
Note

There is currently little doubt that the light emitted by LEDs (non-coherent, monochromatic light; spontaneous emission) is effective in generating a biomodulatory response within living tissue, and therefore has a therapeutic role if used correctly. Tiina Karu (1998: The Science of Low-Power Laser Therapy) states that "...the coherence of light is of no importance in low-power laser clinical effects" and "[t]he primary difference between lasers and LEDs is that the laser's coherent beam produces 'speckles' of relatively high power density which can cause local heating of inhomogeneous tissues".

However, to date, the majority of published research has been conducted using LASERs (coherent, monochromatic light, stimulated emission). Due to the differing properties of LED and LASER generated light, and the relative lack of LED-specific research, it is misleading to suggest that meaningful information about practical LED therapy can be simply derived from LASER therapy research. Until more research is carried out and the mechanisms of photobiomodulation are better understood, this will remain the case.

The following discussion of Low-Level Laser Therapy is based primarily on research conducted with true lasers and, therefore, cannot be directly applied to LED therapy.

Introduction

Laser Therapy is a form of phototherapy which involves the application of monochromatic light over biological tissue to elicit a biomodulative effect within that tissue.

Low-level Laser Therapy (LLLT) - the most widely-used name given to this form of photobiomodulation - can have both a photobiostimulative effect and a photobioinhibitive effect within the irradiated tissue - each of which can be used in a number of therapeutic applications.

LLLT is gaining increasing acceptance in conventional medical, physiotherapy, acupuncture, dental, and veterinary practice - and refers to the "reaction between laser and the irradiated biological tissue" (Baxter, 1994).

LLLT is a complementary form of treatment and, therefore, is not intended to replace other electrotherapeutic modalities, such as ultrasound, interferential therapy, and magnetic therapy. In a number of therapeutic applications, however, LLLT has been rated more highly in its effectiveness than these other modalities (Baxter et al, 1991).

The following information has been compiled in order to raise practitioners' awareness of LLLT, its uses and potential benefits, and to enable the accurate assessment of laser therapy equipment which may be currently available or in use. Spectra-Medics trusts that this information will assist you to make informed decisions when purchasing and using any LLLT system, and to do so economically.

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Low-Level Laser Therapy

Laser Therapy works on the principle of inducing a biological response through energy transfer, in that the photonic energy delivered into the tissue by the laser modulates the biological processes within that tissue, and those within the biological system of which that tissue is a part. The Arndt-Schultz Law of Biomodulation infers that low dosages of photonic energy will stimulate those biological processes, and higher dosages will inhibit them.

The wavelength at which the laser emits determines the effective depth of penetration, within the tissue, of the laser energy delivered. Far-red to infra-red wavelengths (longer than 800nm) will penetrate deeper, and so are indicated for deeper acupuncture points and trigger points, and deeper tissue injuries. Visible red wavelengths (shorter than 800nm) do not penetrate as far, and are therefore more applicable to superficial tissue and treatment points. Photons emitted at shorter wavelengths do, however, have greater energy/mass which is measured in electron-volts (eV).

In clinical applications the effects of Visible Red laser are of use in, but not limited to, the treatment of open and post-operative wounds, decubitus & venous ulcers, acne, and other dermatological conditions. Visible Red laser has also been effective in the tonification and sedation of superficial acupuncture points.

The therapeutic effects of Visible Red laser are, however, also elicited by Infra-Red wavelengths. For example, research conducted by Sugrue et al (1990) indicated that Infra-Red lasers cause significant decreases in the size of venous ulcers, and corresponding decreases in pain. Infra-red wavelengths have the added benefit of deeper penetration into the tissue, which enhances the healing effect by stimulating micro-circulation and lymphatic drainage.

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Clinical Uses of LLLT

There are a number of potential clinical uses for LLLT, such as those in medical, dental, podiatric, chiropractic, osteopathic, and cosmetic applications. Some of the most popular applications of LLLT currently, however, are in physiotherapy, veterinary, and acupuncture practice.

The portability and diversity of battery and mains-powered diode laser systems allows treatment to be carried out in various clinical, hospital, and field locations. This opens up possibilities for the immediate (and thereby more effective) and on-going treatment of sporting and athletic injuries, such as muscle tears, haematomas and tendinopathies (Baxter, 1994).

It is an attractive modality for the treatment of athletes, especially those involved in professional sports, due to the prospect of shorter recovery and lay-off times. Treatment of chronic and acute musculoskeletal disorders is the most common clinical application of LLLT, due to the effectiveness of laser in treating these types of conditions, and the short treatment times required.

Due to its pain-relieving and wound-healing properties, LLLT has many uses in hospitals and aged-care homes, such as for the treatment of pressure sores in bed-ridden patients, and for enhanced post-operative wound healing and pain relief. The effect of LLLT is such that it can accelerate remodelling of scar tissue, and "give a more cosmetically-acceptable result" (Baxter, 1994) to post-operative scarring.

Trelles et al (1987) reviewed the use of local irradiation with Low-Level Laser in therapy. The stimulus was applied mainly to local lesions to elicit the following types of effect:

- biostimulatory effects in ulcers, granulomas, burns, septic wounds and trauma to superficial tissues;
- stimulation of local cell metabolism in damaged tissues in vivo and in vitro;
- stimulated activity of local tissue enzymes;
- enhanced scar formation and tissue regeneration, mitogenic activity, and osteogenic activity.

Trelles et al (1987) and Muxeneder (1987) also reviewed the effects of LLLT in vertebral pain, headaches and local immune responses. Other recorded therapeutic effects of LLLT (Illarionov et al, 1993) are:

- analgesic, antiexudative, antihaemorrhagic;
- anti-inflammatory;
- antineuralgic, antioedematous, antiseptic;
- antispasmodic;
- vasodilatory.

According to Laakso et al (1994), the "...analgesic response to phototherapy may be mediated through hormonal/opoid mechanisms...and...responses to LLLT are dose and wavelength dependent."

Research being carried out around the world is constantly adding to the ever-expanding body of knowledge and understanding of the mechanisms and effects of LLLT.

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Calculating Laser and Treatment Parameters

Laser diodes are generally operated at or below the laser diode manufacturer's recommended maximum optical output power rating of, say, 100mW, to ensure maximum stability and long diode life. It is this rating which is usually used to state the output power of a laser therapy unit. It is necessary, for accurate dosage control, to know the actual optical output power emitted from the laser probe at the aperture. Check with the manufacturer or use an output power meter suitable for the wavelength of the laser in question.

Laser Therapy devices are generally specified in terms of the average output power (milliwatts) of the laser diode, and the wavelength (nanometres) of light they emit. This is necessary information, but not enough with which to accurately define the parameters of the laser system. To do this, one must also know the area of the laser beam (cm2) at the treatment surface (usually the tip of the handpiece when in contact with the skin).

If the output power (mW) and beam area (cm2) are known, it is a reasonably straight-forward exercise to calculate the remaining parameters which allow the precise dosage measurement and delivery.

The output power of a laser, measured in milliwatts, refers to the number of photons emitted at the particular wavelength of the laser diode.

Power Density measures the potential thermal effect of those photons at the treatment area. It is a function of Laser Output Power and Beam area, and is calculated as:

1) $$\text{Power Density (W/cm}^2\text{)} = \frac{\text{Laser Output Power (W)}}{\text{Beam area (cm}^2\text{)}}$$

Beam area can be calculated by either:

2) $$\text{Beam Area (cm}^2\text{)} = \text{Diameter(cm)}^2 \times 0.7854$$

or: $$\text{Beam Area (cm}^2\text{)} = \text{Pi} \times \text{Radius(cm)}^2$$

The total photonic energy delivered into the tissue by a laser diode operating at a particular output power over a certain period is measured in Joules, and is calculated as follows:

3) $$\text{Energy (Joules)} = \text{Laser Output Power (Watts)} \times \text{Time (Secs)}$$

It is important to know the distribution of the total energy over the treatment area, in order to accurately measure dosage. This distribution is measured as Energy Density (Joules/cm^2). "For a given wavelength of light, energy density is the most important factor in determining the tissue reaction" (Baxter, 1994). Energy Density is a function of Power Density and Time in seconds, and is calculated as:

4) $$\text{Energy Density (Joule/cm}^2\text{)} = \frac{\text{Laser Output Power (Watts)} \times \text{Time (Secs)}}{\text{Beam Area (cm}^2\text{)}}$$

OR: $$\text{Energy Density (Joule/cm2)} = \text{Power Density (W/cm}^2\text{)} \times \text{Time (Secs)}$$

To calculate the treatment time for a particular dosage, you will need to know either the Energy Density (J/cm^2) or Energy (J), as well as the Output Power (mW), and Beam Area (cm^2). First, calculate the Output Power Density (mW/cm^2) as per Equation 1, then:

5) $$\text{Treatment Time (Seconds)} = \frac{\text{Energy Density (Joules/cm}^2\text{)}}{\text{Output Power Density (W/cm}^2\text{)}}$$

or: $$\text{Treatment Time (Seconds)} = \frac{\text{Energy (Joules)}}{\text{Laser Output Power (Watts)}}$$

Finally:

$$\text{Laser Output Power (Watts)} = \frac{\text{Laser Output Power (mW)}}{1000}$$

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Laser Parameters for Effective Treatment

"For a given wavelength of light, energy density is the most important factor in determining the tissue reaction" (Baxter, 1994). Research indicates that Energy Densities in the range 0.5 to 4 Joules/cm2 are most effective in triggering a photobiological response in tissue (e.g. Mester & Jaszagi-Nagy, 1973; Mester & Mester, 1989; Mashiko et al, 1983; Haina, 1982), with 4 Joules/cm2 having the greatest effect on wound healing (Mester et al, 1973; Mester et al, 1989).

Australian research suggests that this 'therapeutic window' of biostimulation may be extended to include 5 Joules/cm2 (Laakso et al, 1994), and has applications in other areas of practice, such as Myofascial Trigger Point therapy and pain control. Dosages of 8 - 12 J/cm2 and higher, and the resulting bioinhibition, may also have therapeutic applications, such as in the treatment of keloid scarring and pain control.

Many practitioners have found straight Joules dosages - up to 20 J/point in some cases - to be effective in the treatment of a number of common musculoskeletal disorders. This is possibly due to the combined action of the pain attenuating properties of laser bioinhibition at high dosages, and the biostimulatory effect of the lower-powered 'halo' around the target treatment point. However, the same effect may not be elicited from a different laser unit, due to differences in laser parameters (esp. Power Density) and configuration, and the imprecise nature of Joules dosimetry. It is the Output Power Density which determines the time required to deliver a particular Energy Density (Joules/cm2) dosage, and the Output Power which determines the corresponding Energy (Joules) delivered during that time.

Results obtained from particular dosages and treatments are likely to vary between individual practitioners and patients, therefore, practitioner discretion is recommended in determining the applicable wavelength and dosage parameters for each patient. It is important to note that the appropriate configuration of a laser unit will depend primarily upon the types of conditions most commonly treated, and so specific requirements will generally differ between practitioners.

Table 1. illustrates the difference in Joules and Joules/cm2 dosages for differing output parameters. The calculation of these parameters is explained above.

Output Power (mW)	Beam Spot Size (cm2)	Treatment Time (Secs)	Energy (Joules)	Energy Density (Joules/cm2)
5	0.1	8.0	0.04	0.4
50	0.1	8.0	0.4	4.0
125	0.2	8.0	1.0	5.0
250	0.2	8.0	2.0	10.0
500	0.2	8.0	4.0	20.0

Table 1. Various Laser Parameters v Dosage/Time

Please note that treatment times for Joules/cm2 dosages are the same for a laser unit with any output power, eg: a 100mW diode or a 50mW diode, if the output is collimated to achieve the same Power Density.

Baxter (1994) recommends a number of treatment parameters for common musculoskeletal disorders in terms of both Joules and Joules/cm2 dosages, such as 1 - 2 Joules (8 - 16 J/cm2) for ligament strains (pp205-207). It can be seen that knowing and understanding the relationship between the Joules dosage and its corresponding Joules/cm2 dosage (per your lasers specific configuration), and the resultant biomodulative effect, allows more accurate specification and delivery of a particular treatment dosage. It also makes a successful treatment easier to replicate, and to share results with other practitioners and researchers.

Of course, individual results may vary between patients, so practitioner discretion is advised at all times.

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The Need for Accurate Specification of Laser Parameters

The general lack of understanding of laser dosimetry has, in part, led to the current reliance on dosages only being measured in straight Joules (Output [Watts] x Time [Seconds]). 'Joules' on its own is essentially a meaningless dosimetric unit in the delivery and recording of LLLT treatment parameters, as it does not take into account the treatment area across which laser beam is dispersed, and leads to recorded treatment results which are ambiguous and difficult to replicate (Stuck, 1993; Baxter, 1994).

Imprecise or inadequate recording of laser and dosage paramenters can lead to over-stimulation of the treatment point, which potentially generates negative or undesired results through the inhibition of desired photobiological responses, or understimulation with little or no therapeutic effect. At higher Power Densities there is also potential for the laser to generate a thermal effect in the tissue. This is undesirable for Low-Level Laser Therapy, and potentially unsafe.

One can also see that laser units which allow the user to increase or decrease the output power of the treatment probe (for example, a 100mW probe may be switched between 25, 50, 75, & 100mW settings; or a 40mW probe between 10, 20, 30 & 40mW) will offer no control over the power density, as the beam diameter will remain constant. It is more accurate from a therapeutic perspective to effect dosages changes by maintaining a fixed output power and altering the emission time.

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LLLT & Physiotherapy

Electrotherapy and low-level laser are used in physiotherapy to assist in the attenuation of pain and to stimulate tissue repair. As such, their application is also bound by the Arndt-Schultz Law of Biomodulation, as described above. Thus, it can be seen that the dosage delivered by the practitioner during a laser treatment is determined by the condition being treated, and the desired therapeutic effect. For example, if the desired effect of an initial treatment is that of pain attenuation, an inhibitory dosage (8.0 to 16.0 Joules/cm2) would be indicated.

Australian research has also shown that dosages of between 0.5 and 5 Joules/cm2 (Laakso et al, 1994) applied to Myofascial Trigger Points will effect an analgesic response through the body's hormonal/opoid mechanisms. If the desired effect is that of tissue repair, then the required dosage per treatment point will generally fall within the optimal therapeutic window between 0.5 and 5 Joules/cm2.

Available laser Output Power may range from 5mW to 500mW, with the higher powers indicated for larger muscle groups and treatment of the back. Near-infrared lasers penetrate further into the tissue. Multi-diode cluster probes may be effective in reducing overall treatment times where large tissue areas are to be treated. However, it must be noted that multi-diode cluster probes generally contain multiple wavelengths, which can lead to a degredation of the effectiveness of laser therapy (Karu, 1998)

Treatment will be effected by application of the laser probe to points along tendons and ligaments, and at the origins and insertions of muscles. Larger muscles can be treated by application of the laser in a grid pattern to a series of points across the body of the muscle.

Joint conditions, such as osteoarthritis, can be treated by applying the laser probe to a series of points along the joint line, aiming the probe tip at the articular surface where possible, and to the origins and insertions of muscles around the joint.

Open wound healing can be accelerated through laser therapy, by the application of 4 Joules/cm2 to a series of points in a 1cm square grid pattern across the surface of the wound.

As a gereral rule, optimal biostimulation is effected by the application of smaller dosages-per-point to more points at the treatment site.

Optimal bioinhibition is achieved through applying higher dosages-per-point, but to less treatment points.

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LLLT & Acupuncture

Laser Acupuncture relies upon similar dosage principles as needling, and a knowledge of acupuncture theory and practice is required.

Dosage is determined by way of the intended effect, which is generally characterised as to TONIFY or SEDATE Acupuncture Points (APs), Ah-Shi Points, and Trigger Points (TPs).

Basing dosage selection upon the Arndt-Schultz Law, it can be seen that low dosages will TONIFY, whereas higher dosages will SEDATE.

Dosages of 0.5 to 2.5 J/cm2 are reported to be effective in the stimulation (tonification) of superficial Acupuncture Points, with 2.5 to 5.0 J/cm2 being effective for deeper APs and Myofascial Trigger Points. Higher dosages (8 - 12 J/cm2) are effective for the sedation of APs.

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Treatment Protocol, Frequency, and Response

To maximise irradiance at the target tissue, the laser probe should be held in contact with, and perpendicular to, the tissue surface.

When treating open wounds, the probe should be held slightly away from the tissue surface, whilst still maintaining a 90o angle. The probe tip may be covered with plastic cling film, in order to reduce the likelihood of cross-contamination.

In treating musculoskeletal conditions, manipulative therapies should be completed prior to laser irradiation. Laser therapy should be carried out following cryotherapy, as the vasoconstriction caused by cooling the tissue will increase the penetration depth of the laser irradiation. Heat therapies and various creams and lotions can be applied after laser therapy.

Laser treatments can be carried out by irradiating daily for the first week, then gradually increasing the interval between treatments over successive weeks, according to the progression of the condition being treated. The total dosage should not exceed 100 J in any single treatment session. Laser dosage is cumulative, and so overtreatment causing a degredation of LLLT effectiveness can come from overly-high dosages in one treatment session, or too many treatment sessions in close succession. Individual practitioner discretion is to be used to determine the appropriate maximum session dosage, and the frequency of treatment, for each particular patient.

Patients may report a number of sensations, such as localised feelings of warmth, tingling, or an increase or decrease in symptoms, within the period immediately following laser therapy. Other sensations that may be experienced in response to laser therapy are nausea or dizziness.

Treatment reactions are often reported after initial laser treatments, however, they generally diminish after the second or third treatment. If a severe reaction is experienced during treatment, stop immediately.

To reiterate, optimal biostimulation is effected by the application of smaller dosages-per-point to more points at the treatment site.

Optimal bioinhibition is achieved through applying higher dosages-per-point, but to less treatment points.

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Contraindications and Safety

Due to the mitotic effects of LLLT, it is wise not to irradiate cancerous tissue. Some authors advise against using laser over acutely infected closed swellings, as this may spread the local infection.

Laser light is very intense, and so care must be taken not to direct the laser towards the eyes of the patient or practitioner during operation. This is especially important when using infra-red wavelengths, as infra-red light will not invoke a blink response.

General clinical hygiene standards and protocols apply.

Practitioners should be aware of local regulations governing the use of low-level laser therapy equipment.

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Criticisms of LLLT

Some devices, sold as lasers, do not emit laser light. These devices are based on light emitting diodes (LEDs), which emit non-coherent light. Whilst most research has been conducted using coherent light sources, it has been shown that it is the wavelength and dosage - not coherence of light - that has the most effect on biomodulation. The primary difference between lasers and LEDs is that the laser's coherent beam produces 'speckles' of relatively high power density which can cause local heating of inhomogeneous tissues (Letokhov, 1991).

Laser does have a number of other benefits. A wider range of wavelengths are generally available, and therefore it is easier to find an available wavelength in close proximity to the peak wavelength in a particular action spectra. There is usually a significant price difference between laser diodes and LEDs. However, lasers with significantly higher output powers are becoming a lot more affordable.

One of the major criticisms of low-level laser therapy to date has been the inability of practitioners and researchers to reliably replicate results obtained by other individuals. This is invariably due to the imprecise and incomplete recording of laser and treatment parameters (Stuck, 1993), and of dosages used to obtain these results. It is very difficult to develop an informed opinion about the efficacy of LLLT in these circumstances.

With laser treatment parameters recorded in terms of Output Power, Beam Spot Size, Treatment Time, and Wavelength (Grosman, 1976; Stuck, 1993; Baxter, 1994), a particular treatment can usually be replicated, in vivo and in vitro, not only with the same laser unit but with any laser configured appropriately. This is essential for further research purposes, and offers the potential to add significantly to the overall body of knowledge in the field of low-level laser therapy (especially that derived from human in vivo studies which, due to the imprecise recording of laser and treatment parameters, have in many cases been less than useful).

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Summary

Low-Level Laser Therapy, by definition, has no appreciable thermal effect in irradiated tissue; it works by modulating the biological processes within the tissue through application of photonic energy at specific wavelengths;

Laser's coherent beam produces 'speckles' of relatively high power density which can cause local heating of inhomogeneous tissues;

LEDs and LASERs both generate biomodulatory effects within living tissue, however, most published research relates to LASER;

Therapeutic effects of laser are both wavelength and dosage dependent;

Low dosages stimulate, high dosages inhibit (ref: Arndt-Schultz Law of Biomodulation) - both have therapeutic applications;

Optimal therapeutic window for photobiostimulation - 0.5 to 5.0 Joules/cm2;

Optimal Biostimulation: lower dosages per point - more treatment points;

Optimal Bioinhibition: higher dosages per point - less treatment points;

Visible red wavelengths (~620-690 nanometers) - shallow penetration - superficial tissue treatment, eg. wound healing, superficial APs, acne, etc.;

Infra-red wavelengths (~760-1260 nanometers) - deeper penetration - deeper tissue treatment, eg. musculoskeletal injuries, sports therapy, deeper APs and myofascial TPs, also wound healing,etc;

High Output Power + Infrared Wavelength + Safe Power Density = Maximum Effective Penetration

Treatment parameters to be recorded in minimum terms of Output Power (mW), Beam Spot Size (cm2), Treatment Duration (Seconds), and, Wavelength (nm);

Do not irradiate cancerous tissue;

Be aware of optical safety at all times.

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Treatable Conditions:

Low -Level Laser has been shown to be effective in, but not limited to, treating the following indications:

Infra-Red Wavelengths:

Soft Tissue Injuries such as:

- Capsulitis, Bursitis
- Sprains & Strains
- Haematomas
- Tendonitis, Tenosynovitis
- Myofascial Trigger Points, AhShi Points, & Deep APs

Acute & Chronic Joint problems including:

- Osteoarthritis
- Rheumatoid Arthritis
- Ligament & Tendon injuries
- Chrondomalacial Patella

Chronic Pain such as:

- Post Herpetic Neuralgia
- Chronic Back & Neck Pain
- Metatarsalgia
- Trigeminal Neuralgia

- Brachial Neuralgia
- Plantar Fasciitis
- Frozen Shoulder
- Carpal Tunnel

Fractures such as:

- Non Union
- Small bone

Visible Red Wavelengths:

- Herpes
- Apthous Ulcers
- Leg Ulcers
- Dermatitis
- Wound Healing
- Burns
- Acute Epididymitis
- Otorhinolaryngology
- Gynaecology
- Obstetrics
- Superficial AP Stimulation and Tonification
- Cosmetic
- Acne

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Bibliography and References

Airaksinen,O., Rantanen,P., Kolari,P.J. and Pontinen,P.J. (1988) Effects of IR (904nm) and He-Ne (632.8nm) laser irradiation on pressure algometry at TPs. Paper to Nordic AP Society Annual Congress, Laugarvatn, Iceland, August 26th. Scand. J. of Acupuncture and Electrotherapy, 3,56-61.

Baxter, G. D. (1994) Therapeutic Lasers: Theory and Practice. Churchill Livingstone: Edinburgh

Baxter, G.D., Bell, A.J., Allen, J.M., et al (1991) Low Level Laser Therapy: current clinical practice in Northern Ireland. Physiotherapy 77: 171-178

Dyson,M. and Yang,S. (1986) Effect of laser therapy on wound contraction and cellularity in mice. Lasers in med. science 1/2,125-130.

Grosman. Z. (1976) Effect of laser irradiation on different cell structures. SB Omik Vedeckych Praci Lekarske 19:3-4

Illarionov, V.E, & Priezzhev, A.V Current Status of Low-Energy Laser Therapy in Russia: Search for Mechanisms, Clinical Applications and Equipment Development in Low Energy Laser Effects on Biological Systems, Michal Schwartz, Michael Belkin, (eds), (1993) Proc. SPIE 1883, pp8-13

Karu, T. (1998) The Science of Low-Power Laser Therapy. Gordon & Breach Science Publishers, p.xv

Kolari,P.J., Hietanen,M., v. Nandelstad,P., Airaksinen,O. and Pontinen,P.J. (1988) Lasers in physical therapy-measurement of optical output power. Scand. J. Acupuncture and Electrotherapy.

Laakso, E.L., Cramond, T., Richardson, C., & Galligan, J.P. (1994) Plasma ACTH and b-Endorphin Levels in Response to Low-Level-Laser Therapy (LLLT) for Myofascial Trigger Points. Laser Therapy 6: 133-142

Mester,E., Mester,A.E. and Mester,A. (1985) The biomedical effect of laser application. Lasers in surgery and medicine 5, 31-39.

Mester & Mester, (1989) Wound Healing. Laser Therapy 1: 7-15

Muxeneder,R. (1987). Soft laser in the conservative treatment of chronic skin lesions in the horse. Der Prakt. Tierarzt, 68, No. 1, 12-21.

Pontinen,P.J. (1987) Mid-laser and TNS in back pain. Nordic AP Society Annual Meeting: Seminar on back pain. Oslo, September 26.

Pontinen,P.J. (1995) Low Level Laser Therapy (LLLT) and laser acupuncture: a manual for physicians, dentists, physiotherapists and veterinary surgeons.

Rogers,P.A.M., Janssens,L.A.A. & Jagger,D. (1987) The efficacy of cold laser: A survey of members of the International Veterinary Acupuncture Society. Unpublished.

Rogers P.A.M (1996) Clinical Uses of Low Level Laser Therapy. Medical Acupuncture Web Page.

Stuck, B.E Measuring and reporting physical parameters in laser biomodulation research in Low Energy Laser Effects on Biological Systems, Michal Schwartz, Michael Belkin, (eds), (1993) Proc. SPIE 1883, pp21-26

Sumano,H.L., & Casaulon,T. (1987) Evaluation of electro-AP and TENS effects on wound- and burn-healing. Personal Communication, Veterinary School, Mexico City.

Trelles,M.A., Mayayo,E., Mester,A. & Rigau,J. (1987) Low power laser-therapy: Experimental and clinical data. Scandinavian Journal of Acupuncture & Electrotherapy, 2, 80-100.

Tunér, J & Hode, L (1996) 'Laser Therapy in Dentistry and Medicine'. Prima Books

Tunér, J & Hode, L (1999) 'Low Level Laser Therapy - Clinical Practice and Scientific Background'. Prima Books

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