were stated in text	Low risk		Low risk		High risk	Not stated

Appendix 4a – Characteristics of Included Studies

	Alayat et al, 2014		Ay et al, 2010		Barr et al, 1999		Diaz et al, 2007		Fiore et al, 2011		Gur et al, 2003	
Risk of bias	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*
In complete outcome data addressed? All outcomes – ITT analysis?	High risk		High risk		High risk	Patients who dropped out were not included into analysis	Low risk		Low risk		High risk	
Suggestion of selective outcome reporting?	Low risk		Low risk		Low risk		Low risk		Low risk		Low risk	
Suggestion of selective outcome reporting?	Low risk		Low risk		Low risk		Low risk		High risk		Low risk	
Similarity of baseline characteristics?	Low risk		Low risk		Low risk		Low risk		High risk		Low risk	

	Alayat et al, 2014		Ay et al, 2010		Basford et al, 1999		Djavid et al, 2007		Fiore et al, 2011		Gur et al, 2003	
Risk of bias	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*	*Authors' judgement*	*Support for judgement*
Co-interventions avoided or similar?	Low risk		Low risk		Low risk		Low risk		Low risk		Low risk	
Compliance acceptable?	Low risk		Low risk		Low risk		Low risk		Low risk		Low risk	
Timing outcome assessments similar?	Low risk		Low risk		Unknown risk	Various follow-up duration from initial visit, noted from fig 1 in the article	Low risk		Low risk		Low risk	
Any other risks of bias?	Low risk		Low risk		Low risk		Low risk		Low risk		Low risk	

Appendix 4b - Characteristics of Excluded Studies

Timimi et al, 2014	
Methods	
Study Design	RCT
Unit of Allocation	Patients
Method of randomisation	Using block randomisation with a manual schedule
Allocation concealment	Yes
Blindedness	Therapist blinded only
Participants	
Number	Randomised = 80; analysed = 80
Recruitment of patients	Recruited via referral of local physicians to the clinic of an Occupational Medicine Department
Enrolment dates	Not stated
Age	Between the age of 20 and 60
Sex	Male and Female
Ethnicity	Not stated
Work status	Not stated
Diagnosis of LBP	Not stated
Duration of Pain	At least 12 week history of LBP
Previous treatment	Not stated
Exclusion criteria	Patients with degenerative disc disease, disc herniation, fracture, spondylosis, and spinal stenosis, neurological deficits, abnormal laboratory findings, systemic or psychiatric illness, and pregnancy were excluded

Appendix 4b - Characteristics of Excluded Studies

Timimi et al, 2014		
Intervention		
Groups		LLLT with exercise group (n=25); placebo laser with exercise (n=30); exercise group (n=25)
Laser setting	Sessions	3 sessions a week for 4 weeks
	Laser Medium	Gallium-Aluminium-Arsenide(GaAIAs) laser
	Laser model	Not stated
	Wavelength	760 nm
	Laser mode	Continuous
	Pulse frequency	Not applicable
	Pulse duration	Not applicable
	Peak power	Not stated
	Average power	10 mW
	Average irradiance	Not stated
	Fluency	40 J/cm^2
	Laser class	Not stated
	Spot area	0.2211 cm^2
	Application time	20 mins
	Anatomical location	a series of standardised fields designed to include the L4 to L5 and L5 to S2 apophyseal capsules, dorsolumbar fascia, and interspinous ligaments, as well as the gluteal fascia, posterior sacroiliac ligaments, hamstrings, and gastro-soleus muscles of which pain points were palpated from the low back to the foot
Other combined treatment		Exercise: included strengthening, stretching, moblising, coordinating, and stabilizing the abdominal and back muscle. The first exercise session was conducted with physiotherapist for 1st session before continued exercising at home.
Placebo treatment or other single treatment		Placebo irradiation with deactivated laser radiation. Followed the same exercise regime as LLLT with exercise group

Timimi et al, 2014	
Outcomes	
Measurement by	Not stated
Measured variables	Pain (VAS), lumbar range of movement, functional disability
Follow-up session	At week 4 after the last session of intervention
Intention-to-treat analysis	No
Notes	
Total score	6 / 13
Limitation	Did not provide baseline characteristic of each treatment group; the study only reports the percentage of patients who improved without clearly reporting the extent of improvement; unknown number of subjects included into final data synthesis; patients and assessors were not blinded; unknown drop-out rate; ?effective wavelength

Appendix 4b - Characteristics of Excluded Studies

Timimi et al, 2014		
Risk of bias		
Bias	*Authors' judgement*	*Support of judgement*
Adequate sequence generation?	Low risk	
Allocation concealment?	Low risk	
Blinding? All outcomes – patients?	High risk	
Blinding? All outcomes – providers?	Low risk	
Blinding? All outcomes – outcome assessors?	High risk	
Incomplete outcome data addressed? All outcomes – drop-outs?	High risk	The number of patients included into data analysis was not stated in text
In complete outcome data addressed? All outcomes – ITT analysis?	High risk	
Suggestion of selective outcome reporting?	High risk	The study only reports the percentage of patients who improved without clearly reporting the extent of improvement.
Similarity of baseline characteristics?	High risk	Demographic information and initial findings from pre-treatment were not presented in text
Co-interventions avoided or similar?	Low risk	
Compliance acceptable?	Unknown risk	No information provided in text
Timing outcome assessments similar?	Low risk	
Any other risks of bias?	Low risk	

Table and figure

Table 1 – Population-Intervention-Comparison-Outcome-Study

Population	Individuals, who aged 18 years old or above but less than 60 years old , with diagnosis of chronic or persistent non-specific low back pain with/without referred symptom
Intervention	Any form of laser therapy
Comparison	Laser therapy with/without exercise, placebo laser therapy or other treatment group
Outcomes	Any validated outcome measure for assessing pain intensity; any validated outcome measure for assessing functional disability
Study	Randomised controlled trials (RCTs)

Figure 1 – PRISMA Flowchart

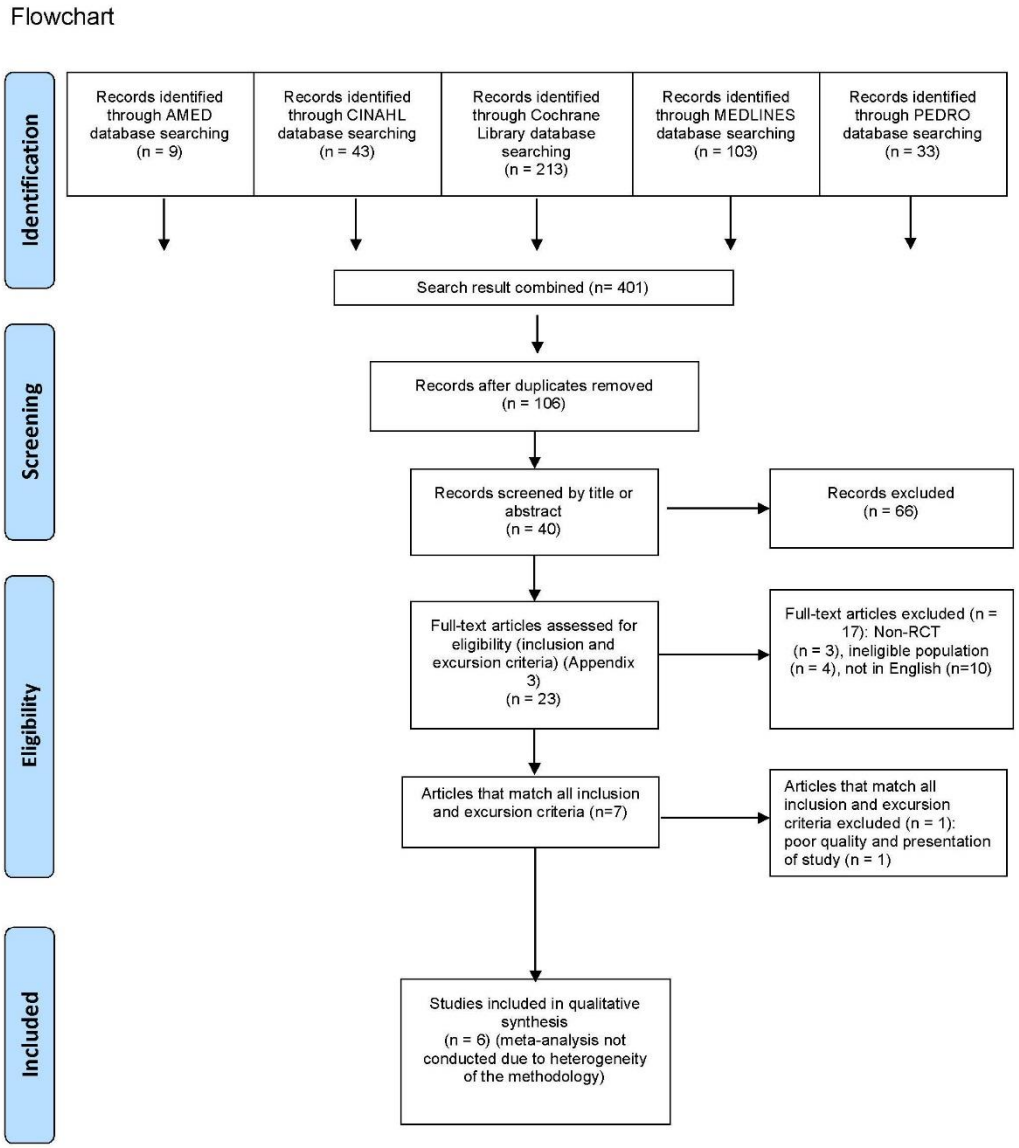

Table 2

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Table 3 - Baseline characteristics of participants in each study

Author	Intervention	n(Group 1/Group 2/Group 3/Group 4)	Gender	Mean age ± SD(year)	Median and Mean of Pain Duration (month)	pain in VAS ± SD (mm)	Oswestry Disability Index (ODI) (mean±SD)
Alayat et al, 2014	Group 1 = high-intensity laser therapy (HILT) plus exercise; Group 2 = placebo laser plus exercise; Group 3 = HILT alone	n=72 (28/24/20)	Overall: Male = 100%	Overall = NG; Group 1 = 33.43± 4.47; Group 2 = 31.54±4.47; Group 3 = 33.50±4.51	Overall: Median = NG; Mean = NG;Group 1: Median = NG; Mean = 13.92± 1.88; Group 2: Median = NG; Mean = 13.33± 1.49; Group 3: Median = NG; Mean = 14.50±1.90	Overall = NG; Group 1 = 83.6±9.5; Group 2 = 82.1±11; Group 3 = 83.5±8.8	Overall = NG; Group 1 = 34.11± 3.14; Group 2 = 34.5±2.93; Group 3 = 35.55±3.62
Fiore et al , 2011	Group 1 = high-intensity laser therapy; Group 2 = ultrasound therapy	n=30 (15/15)	Overall: Male = 36.7% Female = 63.3%; Group 1: Male = 33.3% Female = 66.7%; Group 2: Male = 46.7 % Female = 53.3%	Overall = 51.2±6; Group 1 = NG ; Group 2 = NG	NG any data but one of the inclusion criteria was with at least 3-week histroy of low back pain	No mean value give but median: Overall: NG; Group 1 Median = 7; Group 2 Median = 7	No mean value give but median: Overall: NG; Group 1 Median = 28; Group 2 Median = 28

Key: ? = not reported in the RCT NG = Not given SD=standard deviation

(table 3)

Table 3 - Baseline characteristics of participants in each study (cont.)							
Author	Intervention	n(Group 1/Group 2/Group 3/Group 4)	Gender	Mean age ± SD(year)	Median and Mean of Pain Duration (month)	pain in VAS ± SD (mm)	Oswestry Disability Index (ODI) (mean± SD)
Ay et al, 2010*	Group 1 = Acute back pain + hot-pack +low-intensity laser therapy; Group 2 = Acute back pain + hot-pack +placebo laser therapy; Group 3 = Chronic back pain + hot-pack +low-intensity laser therapy; Group 4 = Chronic back pain + hot-pack +placebo laser therapy;	n= 80 (20/20/20/20)	Overall = NG; Group 1: Male = 30% Female = 70%; Group 2: Male = 40% Female = 60%; Group 3: Male = 55% Female = 45%; Group 4: Male = 45% Female = 55%	Overall = NG; Group 1 = 48.35± 15.22; Group 2 = 45.55± 15.66; Group 3 = 52.25± 10.77; Group 4 = 54.75± 15.02	Overall: Median = NG; Mean = NG; Group 1: Median = NG; Mean = 2.45± 1.43; Group 2: Median = NG; Mean = 2.20±1.28; Group 3: Median = NG; Mean = 50.35± 68.71; Group 4: Median = NG; Mean = 48.40±49.60	Overall = NG; Group 1= 67.0± 21.5; Group 2 = 61.6±2.39; Group 3 = 60 ±22.9; Group 4 = 66.0±22.5	Overall = NG; Group 1 = 19.80±8.25; Group 2 = 20.80± 9.44; Group 3 = 23.90±7.51; Group 4 =24.65±10.04
Basford et al, 1999	Group 1 = low-intensity laser therapy; Group 2 = placebo laser therapy	n=56(27/29)	Overall = NG; Group 1: Male= 60% Female = 40%; Group 2: Male = 55.2% Female = 44.8%	Overall = NG; Group 1 = 47.8±?; Group 2 = 48.2±?	Overall: Median = NG; Mean = NG; Group 1: Median = 4.5; Mean = 6.9±?; Group 2: Median = 6.5; Mean = 12.8±?	Overall = NG; Group 1 = 35.2±?; Group 2 = 37.4±?	Overall = NG; Group 1 = 21±?; Group 2 = 25±?
Key:	? = not reported in the RCT		NG = Not given		SD=standard deviation		
							(table 3)

Table 3 - Baseline characteristics of participants in each study (cont.)							
Author	Intervention	n(Group 1/Group 2/Group 3/Group 4)	Gender	Mean age ± SD(year)	Median and Mean of Pain Duration (month)	pain in VAS ± SD (mm)	Oswestry Disability Index (ODI) (mean±SD)
Djavid et al, 2007	Group 1 = low-intensity laser therapy; Group 2 = low-intensity laser therapy plus exercise; Group 3 = placebo laser therapy plus exercise	n=61(20/21/20)	Overall = NG; Group 1: Male= 43.7% Female = 66.3%; Group 2: Male = 63.2% Female = 46.8%; Group 3: Male = 83.3% Female = 16.7%	Overall = NG; Group 1 = 40± 10; Group 2 = 38±7; Group 3 = 36±10	Overall: Median = NG; Mean = NG; Group 1: Median = NG; Mean = 29±24; Group 2: Median = NG; Mean = 29±30; Group 3: Median = NG; Mean = 25±20	Overall = NG; Group 1 = 73±17; Group 2 = 62±16; Group 3 = 63±20	Overall = NG; Group 1 = 33.0±8.4; Group 2 = 34.0±9.7; Group 3 = 31.8±7.9
Gur et al, 2003	Group 1 = low-intensity laser therapy plus exercise; Group 2 = low-intensity laser therapy; Group 3 = exercise	n=75(25/25/25)	Overall = NG; Group 1: Male = 28% Female = 72%; Group 2: Male = 32% Female = 68%; Group 3: Male = 28% Female = 72%	Overall = 35.6± 10.3; Group 1 = 35.2±10.51; Group 2 = 36.4 ±9.83; Group 3 = 35.4±11.2	Overall: Median - NG; Mean =24.8±4.3; Group 1: Median = NG; Mean = 15.3±10.5; Group 2: Median = NG; Mean = 14.6±9.6; Group 3: Median = NG; Mean = 15.1±11.2	Overall = NG; Group 1 = 62±21; Group 2 = 65±16; Group 3= 61±19	Overall = NG; Group 1 = 32.4±10.6; Group 2 = 30.5±12.3; Group 3 = 33.1±11.8
Key:	? = not reported in the RCT		NG = Not given		SD=standard deviation		
							(table 3)

Table 4 - Summary of Risk of Bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding (performance bias and detection bias): All outcomes - patients ?	Blinding (performance bias and detection bias): All outcomes - providers?	Blinding (performance bias and detection bias): All outcomes - outcome assessors?	Incomplete outcome data (attrition bias): All outcomes - drop-outs?	Incomplete outcome data (attrition bias): All outcomes - Intention-to-treat analysis	Suggestion of selective outcome reporting? (reporting bias)	Similarity of baseline characteristics? (selection bias)	Co-interventions avoided or similar? (performance bias)	Compliance acceptable? (performance bias)	Timing outcome assessments similar? (detection bias)	Other potential bias?	Scores (Max = 11)
Alayat et al, 2014	+	-	+	-	-	?	-	+	+	+	+	+	+	8
Ay et al, 2010	+	-	+	-	+	+	-	+	+	+	+	+	+	10
Basford et al, 1999	+	+	+	+	+	+	-	+	+	+	+	?	+	11
Djavis et al, 2007	+	+	-	-	+	+	+	+	+	+	+	+	+	11
Fiore et al, 2011	+	+	-	-	+	+	+	+	+	+	+	+	+	11
Gur et al, 2003	+	-	-	-	+	?	-	+	+	+	+	+	+	8
Remark:	"+" = low risk; "-" = high risk; "?" = uncertain													(Table 4)

Table 5 - Result and Limitation Table of each study (cont.)					
Author	Aim of the study	Result	Limitation	Score	Included/excluded?
Basford et al, 1999	To assess the effectiveness of low-intensity laser therapy in the treatment of musculoskeletal back pain	The result showed there was a time-dependent improvement in perception of benefit and level of function in low-intensity laser therapy group particularly in mid-way assessment ($p < 0.05$, $p < 0.01$) and at the end of treatment ($p < 0.17$, $p < 0.01$); however, the effect tended to lessen at the 1-month follow-up ($p < 0.10$, $p < 0.04$). This suggests low-intensity laser therapy could produce a moderate pain relief effect and improvement in disability but this was limited and decreased with time.	uncertain on optimal treatment parameters;	9 / 11	Included
Djavid et al, 2007	To investigate the effectiveness of low-intensity laser therapy, low-intensity laser therapy plus exercises and placebo laser therapy plus exercise at decreasing pain, increasing lumbar range of movement and reducing disability	The result showed there was no statistically significant difference for any outcome measure immediately after the 6-week intervention and a further 6 weeks of no intervention respectively between groups. However, in the low level intensity laser therapy plus exercise group pain had reduced by 1.8cm ($p = 0.03$); lumbar range of movement increased by 0.9 cm ($p < 0.01$) and 15 degrees of active flexion ($p < 0.01$); and disability reduced by 9.4 points ($p = 0.03$) on the Oswestry Disability Index.	small sample size to detect change in some outcomes; no power calculation prior to the trial; no data provided to compare the effectivness between low-intensity laser therapy group and low-intesnity laser therapy plus exercises group	9 / 11	Included
Remark:	this table only included studies that matched inclusion and excrusion criteria; ? = uncertain; score refers to sumary of risk of bias (table 3)				(table 5)

Table 5 - Result and Limitation Table of each study (cont.)					
Author	Aim of the study	Result	Limitation	Score	Included/excluded?
Basford et al, 1999	To assess the effectiveness of low-intensity laser therapy in the treatment of musculoskeletal back pain	The result showed there was a time-dependent improvement in perception of benefit and level of function in low-intensity laser therapy group particularly in mid-way assessment ($p < 0.05$, $p < 0.01$) and at the end of treatment ($p < 0.17$, $p < 0.01$); however, the effect tended to lessen at the 1-month follow-up ($p < 0.10$, $p < 0.04$). This suggests low-intensity laser therapy could produce a moderate pain relief effect and improvement in disability but this was limited and decreased with time.	uncertain on optimal treatment parameters;	11 / 13	Included
Djavid et al, 2007	To investigate the effectiveness of low-intensity laser therapy, low-intensity laser therapy plus exercises and placebo laser therapy plus exercise at decreasing pain, increasing lumbar range of movement and reducing disability	The result showed there was no statistically significant difference for any outcome measure immediately after the 6-week intervention and a further 6 weeks of no intervention respectively between groups. However, in the low level intensity laser therapy plus exercise group pain had reduced by 1.8cm ($p = 0.03$); lumbar range of movement increased by 0.9 cm ($p < 0.01$) and 15 degrees of active flexion ($p < 0.01$); and disability reduced by 9.4 points ($p = 0.03$) on the Oswestry Disability Index.	small sample size to detect change in some outcomes; no power calculation prior to the trial; no data provided to compare the effectivness between low-intensity laser therapy group and low-intesnity laser therapy plus exercises group	11 / 13	Included
Remark:	this table only included studies that matched inclusion and excrusion criteria; ? = uncertain; score refers to sumary of risk of bias (table 3)				(table 5)

Table 5 - Result and Limitation Table of each study (cont.)					
Author	Aim of the study	Result	Limitation	Score	Included/excluded?
Ay et al, 2010	To compare the effectiveness of low-intensity laser therapy on pain and functional capacity in patients with acute and chronic low back pain caused by lumbar disk herniation.	Result showed no significant difference were detected between four treatment group in all outcome measures ($p > 0.05$), suggesting there were no differences between laser and placebo laser therapy on pain severity and functional capacity in patients whose pain was caused by lumbar disk herniation.	hot-pack was used in each group, leading to potential mask effect; ? peak output of laser therapy; ?optimum irradiance; short follow-up duration; no placebo group alone; participants were not blinded	10 / 13	Included
Gur et al, 2003	To determine whether low-intensity laser therapy is useful or not for the therapy of chronic low back pain.	Result showed no significant difference between any therapy groups. All therapy groups had significant improvements in pain intensity and disability ($p<0.05$) with exception of lateral flexion but pain intensity in low-intensity laser therapy plus exercise group decreased more than the exercise group alone.	no concealed allocation; participants and therapists were not blinded; no intention-to-treatment analysis; inadequate follow-up; ?optimum irradiance	8 / 13	Included
Remark:	this table only included studies that matched inclusion and excrusion criteria; ? = uncertain; score refers to sumary of risk of bias (table 3)				(table 5)