Low Level Laser Therapy (LLLT): A 2008 Review

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Introduction

Physiotherapists are presented with a wide range of treatment techniques and modalities to care for their patients. Low Intensity Laser Therapy (LILT) or Low Level Laser Therapy (LLLT) emits a non-thermal emission which is thought to produce a photochemical reaction in the cells. LLLT has been used in the treatment of a variety of acute and chronic musculoskeletal injuries, degenerative conditions and wound healing. The purpose of this paper is to examine and present the literature regarding the effective use of LLLT as an adjunct to physiotherapy care. The paper aims to establish if there are appropriate application and dosage guidelines to optimize patient outcomes for common pathological conditions. Overall the goal of the paper is to have a basic understanding of LLLT and when it is an effective adjunct therapy.

Low Level Laser Therapy- what is it?

Laser light is produced when an electron of an active medium undergoes a stimulated quantum jump from a higher to a lower energy state, causing an emission of photons. The emitted photons collide with other excited electrons, causing increased

photon emission. This chain reaction of events is the mixture of two inert gases and is referred to as the active medium [1]. Laser light is different from other light forms because it is monochromatic, coherent and directional. Monochromatic (light is all of the same frequency), coherent (wavelengths in the same phase) and directional (light has very little divergence of the beam). These properties allow for a laser beam to focus on a very precise small target and the monochromatic light allows absorption to be targeted to a specific wavelength by photosensitive molecules called chromophores [2].

Classes of lasers range from 1 to 5. High intensity laser, known as Class 4 and 5 lasers, heat and destroy tissue. They are used medically for incisions and cautery during surgical procedures. Low intensity lasers known as Class 1 to 3B have less than 500mW power, 50mW/cm2 power density and 40 J/cm^2 energy density and are referred to as low level lasers and are used as adjunct therapy in rehabilitation.

The passage of light into skin is necessary to achieve the physiological effects. Short-wavelength (400-700nm) lasers have visible red light such as Helium-Neon Laser (HeNe) and are highly pigment specific. Longer-wavelength (600-1200nm), invisible infrared lights such as Galium-Arsenide (Ga-As) lasers are much less pigment-specific and penetrate deeper than the HeNe Lasers. There is consensus that the visible light (He-Ne) penetrates 1-2 mm and invisible light (Ga-As) penetrates 2-4 mm in soft tissue [2-4]. For example, the potential of low intensity infrared laser irradiation applied to the skin over the course of peripheral nerve to significantly affect conduction latencies in that nerve has been demonstrated [5]. Some manufacturers claim their devices penetrate to depths of 10-13 cm (Super Pulsed Infrared Laser Radiation), however we could find no peer reviewed publications for confirmation.

Two types of probes are used, the most familiar type being the handheld, pencil-like, monodiode probe. The other type of probe, known as cluster probe (mulitdiode), allows for a larger beam area and therefore a larger treatment area. LLLT is usually applied in contact with the skin and can include manual gridding, manual scanning or single point application. Gridding consists of mapping the entire treatment surface with $1cm^2$ surfaces. Scanning involves repeated scanning-like movements of the laser probe over the entire treatment surface. Single point (sometimes referred to as laser acupuncture) occurs over one particular spot on the patient.

Laser light parameters include power (mW), power density (mW/cm^2), energy density (J/cm^2), wavelength (nm), duty cycle (pulsed or continuous), duration (time) and percent of total power [1;2;4]. The use of "photobiomodulated" therapy or LLLT began back in 1960s by Andreas Mester. They reported a therapeutic response rate of approximately 90% after treating more than a 1000 patients with various chronic and recalcitrant wounds and ulcers using LLLT at doses less than 4 J/cm^2 [1].

Search Strategy

A literature review was conducted using PubMed/Medline and Cochrane Review databases, the following search terms were utilized:

- Low Level Laser Therapy or LLLT or LILT or Low Intensity Laser Therapy or Laser Therapy
- Laser AND Therapy
- Low AND Level AND Laser AND Therapy

- Therapeutic Agent/ Electrical Modality textbooks were consulted and reference material was investigated

In addition, the following strategies were employed to add to the grey literature/information using Google Search

- Laser Therapy Manufactures OR Laser Therapy Equipment
- Laser Therapy Winnipeg or Laser Winnipeg
- Interview with a Physiotherapist using LLLT in Winnipeg

Therapeutic and Physiological Effects

The two main therapeutic effects for LLLT found in the literature propose increased tissue healing and reduction/control of pain. The mechanisms to achieve the therapeutic effects are still not clearly understood but many have attempted to confirm the effects with in-vitro and in-vivo studies.

Laboratory in-vitro studies suggest short-term activation of the electron transport chain, ATP synthesis, and reduction in cellular pH with the application of LLLT. It is proposed that LLLT initiates reactions at the cell membrane level via photophysical effects on calcium channels. These changes in cell membrane permeability are believed to cause increases in macrophage, fibroblast, and lymphocyte activity observed in LLLT [6;7] which provide the main indications for use of LLLT as a therapeutic agent. Cellular effects of LLLT were investigated by irradiating human red blood cells to determine if any structural changes occur to the protein and lipid components of red blood cell membranes and its functional properties. The study demonstrated changes in the activity of the membrane ion pumps with transitions of red blood cell membrane proteins and

lipid bi-layers which resulted in the modulation of membrane functional properties, which lead to changes in membrane ion flows [8]. Another study exposed macrophage like cell cultures to various wavelengths of light. At 660 nm, 820 nm, 870 nm wavelengths the macrophages released factors over a 5-day period to stimulate or inhibit fibroblast proliferation [6]. Similarly, the effects of delivering various wavelengths (630-905 nm) at different energy densities have been examined on the growth/inhibition of bacteria in-vitro [9;10]. Some wavelengths and intensities inhibited bacteria growth and some increased it depending on the type of bacteria present, showing the need for wound cultures prior to treatment with LLLT. Since most cellular mechanism studies with LLLT are done in-vitro, it is unknown if the cellular effects occur in live human models.

The mechanism of pain reduction by laser therapy is not well understood. There is debate on whether the main effect is anti-inflammatory, collagen proliferation, circulation enhancement, analgesic and/or an inhibition of nociceptive signals at peripheral nerves. Anti-inflammatory effects have been demonstrated both in-vitro and in-vivo [11-16].

Contraindications and Adverse Effects

LLLT is a safe and non-thermal modality. There are no published reports of serious adverse effects, however, a few patients do report feelings of tingling, mild erythema, burning sensation, numbness or skin rash in [4]. Irradiation to the eyes is the main contraindication to LLLT, thus, both the therapist and patient must wear protective goggles to block the emission. Other contraindications include avoiding LLLT four to six months after radiotherapy, hemorrhaging regions and endocrine glands. Caution is

advised when applying LLLT to patients with epilepsy, fever, malignancy, abdomen area during pregnancy, epiphyseal plates of children and infected tissue [4].

Clinical Usage in Common Pathological Conditions

Osteoarthritis and Rheumatoid Arthritis

A review on osteoarthritis (OA) and rheumatoid arthritis (RA) was conducted comparing 13 randomized control trials. The results conclude that LLLT may be used for short term relief of pain and morning stiffness in RA but is no better than placebo at reducing pain, morning stiffness, or improving functional status for patients with OA. The authors reported that the method of application was not well documented in many studies making it difficult to compare and determine the effectiveness of LLLT on OA [17].

Others have reported similar results for treatment of OA with LLLT [18;19], however some studies have shown positive results in relieving pain and disability in degenerative OA of the knee [20], reducing periarticular swelling when compared to placebo [21] and improved function and quality of life in people with painful OA of the knee [22].

Plantar Fasciitis

Clinically, there appears to be positive results in treating plantar fasciitis with a combination of cluster and hand-held laser probes as an adjunct in physiotherapy treatment (personal communication, Aikenhead 2008). Consistent with clinical testimony, the laser therapy manufacturers claim LLLT is very effective in treating plantar fasciitis, however there were few studies investigating LLLT on treating plantar

fasciitis found in the literature. A randomized control trial study did not provide positive results to indicate the use of LLLT for plantar fasciitis [23]. Although the differences between groups were not significant there appears to be a bias in that the treatment group had more severe symptoms and spent more time spent on their feet compared to the sham laser group. Also, LLLT was applied as the main treatment and not as an adjunct which may explain the lack of difference between the groups. Clearly more work needs to be done in this area to increase confidence in the effective use of LLLT for plantar fasciitis.

Low Back Pain

Positive results in the treatment of low back pain with LLLT include decreased pain and improved function. Two RCTs showed improvements in pain and function, but effects were minimal and lessened over time. Both these studies were completed over a 4-week period with no follow-up period to examine long-term effectiveness of LLLT [24;25].

Ankle Sprains

LLLT reduced edema post ankle sprain [26], which is consistent with other studies that report a decrease in swelling [27-29]. One other study used LLLT in the treatment of ankle sprains and while the results showed no positive findings, their outcome measures were focused on pain and function, and not swelling [30].

Tendinopathies

Results with LLLT in the treatment of tendinopathies are inconsistent. In some studies it has been used with success [31;32] while others have found no overall effects in the experimental groups [33-35]. In a review of 18 studies utilizing randomised placebo-controlled trials with laser therapy for tendinopathy, it was concluded that laser therapy can reduce pain in sub acute and chronic tendinopathy if a valid treatment procedure and location-specific dose is used [36].

Myofascial Pain

Similarly, studies show conflicting results on outcomes obtained using LLLT for the treatment of myofascial pain. One study demonstrated positive benefits with respect to pain relief and improvement in function [37], whereas others have concluded there was no therapeutic effect with the use of LLLT on myofascial pain [38;39]. Further, LLLT has been shown to be ineffective in reducing delayed onset muscle soreness [40-42].

Wound and Ulcer Healing

Laser therapy manufacturers claim to have huge success with LLLT on wound healing. One study showed decreased reoccurrence of herpes simplex infection with the use of laser therapy [43], however, the bulk of the literature indicates little evidence that LLLT has a significant effect on wound and ulcer healing [44-49].

Summary

LLLT has been in use and studied since the 1960s. To date, the research is still debating the effectiveness of LLLT to treat various pathological conditions. In terms of the

physiological effects of LLLT the in-vitro studies have not been replicated on human models. A few concerns arise when examining the literature on LLLT. Many studies do not publish all their treatment parameters, which makes it difficult for the findings to be translated into clinical practice. The site of application, application method and technique, and the dosage are poorly documented. Thus, few studies meet the systemic review inclusion criteria; this limits attempts to complete meta-analyses on LLLT effectiveness. To date, very few studies have investigated the optimal wavelength, power, frequency and treatment time to obtain a therapeutic effect. Another concern is that many studies compare a laser therapy group to a sham/placebo laser group. Ideally, the study design should incorporate the use of laser as a modality or adjunct as it is intended for use in rehabilitation. Having said this, there is some evidence to suggest that LLLT decreases swelling, reduces pain and improves function. Overall the literature and research on low level laser therapy are insufficient to make conclusions on the effectiveness of laser therapy. Currently the practice of using LLLT is ahead of the evidence to support the use of the technology. This is common for most modalities used in physiotherapy and eventually the research catches up to clinical usage. Some studies may convince the therapist to use LLLT for conditions involving inflammation and for providing pain relief. The missing gaps in the literature will hopefully be filled in the near future to provide further confidence that laser therapy is an effective adjunct treatment modality in the management and healing of neuromusculoskeletal conditions.

Appendix 1

Low Level Laser Therapy in Practice

Costs

1) The Unit

Low Level Laser Therapy System Options:

- Professional System: $25,000-$30,000
- Therapeutic System: $12,000
- Laser Probe (referred to as Home Systems);$3,500-$7,000

Certified Training: $495 weekend training throughout Canada

Life span of units: 5000-20000 hours predetermined by manufacturer

Calibration and Maintenance: Annual maintenance and calibration. Many manufacturers provide a one or two-year warranty.

2) Additional Treatment Time: Treatment times are poorly documented but range anywhere from 2 minutes to 45 minutes. The use of hand-held probe lasers also requires a laser technician to apply the laser for the entire treatment time. The treatment time cost must include the additional therapist/technician time and the additional treatment time for the patient.

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