

## Annotated Bibliography >> Master

\*Larkin, Kelly, et al. "Phototherapy prolongs time to task failure in older adults." Neuroscience 2012. New Orleans, LA. October 2012. Abstract Presentation. (LiteCure® Research Collaboration)

42 right-hand dominant subjects, equally divided in age groups 18-35yrs or 65-90yrs, were randomized to treatment and control groups. The treatment group received 10J/cm<sup>2</sup> pre-treatment to the first dorsal interosseus before exercise to failure. Results indicate that laser therapy shows promise to enhance time to task failure, prevent loss of muscular strength and delay the onset of musculoskeletal fatigue in older adults.

\*Anders, Juanita, et al. "Light interaction with the peripheral nervous system: in vivo and in vitro models of neuropathy." WALT. Queensland, Australia. September 2012. Abstract Presentation. (LiteCure® Research Collaboration)

Dr. Anders presented a series of studies on the effect of laser therapy on nerves. Cell culture experiments on rat cortical and dorsal root ganglion neurite extension were used to determine optimal laser dosing at 980nm and 810nm. After measuring real penetration to the target tissue, these dosing criteria were then tested successfully in functional models of rabbit peroneal nerve injury and a rat spared nerve injury. Preliminary histology results were presented to support the functional result.

Dostalová, Tatjana, et al. "Effectiveness of Physiotherapy and GaAlAs Laser in the Management of Temporomandibular Joint Disorders." *Photomedicine and Laser Surgery* 30.5 (2012): 275–280.

27 patient prospective case series on patients with clinically verified TMJ disorder. Subjects received 5 weekly treatments using a 830nm laser on 3 points in contact mode at an energy density of 15.4J/cm<sup>2</sup>. After treatment population VAS was reduced by 85% and jaw range of motion increased by 24%. "The laser therapy was effective in the improvement of the range of temporomandibular disorders (TMD) and promoted a significant reduction of pain symptoms."

Fiore, P., et al. "Short-term effects of high-intensity laser therapy versus ultrasound therapy in the treatment of low back pain: a randomized controlled trial." *European Journal of Physical and Rehabilitation Medicine* 47.3 (September 2011): 367-373.

30 consecutive patients with clinically verified sub-acute or chronic low back pain. Patients were randomized to receive 15 treatments (5 days a week for 3 weeks) of either ultrasound or laser therapy. Ultrasound was administered at 1MHz for 10 minutes. 2600J of laser therapy was administered to the same treatment area over 10 minutes. The laser therapy group "showed a statistically significant reduction of Visual Analog Scale pain and Oswestry Low Back Pain Disability Questionnaire scores with respect to Ultrasound at the end of treatment (P<0.005)"

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Roberts, Delia, et al. "The Efficacy of Class IV Laser Treatment for Epicondylitis: A Randomized Controlled Trial." ACSM. Selkirk College and ProMedica Health System. Denver, CO. May/June 2011. Poster Presentation. (LiteCure® Laser used in study)

15 patients with documented chronic tendinosis of the elbow were randomized into sham or laser therapy treatment. The laser group received eight 5.5 minute treatments of 10J/cm<sup>2</sup> every-other day for 18 days. Follow-up evaluations were made at 3, 6 and 12 months. Multiple pain measures, handgrip strength and functional impairment all improved with respect to sham treatment. Statistical significance was maintained to 1 year follow-up.

\*Naeser, Margaret A., et al. "Improved Cognitive Function After Transcranial, Light-Emitting Diode Treatments in Chronic, Traumatic Brain Injury: Two Case Reports." *Photomedicine and Laser Surgery* 29.5 (May 2011): 351-358.

2 case studies are presented that demonstrate the potential effectiveness of laser therapy applied transcranially to the forehead and scalp for the treatment of traumatic brain injury (TBI).

\*Moges, Helina, et al. "980nm laser irradiation improved functional recovery after peroneal nerve injury in rabbits." ASLMS. Dallas, TX. April 2011. Abstract Presentation. (LiteCure® Research Collaboration)

12 rabbits were subjected to peroneal nerve injury followed by primary repair and randomized into laser therapy and control groups. The laser group received 10 daily treatments at 980nm light for 40 seconds totaling 7.5J/cm<sup>2</sup>. Functional recovery was assessed weekly for 9 weeks using the toe-spread reflex. At week 6 the laser therapy group showed statistically significant functional recovery over the sham group and continued to improve to week 9. Functional recovery in the laser therapy group was 86.9% at week 9. "980 laser irradiation successfully promoted earlier and faster functional recovery after peroneal nerve transection and surgical repair"

Favejee M. M., B M A Huisstede, and B W Koes. "Frozen shoulder: the effectiveness of conservative and surgical interventions— systematic review." *British Journal of Sports Medicine* 45.1 (January 2011): 49-56.

70 patients with clinically verified subacromial impingement were randomized to receive 10 treatments (5 days a week for 2 weeks) of either ultrasound or laser therapy. Ultrasound was administered at 1MHz for 10 minutes. 2050J of laser therapy was administered to the same treatment area over 10 minutes. After the treatment period the laser therapy group had reduced pain, improved articular movement, functionality and muscle strength in the affected shoulder compared to the ultrasound group (P<0.005).

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\*Pires, Débora, et al. "Low-level laser therapy (LLLT; 780 nm) acts differently on mRNA expression of anti- and pro-inflammatory mediators in an experimental model of collagenase-induced tendinitis in rat." *Lasers in Medical Science* 26 (January 2011): 85–94. Print.

A rat model of induced tendonitis was used to evaluate the effect of laser therapy on inflammatory signaling. 42 rats were randomized evenly into laser and control populations. Rats in the laser group were treated at 780nm with a fluence of 7.7J/cm<sup>2</sup> every-other day starting at 12h or day 7 through the end of the study. The laser group had significantly lower IL-6, COX-2 and TGF- $\beta$  than control animals in both acute and chronic phases. Laser therapy significantly reduced TNF- $\alpha$  only at the chronic phase. Laser therapy is effective for the reduction of mRNA expression for pro-inflammatory mediators.

Chow, Roberta, et al. "Inhibitory Effects of Laser Irradiation on Peripheral Mammalian Nerves and Relevance to Analgesic Effects: A Systematic Review." *Photomedicine and Laser Surgery* 29.6 (2011): 365-381.

44 studies of laser therapy were reviewed for inhibitory effects on peripheral nerve pain. In 13 of 18 human studies laser therapy was shown to slow conduction velocity and/or reduce the amplitude of compound action potentials. Several mechanisms for the analgesic effects of laser therapy are also discussed.

Carcia, Christopher R., et al. "Achilles Pain, Stiffness, and Muscle Power Deficits: Achilles Tendinitis--Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association." *Journal of Orthopaedic & Sports Physical Therapy* 40.9 (September 2010): A1-A26.

The Orthopaedic Section of the APTA recommends that clinicians should consider the use of laser therapy to decrease pain and stiffness in patients with Achilles tendinopathy.

\*Frigo, Lucio, et al. "Low-Level Laser Irradiation (InGaAlP-660 nm) Increases Fibroblast Cell Proliferation and Reduces Cell Death in a Dose-Dependent Manner." *Photomedicine and Laser Surgery* 28.1 (August 2010): S151–S156.

In cell culture, primary fibroblasts treated with laser at 660nm were shown to increase proliferation and decrease cell death at an irradiance of 2.5W/cm<sup>2</sup> and a fluence of 150J/cm<sup>2</sup>.

Hashmi, J.T., et al. "Effect of Pulsing in Low Level Light Therapy." *Lasers in Surgery and Medicine* 42.6 (August 2010): 450–466.

33 studies comparing Continuous Wave (CW) and pulsed laser treatments were reviewed. A common criticism of these studies is the lack of direct, like-for-like comparison of pulsed treatment to CW. The article concludes "CW is the gold standard and has been used for all LLLT applications" and "there is no consensus on the effects of different frequencies and pulse parameters on the physiology and therapeutic response of various disease states that are often treated with laser therapy. This has allowed manufacturers to claim advantages of pulsing without hard evidence to back up their claims."

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Morries, L.D. "Class IV Laser Therapy; Effective For Back And Neck/Shoulder Pain." 2010 ACBSP Annual Conference. University of Colorado Denver. Los Angeles. June 2010. Poster Presentation. (LiteCure® Laser used in study)

55 patients with low back pain were randomized to receive either manual adjustment or adjustment followed by laser therapy. After 4 weeks the laser therapy group had a 71% reduction in pain score (VAS) and was significantly better than manipulation alone.

Williams, Kristen, et al. "Effects of Class IV Laser Therapy on Disease Impact and Function in Women with Fibromyalgia." ACSM. Baltimore, MD. 5 June 2010. Abstract Presentation. (LiteCure® Laser used in study)

39 women with Fibromyalgia Syndrome were randomized to receive laser therapy treatment or sham heat gun treatment. Treatments were administered twice a week for 4 weeks at eight tender points across the neck, shoulders and back. Laser therapy treatment significantly improved upper body flexibility, fibromyalgia impact score and a composite measure of pain compared to the sham treatment.

\*Wu, Xingjia, et al. "Differential response of neurons to light irradiation in an in vitro diabetic model." ASLMS. Phoenix, AZ. April 2010. Abstract Presentation. (LiteCure® Research Collaboration)

Primary cortical and dorsal root ganglion neurons were pre-treated in high glucose media to induce die-back in a cell culture model of diabetic cell damage. In cortical neurons 980nm irradiation at 0.01, 0.05 and 0.2J/cm<sup>2</sup> significantly increased neurite extension. For DRG's subjected to high glucose media, 810nm light at 0.01J/cm<sup>2</sup> significantly increased neurite extension.

Tumilty, Steve, et al. "Low Level Laser Treatment of Tendinopathy: A Systematic Review with Meta-analysis." *Photomedicine and Laser Surgery* 28.1 (February 2010): 3-16.

A review of 25 clinical trials of laser therapy for the treatment of tendinopathy. 12 trials had positive results and 13 were inconclusive or showed no significant effect. Dosing in the 12 positive trials supports the existence of an effective dosing window from 1-9 J/cm<sup>2</sup> depending on the depth of the tendon.

Erbele, Isaac, et al. "Optimization of dose and power density of 980nm and 810nm light based on mitochondrial activity." SPIE. The Moscone Center, San Francisco. 23 January 2010. Abstract Presentation. (LiteCure® Research Collaboration)

Human fibroblasts were exposed to 980nm and 810nm irradiation at a range of irradiance and fluence parameters in cell culture. Response was measured by MTS assay for mitochondrial activity. A 980nm dose of 5J/cm<sup>2</sup> at 10mW/cm<sup>2</sup> caused an 11% increase in mitochondrial activity. 810nm doses of 1 and 5 J/cm<sup>2</sup> at 50mW/cm<sup>2</sup> caused a 40% increase. Results indicate that different wavelengths require different dosing to increase mitochondrial activity.

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International Association for the Study of Pain. "Myofascial Pain." Global Year Against Musculoskeletal Pain. IASP. October 2009-October 2010. Web. August 4, 2012. < <http://www.iasp-pain.org/Content/NavigationMenu/GlobalYearAgainstPain/20092010MusculoskeletalPain/FactSheets/default.htm>>.

Position paper from the International Association for the Study of Pain that recommends the use of laser therapy in the treatment of Myofascial Pain: "Laser Therapy shows strong evidence of effectiveness for pain relief."

Chow, Roberta T., et al. "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." *The Lancet* 374 (5 December 2009): 1897–1908.

Seminal review of Laser Therapy for Neck Pain published in a top-tier medical journal. 16 RCTs including 820 individual patients were included in the review. Laser therapy was found to immediately reduce neck pain and maintained results up to 22 weeks after completion of treatment. Also, most statistical heterogeneity disappeared when Chow excluded studies with small doses or flaws in treatment procedure.

Santamato, Andrea, et al. "Short-term Effects of High-Intensity Laser Therapy Versus Ultrasound Therapy in the Treatment of People With Subacromial Impingement Syndrome: A Randomized Clinical Trial." *Physical Therapy* 89.7 (July 2009): 643-652.

RCT of laser therapy vs. therapeutic ultrasound in 70 patients with clinically verified subacromial impingement syndrome. Laser therapy was shown to have significantly greater benefit than ultrasound in reducing pain and improving the articular movement, functionality and muscle strength of the affected shoulder.

Huang, Ying-Ying, et al. "Biphasic Dose Response In Low Level Light Therapy." *Dose-Response* 7 (2009): 358–383.

This review paper covers the current theory on basic mechanisms of laser therapy and discusses the effects of different dosing strategies. Cytochrome C is identified as the primary absorber of light in the near infrared leading to cellular changes related to ATP, NO and ROS levels. Different doses of laser therapy are shown to either stimulate or inhibit multiple metabolic and cell signaling pathways.

Haldeman, Scott, et al. "The Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders." *Spine* 33.45 (February 2008): 55-57.

World Health Organization (WHO) taskforce concludes that laser therapy is beneficial for the treatment of neck pain.

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Naeser, Margaret A. "Photobiomodulation of Pain in Carpal Tunnel Syndrome: Review of Seven Laser Therapy Studies." *Photomedicine and Laser Surgery* 24.2 (April 2006): 101-110.

Review of 7 studies using laser therapy to treat carpal tunnel syndrome. 5 of the 7 studies (226 total subjects) had positive findings for laser therapy treatment. These studies had an average success rate of 84% in cases of mild/moderate carpal tunnel syndrome. In general higher dosages applied to the median nerve at multiple locations were used in the successful studies. "Photoradiation is a promising new, conservative treatment for mild/moderate CTS. It is cost effective compared to current treatments."

Hamblin, Michael R., and Tatiana N Demidova. *Mechanisms of Low Level Light Therapy*. Proc. of SPIE Photonics West, 22 January 2006, San Jose, California.

This review paper covers the current theory on basic mechanisms of laser therapy. Cytochrome C oxidase is identified as the primary absorber of light in the near infrared leading to cellular changes related to ATP, NO and ROS levels. The "optical window" for tissue penetration is identified from 600nm to 1.4µm. A review of animal and clinical studies is also presented for applications including wound healing, nerve regeneration and numerous musculoskeletal conditions.

Bashkatov, A N, et al. "Optical properties of human skin, subcutaneous and mucous tissues in the wavelength range from 400 to 2000nm." *Journal Of Physics D: Applied Physics* 38 (2005): 2543-2555.

Bashkatov investigates the optical properties of human tissue in the visible and near infrared. Tissue penetration depth, defined as the depth of 37% of surface exposure, is found to be between 2.25 mm and 2.50 mm into skin and between 4.5 mm and 6.0 mm in mucous tissue for the wavelengths used in laser therapy devices.

\*Anders, Juanita J., Stefano Geuna and Shimon Rochkind. "Phototherapy promotes regeneration and functional recovery of injured peripheral nerve." *Neurological Research* 26 (March 2004): 233-239.

This review presents several studies that evaluate the efficacy of laser therapy to promote regeneration and recovery of injured peripheral nerve. Studies include a crush injury model of the rat facial nerve, injured rat sciatic nerve and regeneration after surgical repair. All studies demonstrated the efficacy of laser therapy for treating nerves and the technique was identified as "one of the most promising therapies to date" for these difficult pathologies.

\*Al-Watban, Farouk A.H., and X. Y. Zhang. "The Comparison of Effects between Pulsed and CW Lasers on Wound Healing." *Journal of Clinical Laser Medicine & Surgery* 22.1 (2004) 15-18.

This study evaluated both Continuous Wave (CW) and pulsed laser therapy in an elliptic wound model in rats. This study is one of the few published reports that evaluates both pulsed and CW therapy compared to a sham control. All laser parameters improved wound healing. Maximal benefit was achieved using CW laser therapy. Optimal dosing for wound healing was 5 J/cm<sup>2</sup>.

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Kulekcioglu, Sevinc, et al. "Effectiveness of low-level laser therapy in temporomandibular disorder." *Scandinavian Journal of Rheumatology* 32 (January 2003): 114-118.

35 patients with TMJ verified by MRI were randomized to laser therapy treatment or control. Patients in the treatment group received 15 treatments of 3 J/cm<sup>2</sup> at 904nm. Both groups improved in all measures over the study period. The laser group had significantly better improvement in the number of tender points and all range of motion measures.

Whelan, Harry T., et al. "NASA Light-Emitting Diodes for the Prevention of Oral Mucositis in Pediatric Bone Marrow Transplant Patients." *Journal of Clinical Laser Medicine & Surgery* 20.6 (December 2002): 319-324.

23 consecutive pediatric patients that received chemotherapy in preparation for bone marrow transplant were given 4 J/cm<sup>2</sup> phototherapy daily for 14 days at 670nm. Ulcerative oral mucositis rates in this case series were reduced by 20-40% compared to historical controls.

Karu, Tiina I., et al. "Changes in Absorbance of Monolayer of Living Cells Induced by Laser Radiation at 633, 670, and 820 nm." *Ieee Journal On Selected Topics In Quantum Electronics* 7.6 (2001): 982-988.

Absorption changes in HeLa cells were evaluated from 530-890nm. Irradiation causes changes in the spectrum of the cells in the ranges from 754-795nm and 812-873nm. Cytochrome C oxidase becomes more oxidized (implying increased cellular oxidative metabolism) at all wavelengths used. This study supports the hypothesis that the mechanism of photobiomodulation is related to the chromophore Cytochrome C.

Gür, Ali, et al. "An Investigation of Efficacy of Low Energy Laser and Placebo Laser Therapies in Fibromyalgia." *Journal of Medical School* 27.2 (2000): 69-75.

40 patients with Fibromyalgia Syndrome were randomized to receive laser therapy or placebo treatment 5 days a week for 2 weeks. Laser therapy consisted of treating all active trigger points for 3 minutes each. Both the sham and treatment groups improved in all measures except sleep disturbance and tender point sensitivity. The treatment group improved significantly compared to sham in pain, muscle spasm, morning stiffness and number of tender points.

Karu, Tiina I. "Yearly Review: Effects of Visible Radiation on Cultured Cells." *Photochemistry and Photobiology*. 52.6 (1990) 1089-1098.

Several effects of light on living cells are discussed. Proliferation, migration, metabolism, DNA synthesis, cell signaling and antimicrobial effects are identified. Future areas for research are identified.

Karu, Tiina I. "Molecular Mechanism of the Therapeutic Effect of Low-Intensity Laser Radiation." *Lasers in the Life Sciences* 2.1 (1988): 53-74.

Early study of laser therapy mechanisms that evaluated the structure of cytochrome C and other potential chromophores in the respiratory chain. Mechanisms for stimulation and inhibition are discussed as well as effects of laser therapy at the systemic level and possible limitations of the technology.

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