A systematic review of low level laser therapy with location-specific doses for pain from chronic joint disorders

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We investigated if low level laser therapy (LLLT) of the joint capsule can reduce pain in chronic joint disorders. A literature search identified 88 randomised controlled trials, of which 20 trials included patients with chronic joint disorders. Six trials were excluded for not irradiating the joint capsule. Three trials used doses lower than a dose range nominated a priori for reducing inflammation in the joint capsule. These trials found no significant difference between active and placebo treatments. The remaining 11 trials including 565 patients were of acceptable methodological quality with an average PEDro score of 6.9 (range 5-9). In these trials, LLLT within the suggested dose range was administered to the knee, temporomandibular or zygapophyseal joints. The results showed a mean weighted difference in change of pain on VAS of 29.8 mm (95% CI, 18.9 to 40.7) in favour of the active LLLT groups. Global health status improved for more patients in the active LLLT groups (relative risk of 0.52; 95% CI 0.36 to 0.76). Low level laser therapy with the suggested dose range significantly reduces pain and improves health status in chronic joint disorders, but the heterogeneity in patient samples, treatment procedures and trial design calls for cautious interpretation of the results. **[Bjordal JM, Couppé C, Chow RT, Tunér J and Ljunggren AE (2003): A systematic review of low level laser therapy with location-specific doses for pain from joint disorders. *Australian Journal of Physiotherapy* 49: 107-116]**

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Introduction

Chronic joint disorders represent some of the most prevalent pain conditions treated in primary care (Carmona et al 2001, Mantyselka et al 2001). They constitute several entities, with the common factor that pain is located at the articular structures.

Osteoarthritis is probably the most common entity and the prevalence of osteoarthritis is rising parallel to the increasing age of the population (Felson et al 2000). Temporomandibular joint disorders, patellofemoral pain syndrome and mechanical spine disorders are other examples of chronic joint disorders. These conditions can be associated with impaired muscular stabilisation (Cowan et al 2001, Radebold et al 2001), reduced range of motion (McNamara et al 1996, Steultjens et al 2000) and inflammation of the joint capsule (Speldewinde et al 2001, Suenaga et al 2001, Vaatainen et al 1998).

A link has been established between synovial inflammatory activity and worsening of cartilage degeneration in osteoarthritis (Chikanza and Fernandes 2000). In this context, it is interesting to investigate if an anti-inflammatory action can be induced clinically by electrophysical agents.

Controlled laboratory trials have found that LLLT can reduce inflammation through reduction of PGE_2-levels and inhibition of cyclooxygenase-2 (COX-2) in cell cultures (Campaña et al 1993, Honmura et al 1993, Sakurai et al 2000, Shimizu et al 1995). The transformation of encouraging laboratory results into clinical effectiveness has been a difficult task (Basford 1995), and clinical effectiveness of LLLT has been questioned in systematic reviews on a broad range of conditions (de Bie et al 1998, Del Mar et al 2001, Gam et al 1993). A recent Cochrane systematic review on LLLT found a minor positive effect on rheumatoid arthritis, but the material on osteoarthritis was conflicting (Brosseau et al 2000). In the following review, our hypothesis is that laser irradiation of the joint capsule can reduce pain in chronic joint disorders if the dose is adjusted to inhibit inflammatory activity in the joint capsule.

Materials and methods A detailed review protocol was specified prior to conducting the review. This included a sequential four-step reviewing procedure involving predetermination of an optimal dose range, conduct of a sensitive literature search, application of a pre-specified inclusion/exclusion procedure, and testing of differences between trials with and without optimal dose.

The optimal dose range was derived from successful laboratory trials prior to the literature search. In the first step of the reviewing procedure, an optimal dose range was

Table 1. Suggested range of power densities and dose for the most common joints for infrared GaAlAs and Nd:YAG (continuous) lasers with wavelength 820, 830 and 1060 nm; infrared GaAs (pulse) lasers with wavelength 904 nm; and red HeNe (continuous) lasers with wavelength 632 nm.

Location	IR 820, 830, 1060 nm		IR 904 nm		HeNe 632 nm	
	Power density (mW/cm^2)	Dose (Joules)	Power density (mW/cm^2)	Dose (Joules)	Power density (mW/cm^2)	Dose (Joules)
Finger/toe/ temporomandibular 1 point/1 cm^2 Depth 2 mm	15 - 105	0.5 - 15	6 - 42	0.2 - 1.4	30 - 210	6 - 30
Knee 3 points/3 cm^2 Depth 4 mm	30 - 210	6 - 180	12 - 60	1.2 - 84	90 - 500	9 - 2700
Cervical spine 3 points/3 cm^2 Depth 12 mm	50 - 350	11 - 360	24 - 60	0.8 - 56	150 - 500	5 - 150
Lumbar spine 3 points/3 cm^2 Depth 30 mm	180 - 500	48 - 480	30 - 210	15 - 105	Not applicable as optimal power density is above safety regulations for laser	Not applicable

determined at the target location and then adjusted according to energy loss estimates for each anatomical location and the size of affected peripheral, facial and spinal joints.

Determination of possible anti-inflammatory LLLT dose at target location In *in vitro* trials, LLLT has been reported to suppress inflammation by a reduction of PGE_2 in ligament cell cultures (Sakurai et al 2000, Sattayut et al 1999, Shimizu et al 1995). Low level laser therapy has also been found to reduce PGE_2 levels in the joint capsule of animals in *in vivo* trials (Campaña et al 1993 and 1999, Honmura et al 1993, Sakurai et al 2000) . This effect was reported within a range between 0.4 and 19 J and a power density of 5-21.2 mW/cm^2. The lower range limits for PGE_2 reduction were identified because data showed no effect below this threshold. Upper range limits could not be identified, as there were no data available to show when or if this effect would level off. However, it has been shown that power densities above 20 mW/cm^2 temporarily inhibit fibroblast metabolism (van Breugel and Bar 1992), and numerous fibroblast cells are found in the joint capsule. We assumed doses of 0.4-19 J and power density of 5-21 mW/cm^2 would be capable of reducing inflammation at the target joint capsule without compromising fibroblast metabolism.

Location-specific dose adjustment for energy loss and anatomical size Data on beam diameter and laser output were collected from the manufacturers' manuals. Power density and dose were calculated according to the following formulas:

Power density for GaAs 904 nm pulse lasers (mW/cm^2) = (peak power pulse x pulse duration x pulses frequency) /spot size on skin.

Power density for lasers with continuous output (mW/cm^2) = mean power/spot size on skin.

Dose (J) = mean power x treatment time per session.

Measurement of light penetration and absorption in biological tissue is dependent on several variables. Two anatomical factors are essential to LLLT dose calculations: distance from skin to synovia and size (area) of the affected synovia. For knee (anteromedial and anterolateral part), finger, toe and temporomandibular joint, the distance from skin ranges from 1.5 to 5 mm (authors' unpublished data; 10 persons scanned by 7.5 MHz ultrasound imaging). The distance from skin surface to the zygapophyseal joints was 8 to 20 mm for the cervical spine and 25-35 mm for the lumbar spine. Another variable that affects penetration is the wavelength of the laser. Infrared laser light has been demonstrated to have a typical penetration depth (ie the distance which reduces the incident energy to 37%) of nearly 3 mm, while red laser light has a penetration depth of 1 mm (Kolari and Airaksinen 1988). Although energy loss is exponential near the laser source, optical measurements have demonstrated that energy loss is nearly linear at greater distances (Faris et al 1991). In an experimental porcine tongue model, a 200 mW GaAlAs laser had intensity reduced to 16 mW after the first 15 mm, which is within our suggested optimal dose range (Bradley et al 1998, Gursoy and Bradley 1994). From this depth, intensities fell at a slower almost linear rate to 1.4 mW at 35 mm. In vivo trials with 904 nm pulse lasers have

Table 2. List of excluded studies.

Author	Joint (s)	Result	Reason for exclusion
Gallachi 1981	Cervical and lumbar	No significant differences	Acupuncture and trigger point exposure only
Lewith 1981	Knee	LLLT significantly better than placebo	Trigger point exposure only
Walker 1983	Not stated	LLLT significantly better than placebo	Peripheral nerve exposure only, randomisation doubtful
Waylonis 1988	Low back	No significant differences	Trigger point exposure only
Snyder-Mackler 1989	Lumbar and cervical	LLLT significantly better than placebo	Trigger point exposure only
Rogvi-Hansen 1991	Knee	No significant differences	Did not irradiate joint, but peripheral nerves and top of patella only

demonstrated that these lasers achieve similar effects on collagen production with far lower doses on the animals' skin than lasers with continuous output (Enwemeka 1991, van der Veen and Lievens 2000). This effect can be attributed to the photobleaching phenomenon, where the first strong pulse bleaches the opaque barrier of tissue, letting the second pulse pass through the tissue barrier with less loss of energy (Kusnetzow et al 2001).

We postulate that energy loss due to the skin barrier for continuous HeNe (632nm) laser is 90%, for continuous GaAlAs (820nm) and NdYag IR lasers, 80% and for GaAs (904 nm) infrared pulse laser, 50%. Further energy loss is, according to the porcine penetration model, postulated to be linear at 5% per mm of tissue for infrared lasers. For red HeNe laser we postulate that further energy loss is 10% per mm of tissue.

The synovial area is rather small in finger, toe and temporomandibular joints, and we postulate that at least one single point is necessary to deliver an optimal dose of LLLT in these locations. We also postulate that a minimum of three points of the synovial membranes of the knee and the zygapaphyseal joints of the spine must be irradiated to provide a sufficient dose for these locations.

Estimations of dose and power densities required for the different anatomical locations are shown in Table 1.

Literature search A pre-specified literature search was performed from 1980 through to November 2001 on MEDLINE, Embase, CINAHL, PEDro and the Cochrane Controlled Trials Register (Central) for randomised controlled clinical trials.

Key words were: Low level laser therapy, low intensity laser therapy, low energy laser therapy, HeNe laser, IR laser, GaAlAs, GaAs, diode laser, osteoarthritis, chronic joint disorder, temporomandibular joint, hip, knee, thumb, spine. Hand searching was also performed on national physiotherapy and medical journals from Norway, Denmark, Sweden, The Netherlands, Germany, Switzerland, England, USA, Canada and Australia. Additional information on randomised controlled trials was gathered from researchers in the field. The literature search was concluded by the end of November 2001.

Methods

Inclusion criteria The trials were subjected to six inclusion criteria: joint disorder of more than six months duration or osteoarthritis verified by x-ray, random allocation of patients to groups, control group received identical placebo treatment, blind patients and outcome assessors, laser exposure of skin overlying inflammatory joint capsule, and outcome measure of pain and change in health status.

Assessment of methodological quality A criteria list of 10 methodological criteria developed for the PEDro database of physiotherapy trials at The University of Sydney, Australia, was used (Moseley et al 2002). Assessments of methodology were made by an assessor who was blinded to the trial results. No specific cut-off limit for method scores was pre-planned as a criterion for exclusion.

Outcome measures We selected pain on a visual analogue scale (VAS) as the first of two main outcome measures. In trials where several aspects of pain were measured, measures of pain during physical activity were preferred. Variance was calculated from post-treatment data and given as 95% confidence intervals (95% CI) in millimetres on VAS. Results were presented as weighted mean differences (WMD), ie a pooled estimate of the difference in mean change of the treatment and the placebo groups weighted by the inverse of the variance using a random effects model. Variance was calculated from the standard deviation (SD) of post-treatment data and given as 95% CIs. If variance data were reported as interquartiles, then the average SD from the other included trials was used for the statistical pooling.

The second main outcome measure was categorical data of change in global health status. Improved global health status was defined as any one of the following categories: "improved", "good", "better", "much improved", "pain-

Table 3. List of included trials with treatment specifications.

First author and year of publication	Location	Laser type, manufacturer	Laser continuous output (maximum pulse) and treatment time	Power density (mW/cm^2)	Dose (Joule)	No. of sessions/ sessions per week	Co-interventions
Basford 1987	*Thumb*	*632 nm (P) Dynatronics*	*0.4 mW 1 min*	*90*	*0.0135**	*9/3*	*Drugs registered*
Jensen 1987	*Knee*	*904nm (P) Space CEB*	*0.3 mW*(2W) (200 Hz) 6 min*	*0.3*	*0.05**	*5/5*	*Analgesics registered*
Klein 1990	*Lumbar spine*	*904 nm (P) Physio Technology*	*0.4mW* (2W) 4 min*	*0.4*	*0.1 **	*8/2*	*Exercises NSAIDs*
Stelian 1991	Knee	630 nm (P) 820 nm (P) Amcor	75 mW 25 mW 15 min	34 11	10.3 11.1	20/10	Analgesics
Nivbrant 1992	Knee	904 nm (P) ASA	4 mW(10 W) 5000 Hz, 3 min (C)	57	2.1	6/3	Analgesics registered, NSAIDs not allowed
Bulow 1994	Knee	830 nm (P) Unilaser	25 mW 15 min (C)	110	22.5	9/3	Drugs registered
Gray 1994	TMJ	904 nm (P) Space CEB	4 mW(27 W)* 3 min	57	0.7*	12/3	Not registered
Toya 1994	Lumbar Cervical Extremity	830 nm (P) OhLase3D1	60 mW 9 min	3000	48-60	1/1	Not allowed
Bertolucci 1995	TMJ	904 nm ASA	4 mW (10W) (700 Hz) 9 min	57	2.1	9/3	Not registered
Gøtte 1995	Knee	904 nm Felas	12 mW (25W) 13 min	4	12*	12/3	NSAIDs not allowed
Conti 1997	TMJ	830 nm (P) Omnilase	100mW 40 sec	38887	4	4/1	Not registered
Soriano 1998	Lumbar spine	904 nm (P) Brand missing	40 mW (20W)10 kHz	40	16*	10/5	NSAIDs and physiotherapy not allowed
Basford 1999	Lumbar spine	NdYag Laser Biotherapy	1626 mW, 6 min (C)	542	48.8	12/3	NSAIDs allowed
Özdemir 2001	Cervical spine	830 nm (P) Enraf Nonius	50 mW 3 min	390	10.8	10/7	Not registered

Trials with dose or power density outside suggested range in Italics. NSAID, non-steroidal anti-inflammatory drug; P, pointer; *, dose revised by reviewers; TMJ, temporomandibular joint.

free", "excellent". If sufficient data from the trial reports were provided, then the proportions of "improved" and "not improved" patients were pooled and expressed as a relative risk. A random effects model was used for statistical pooling.

Results

Included studies The literature search identified 88 randomised controlled trials of LLLT, of which 20 included chronic joint disorders. Six trials were excluded for not irradiating the skin directly overlying the joint capsule (Gallachi et al 1981, Lewith and Machin 1981, Rogvi Hansen et al 1991, Snyder-Mackler et al 1989, Walker 1983, Waylonis et al 1988) (Table 2).

A total of 14 trials with 695 patients (Basford et al 1987 and 1999, Bertolucci and Grey 1995, Bulow et al 1994, Conti 1997, Gray et al 1994, Götte et al 1995, Jensen et al 1987, Klein and Eek 1990, Nivbrant and Friberg 1992,

Table 4. Method scores (PEDro scale).

First author	Random-isation performed	Concealed allocation to groups	Baseline similarity	Patient blinded	Therapist blinded	Observer blinded	With-drawals/ dropouts < 15%	Intention-to-treat-analysis	Between-groups difference tested statistically	Mean and variability data	Total score
Basford 1987	*1*	*0*	*1*	*1*	*1*	*1*	*1*	*0*	*1*	*1*	*8**
Jensen 1987	*1*	*0*	*0*	*1 (0)*	*0*	*1 (0)*	*1*	*0*	*1*	*0*	*5(3*)*
Klein 1990	*1*	*0*	*1*	*1*	*1*	*1*	*0*	*0*	*1*	*1*	*7**
Stelian 1991	1	0	1	1	1	1	1	0	1	1	8
Nivbrant 1992	1	0	1	1	1	1	1	0	0	1	7
Bulow 1994	1	0	0	1	1	0	1	0	1	1	6
Gray 1994	1	0	0	0	1	1	0	0	1	1	5*
Toya 1994	1	1	1	1	1	1	1	0	1	1	9*
Bertolucci 1995	1	0	0	1	1	0	1	0	1	1	6
Gøtte 1995	1	0	1	1	0	1	1	0	1	1	7
Conti 1997	1	0	1	1	0	1	1	1	0	0	6
Soriano 1998	1	0	1	1	1	1	0	0	1	1	7*
Basford 1999	1	0	1	1	1	1	1	0	1	1	8*
Özdemir 2001	1	0	1	1	1	0	1	0	1	1	7

Trials shown in Italics gave treatment outside suggested dose range. * indicates that the same method scores have been given by PEDro reviewers. (*) indicates method score by PEDro reviewers where disagreement with our assessment existed.

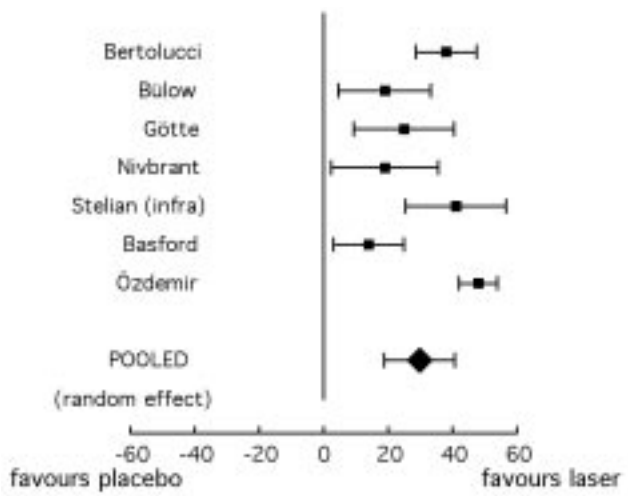

Figure 1. Effect of low level laser therapy on pain (mm on a 100 mm VAS).

Özdemir et al 2001, Soriano and Rios 1998, Stelian et al 1992, Toya et al 1994) satisfied our inclusion criteria. A list of included trials and their treatment characteristics is summarised in Table 3.

Dose assessment The results of the dose assessment revealed that three trials (Basford et al 1987, Jensen et al 1987 and Klein and Eek 1990) did not use doses inside our dose suggested range. These trials are indicated in Italics in Table 3. The remaining 11 trials, which included 565 patients, adhered to the suggested dose range.

Method scoring Method scores for trials that used the suggested dose range satisfied on average 6.9 out of 10 possible criteria on the PEDro scale, while the remaining three trials satisfied six out of all 10 criteria on the PEDro scale. Seven trials had previously been assessed by PEDro reviewers. For one trial, our assessment differed from the PEDro database scores (Jensen et al 1987). Missing concealed allocation to groups and intention to treat analysis were the most frequent shortcomings in the included trials. The results of the method scoring is summarised in Table 4.

Pain reduction on VAS Nine trials provided data of pain on VAS (Table 5). Two trials used a dose outside our suggested dose range and both reported a non-significant difference in pain reduction (Conti 1997, Klein and Eek 1990). Of the remaining eight trials with LLLT dose inside our suggested dose range, one trial reported variance data as interquartiles (Bulow et al 1994). These variance data were substituted by the average SD of the other six trials in the statistical pooling. By using a random effects model, WMD in change of pain on a 100 mm VAS was calculated to 29.8 mm (95% CI 18.9 to 40.7) in favour of active laser (Figure 1).

Table 5. List of included trials with data on treatment outcome.

First author	No. of patients	Condition	Mean pain (mm) before treatment	Mean pain (mm) after treatment	Mean change in pain (mm)	Proportions of patients improved	Author's test of significance
Basford 1987	*81*	*Active* *Placebo*	*53* *48*	*(missing data)* *(missing data)*		*22/47* *16/34*	*N.S.*
Jensen 1987	*29*		*No separate pain score (medication included)*				*N.S.*
Klein 1990	*20*	*Active* *Placebo*	*40* *44*	*23* *28*	*17* *16*		*N.S.*
Stelian 1991	50	Active(Red) Active(Infra) Placebo	65 72 62	33 32 63	32 40 -1		$p < 0.0001$ (Before/ after)
Nivbrant 1992	30	Active Placebo	67 58	44 54	23 4		$p < 0.01$ (Before/ after)
Bulow 1994	29	Active Placebo	82 71	61 69	21 2	7/14 9/15	N.S.
Gray 1994	55	Active Placebo				20/29 14/26	$p < 0.001$
Toya 1994	115	Active Placebo				43/59 16/56	$p < 0.0001$
Bertolucci 1995	32	Active Placebo				40 2	$p < 0.01$
Gøtte 1995	40	Active * Placebo*	69 70	42 68	27 2	13/20 2/20	"Significant" (no *p*-value)
Conti 1997	20	Active Placebo	58 49	27 38	31 11		N.S.
Soriano 1998	71	Active Placebo	79 81	(missing data) (missing data)		27/38 12/33	$p < 0.007$
Basford 1999	63	Active Placebo	35 37	17 33	18 4		$p < 0.001$
Özdemir 2001	60	Active Placebo	77 73	24 68	53 5		$p < 0.001$

Randomised placebo-controlled trials where LLLT has been used for CJD. Outcome data are extracted from trial reports. Trials shown in Italics gave treatment outside suggested dose range. *Visual estimates of data from graphs in trial report. Blank boxes indicate missing data in trial report. N.S. = not statistically significant.

Health status Six trials measured change in health status, and provided data that made it possible to calculate the number of patients that improved their health status in active LLLT groups and placebo laser groups (Table 5). In one trial that used a lower dose than our suggested dose range, no significant difference was registered between groups (44% versus 47% with improved status; Basford et al 1987). The remaining six trials used doses within our suggested dose range. In one of them (Basford et al 1999), the data showed a significant effect in favour of active laser but the presentation of the data did not allow for identification of the number of patients who experienced improvement. Five trials reported improved health status for a total of 110 patients in the active LLLT groups versus 53 in the placebo groups. Health status remained unchanged for 50 patients in the active LLLT-groups and 97 patients in the placebo groups. The pooled estimate of the change of health status was significantly in favour of active LLLT with a relative risk of 0.52 (95% CI 0.36 to 0.76) when calculated by a random effects model. The results for health status are summarised in Figure 2.

Duration of pain relief Six trials with assumed optimal treatment employed follow-up measurement of at least three weeks. Four of these trials reported pain relief under blinded conditions (Basford et al 1999, Götte et al 1995, Gray et al 1994, Nivbrant and Friberg 1992). Two trials with intensive, daily treatment regimens (Soriano and Rios 1998, Stelian et al 1992) reported pain reduction from LLLT for four to six months, but evaluation in the follow-up period was unblinded.

Side effects and adverse reactions In terms of side effects, six of the LLLT trials with optimal dose (Basford et al

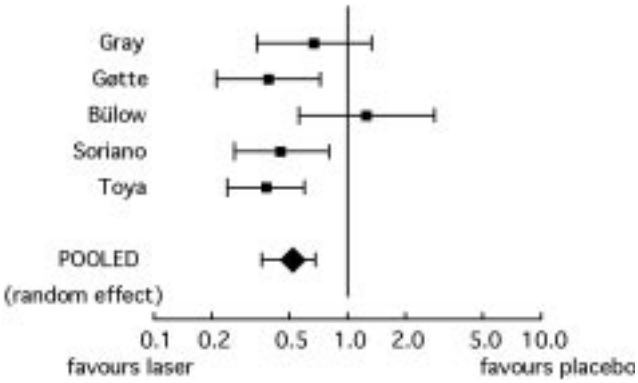

Figure 2. Effect of low level laser therapy on health status (Relative risk of not improving)

1999, Bulow et al 1994, Götte et al 1995, Nivbrant and Friberg 1992, Soriano and Rios 1998, Stelian et al 1992) explicitly stated in their report that no adverse effects were observed. One trial reported an incident of transient adverse effects for one patient in each group (Basford et al 1987).

Discussion

The results of this review were surprisingly unequivocal in favour of active LLLT when dosage was titrated above the suggested lower dose limit for reduction of inflammation. In our opinion, many trial authors and reviewers have investigated clinical effects without having a hypothesis of which biological action they expect from LLLT. They have often disregarded the fact that LLLT dose is affected by physical and anatomical penetration characteristics. Although we have tried to cater for these factors, it must be remembered that our estimate range of laser penetration (Table 1) is hypothetical. We currently lack hard data on what biological effects laser causes at certain depths and tissues in the human body.

Perhaps the weakest point of this review is the heterogeneity in treatment procedures and within the patient sample. The latter is reflected by mean baseline pain scores that ranged from 35 mm to 82 mm on VAS (Table 5). In two trials it was explicitly stated that patients were excluded if they experienced an acute episode of exacerbation (Basford et al 1999, Klein and Eek 1990). For the other trials, baseline pain was above 48 mm on the VAS.

Another issue that can partly explain heterogeneity in results is that only some trials prohibited co-intervention by anti-inflammatory drugs. The overall effect in trials that explicitly allowed anti-inflammatory drugs was poorer than those which did not allow for this co-intervention. This adds support for our hypothesis that pain reduction from LLLT is achieved through an anti-inflammatory action.

The differences in numbers and frequencies of the treatment sessions may also increase heterogeneity in results. However, the majority of trials involved treatment for two to four weeks, and only one trial (Toya et al 1994) treated once and measured the immediate effect of LLLT. We were in doubt whether this trial should be removed from the calculations of improved health status.

The structures which contribute to neck pain or low back pain are disputed, but both muscular and articular structures seem to be involved. The majority of patients with chronic spinal pain in our review had an x-ray confirmed diagnosis of osteoarthritis (Basford et al 1999, Ozdemir et al 2001, Soriano and Rios 1998). The presence of inflammation, however variable in activity, is a cardinal sign in osteoarthritis (Pelletier and Martel-Pelletier 2002). For this reason, we decided to include these trials as chronic joint disorders trials.

We think that the inclusion of pain from the temporomandibular joint is fairly uncontroversial. It is a common condition and, like other chronic joint disorders, is characterised by pain, synovial inflammation and decreased range of motion (Rauhala et al 2000).

Assessing scientific evidence from clinical trials is always a complex matter. We do agree that the methodological quality of trials is important, and have assessed the trials according to a widely accepted standard (the PEDro scale). Fortunately, the included trials were all of acceptable methodological quality, which made it unnecessary to exclude any of them from our conclusion. Six of the trials have been assessed by PEDro reviewers and confirm our method scores. For one trial we found that partial blinding was performed, which contradicts the PEDro review. In addition, two other trials (Bertolucci and Grey 1995, Stelian et al 1992) have previously been assessed by other reviewers who found that they fulfilled more than half of the quality criteria on the Jadad and Maastricht lists, respectively. There is, however, genuine disagreement between our method score and the score of a Swedish trial (Nivbrant et al 1992) in another review (de Bie et al 1998). This may be attributed to linguistic difficulties, or the fact that two reports have been published from this trial.

There is some evidence that LLLT may inhibit fibroblast activity (Loevschall and Arenholt-Bindslev 1994) when dose exceeds 4 J. As the joint capsule is populated by fibroblasts, future research is needed to clarify the matter of optimal balance between biological effects such as COX-2 inhibition and fibroblast activity.

Laser dosage is a complex topic, and missing parameters can give a misleading picture if they are not fully reported. We have retrieved the missing laser parameters by getting specifications from the manufacturers of all the lasers used in the included trials and we have recalculated all power densities, dose per treatment sessions and weekly doses. However, it is a weakness that testing and calibration of laser output was only performed in two of the clinical trials (Basford et al 1999, Bulow et al 1994).

In five of six LLLT trials with follow-up, pain reduction remained significant for three weeks, and unblinded follow-up suggested significant pain reduction for up to six months (Stelian et al 1992).

The literature on LLLT is full of conflicting reports, and we believe that much of this is caused by the lack of dosage consensus. One large, well-designed trial found no effect from LLLT on ankle sprains (de Bie et al 1998). In our opinion, the poor results may have been caused by insufficient irradiation, because only a single 1 cm^2 point of the swollen joint capsule was treated by LLLT. In a recent review on LLLT effectiveness (Brosseau et al 2000), results for osteoarthritis were conflicting. This review lacked procedural assessment of the laser exposure technique, and dose analysis was not used to adjust for differences in energy loss for each anatomical location. In addition, our literature search is more recent and extensive and includes two more trials on osteoarthritis of the knee (Götte et al 1995, Nivbrant and Friberg 1992), in addition to trials with spinal and temporomandibular joint disorders.

Conclusion

Although the heterogeneity of the trial results calls for caution in interpretation, LLLT seemed to be effective in reducing pain from chronic joint disorders. The hypothesis that LLLT acts through a dose-specific anti-inflammatory effect in the irradiated joint capsule is a potential explanation of the positive results. This hypothesis needs to be verified or refuted in studies where outcome measures of inflammatory activity are used. More and larger trials are needed to precisely determine optimal treatment procedures for LLLT and possible interaction with other therapies for chronic joint disorders.

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