

Low Level Laser Therapy And Its Potential Wide Use In Sports Medicine

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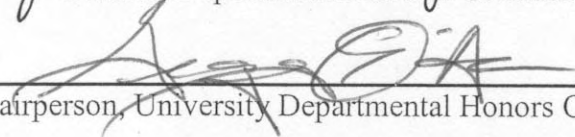
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Fifty thousand year old cave drawings show scenes of men hunting and are considered by scholars to be the earliest evidence that hunting was man's first sport. Therefore, out of the need to survive man has always attempted to improve his physical condition and performance. Evidence indicates that running, swimming, archery, rowing, and wrestling existed in the ancient cities of Thebes and Giza by the river Nile. Egyptian hieroglyphics show that boxing was a very popular sport all along the Nile River. The first medical text for sports is the Kuhn Papyrus from the Egyptian Kingdom around 1900 B.C. Following Egyptians, Ancient Greeks also practiced sports medicine and various medical therapies for external injuries and joint dislocations were developed during Hippocrates' time (5th Century B.C.). By the end of Hippocrates' era, the Greeks knew how to reset dislocations, clean wounds, remove foreign objects, and cauterize blood vessels.¹

Hard working, self-taught men who were very physical with their patients characterized the early years of sports medicine. Later, professionally trained personnel were introduced to the field. The field of sports medicine has undergone vast expansions during the 20th century. The application of the X-ray, drugs, ultrasound, electrical stimulation, and various other technologies has allowed professionals to diagnose and treat problems more accurately. The field of sports medicine continues to grow while giving aid to people all across the world. New methods and technologies have been applied, one of which is the application of lasers.

BACKGROUND ON LASERS:

The theoretical background to the laser was laid in 1917 when Einstein, in his publication, “Zur Quantum Theorie der Strahlung,” established the concepts of stimulated emission. It was not until 1953 that the use of stimulated emission for microwave amplification was proposed by Weber at the University of Maryland, by Townes and his students at Columbia University, and by Basov and Prokhorov in the Soviet Union. The development of the MASER (“microwave amplification by stimulated emission of radiation”) allowed Townes and Weber in the U.S. and Basov and Prokhorov in Russia to develop the concept of the laser. LASER stands for light amplification by stimulated emission of radiation. Maiman exhibited the first ruby laser on July 7, 1960. Most notable were the works of Schawlow and Townes, who explored the general physical conditions necessary for the operation of a laser in either the gaseous or the solid state and who have analyzed the feasibility of several possible systems. These systems include the optically excited potassium vapor and even the optical excitation of several of the fluorescent lines of ruby, which were later found suitable for laser action.²

One must know the basic physics and chemistry of the atom to understand the fundamentals of lasers. The simple atom consists of a nucleus, containing protons and neutrons, and an electron cloud. It is helpful to think of the electrons in this cloud circling the nucleus in many different orbits. Although more modern views of the atom do not depict discrete orbits for the electrons, it can be useful to think of these orbits as the different energy levels of the atom. Atoms are constantly in motion. They continuously

vibrate, move and rotate. Even the atoms that make up the chairs that we sit in are moving around. Atoms can be in different states of excitation. In other words, they can have different energies. If we apply a lot of energy to an atom, it can leave what is called the ground-state energy level and go to an excited level. The level of excitation depends on the amount of energy that is applied to the atom via heat, light, or electricity. In other words, if we apply some heat to an atom, we might expect that some of the electrons in the lower-energy orbitals would transfer to higher-energy orbitals farther away from the nucleus.³

This is a highly simplified view of things, but it actually reflects the core idea of how atoms work in terms of lasers. Once an electron moves to a higher-energy orbit, it eventually wants to return to the ground state. When it does, it releases its energy as a photon or a particle of light. You see atoms releasing energy as photons all the time, for example, when the heating element in a toaster turns bright red. Atoms, excited by heat, releasing red photons, cause the red color. When you see a picture on a TV screen, what you are seeing is phosphor atoms, excited by high-speed electrons, emitting different colors of light. Anything that produces light, and examples of this would be fluorescent lights, gas lanterns, incandescent bulbs, etc., etc., do it through the action of electrons changing orbits and releasing photons.³

A laser is a device that controls the way that energized atoms release photons. Although there are many types of lasers, all have certain essential features. In a laser, the lasing medium is “pumped” to get the atoms into an excited state. Typically, very intense flashes of light or electrical discharges pump the lasing medium and create a large collection of excited-state atoms (atoms with higher-energy electrons). It is necessary to

have a large collection of atoms in the excited state for the laser to work efficiently. In general, the atoms are excited to a level that is two or three levels above the ground state. This increases the degree of population inversion, which is the number of atoms in the excited state versus the number in ground state. Once the lasing medium is pumped, it contains a collection of atoms with some electrons sitting in excited levels. Just as the electron absorbs some amount of energy to reach this excited level, it can also release this energy. The electron can simply relax, and in turn rid itself of some energy. This emitted energy comes in the form of photons or light energy. The photon emitted has a very specific wavelength that depends on the state of the electron's energy when the photon is released. Two identical atoms with electrons in identical states will release photons with identical wavelengths.³

Laser light is very different from normal light in the following ways: first, the light released is monochromatic, which means that it contains only one wavelength of light. The wavelength is determined by the amount of energy released when the electron drops to a lower orbit. Second, the light released is coherent, which means that it is “organized” in that each photon moves in step with the others, so that all of the photons have wave fronts that move in unison. Third, the light is directional, or non-divergent. A laser light has a very tight beam, which is very strong and concentrated. A flashlight, on the other hand, releases light in many directions, and the light is very weak and diffused. To make these three properties occur takes something called stimulated emission, which does not occur in an ordinary flashlight, where all of the atoms release their photons randomly. However, in stimulated emission, photon emission is organized. The photon that any atom releases has a certain wavelength that is dependent on the energy difference

between the excited state and the ground state. If this photon should encounter another atom that has an electron in the same excited state, stimulated emission can occur. The first photon can stimulate or induce atomic emission such that the emitted photon vibrates with the same frequency and direction as the incoming photon. The other essential feature of a laser is a pair of mirrors, one at each end of the lasing medium. Photons, with a very specific wavelength and phase, reflect off the mirrors to travel back and forth through the lasing medium. In the process, they stimulate other electrons to make the downward energy jump, causing the emission of more photons of the same wavelength and phase. A cascade effect occurs, with the propagation of many, many photons of the same wavelength and phase. The mirror at one end of the laser is "half-silvered," meaning it reflects some light and lets some light through. The light that passes through is the laser light.³

There are many different types of lasers. The laser medium can be a solid, gas, liquid, or semiconductor. Lasers are commonly designated by the type of lasing material they employ. Solid-state lasers have lasing material distributed in a solid matrix (such as the ruby or neodymium yttrium-aluminum garnet "Yag" lasers). The neodymium-Yag laser emits infrared light at 1,064 nanometers (nm). Gas lasers (helium and helium-neon, HeNe, are the most common gas lasers) have a primary output of visible red light. CO₂ lasers emit energy far in the infrared section of the spectrum, and are used for cutting hard materials. Excimer lasers (the name is derived from the terms *excited* and *dimers*) use reactive gases, such as chlorine and fluorine, mixed with inert gases such as argon, krypton or xenon. When electrically stimulated, a pseudo molecule (dimer) is produced. When lased, the dimer produces light in the ultraviolet range. Liquid lasers use complex

organic dyes, such as rhodamine 6G, in liquid solution or suspension as lasing media. They are tunable over a broad range of wavelengths. Semiconductor lasers, sometimes called diode lasers, are not solid-state lasers; they are generally very small and use low power. They may be built into larger arrays, such as those that are used in some laser printers or CD players.⁴

Lasers are internationally classified into four broad categories depending on their potential for causing biological damage. Lasers should be labeled with one of four class designations. Class I lasers cannot emit laser radiation at known hazard levels. Class I.A. is a special designation that applies only to lasers that are "not intended for viewing," such as a supermarket laser scanner. The upper power limit of Class I.A. is 4.0 mW. Class II are low-power visible lasers that emit above Class I levels but at a radiant power not above 1 mW. The concept is that the human aversion reaction to bright light will protect a person. Class IIIA is composed of the intermediate-power lasers (1-5 mW), which are hazardous only for intrabeam viewing. Most pen-like pointing lasers are in this class. Class IIIB is composed of moderate-power lasers. Class IV are high-power lasers, which are hazardous to view under any condition (directly or diffusely scattered), and are a potential fire hazard and a skin hazard. Significant controls are required for Class IV laser facilities.³

There is a difference between surgical and therapeutic lasers in the medical field. The carbon dioxide laser is often referred to as "surgical," since its effects most resemble traditional surgery. Its action on tissue is directly visible as it is being used. It was the first laser to be widely used by surgeons, and is still the most used of all of the medical

lasers. The output of the carbon dioxide laser is strongly absorbed by water, which makes up 80% of soft tissue. It emits a continuous wave or pulsed far infrared light at 10,600 nanometers, and it can be focused into a beam and used to cut like a scalpel. It can also be defocused to vaporize or shave soft tissue. The carbon dioxide laser can also be operated in pulsed mode or used with scanning devices to control the depth and area of ablation. The carbon dioxide laser is used for the removal of benign skin lesions, removal of tumors, surgery for snoring, removal of scars and other skin irregularities, removal of wrinkles, and as a laser scalpel.⁵

YAG lasers use a Yttrium-Aluminum-Garnet crystal rod as the lasing medium. There are different types of YAG lasers such as neodymium YAG, potassium-titanyl-phosphate YAG, Erbium YAG, and Holmium YAG lasers. All YAG lasers can be operated in continuous or pulsed mode. Continuous and pulsed delivery is through fiber optic cables, either bare-fiber or through hand-held instruments or scanners, and Q-switched delivery, because of the high power, is through an articulated arm. The 'Q' of a laser is talking about the actual cavity and says how good the cavity is at keeping light in it. The more loss your cavity has, the less efficiently it will operate. In a Q-switched laser, the Q is initially made too low to lase by blocking or misaligning one mirror. While the Q is very low, light energy builds up in the laser medium. When the Q is restored, the laser starts lasing, and the result is a large high power pulse. The neodymium YAG laser produces a beam of light at 1064 nm and is used to directly coagulate tissue, for black ink tattoo removal, and for long-term hair removal. The potassium-titanyl-phosphate crystal YAG laser also produces a beam at 1064 nm, but it is used for vascular lesions and red/orange ink tattoo removal. The Erbium YAG laser produces a beam at 2940 nm and

is used for the removal of wrinkles, and as a dental drill. The Holmium YAG laser produces a beam at 2070 nm and is used to ablate bone and cartilage, for the removal of kidney stones, endoscopic disc removal, and it has many applications in orthopedics for arthroscopy. This particular YAG laser has recently been approved for prostate removal.

The Argon Laser was one of the first lasers to be used clinically. It is a continuous wave gas laser that emits blue-green light at 488 and 514 nm, which is strongly absorbed by hemoglobin and melanin. Although the beam may be mechanically pulsed, there is significant non-selective heating in surrounding tissues, which increases the chance for scar formation. It is used for retinal and inner ear surgery, facial spider veins, small dark moles, treatment of thick or nodular port wine birthmarks, and hemangioma.

The ruby laser emits a red light with a wavelength of 964 nm. The lasing medium is a synthetic ruby crystal of aluminum oxide and chromium atoms, which is excited by flash lamps. The ruby laser light is strongly absorbed by blue and black pigment, and by melanin in skin and hair. Modern ruby laser systems are available with the reticulating arm, Q-switched mode, “free running” mode with a fiber optic cable delivery, or as dual mode lasers. They are used for the treatment of pigmented lesions including freckles, liver spots, Nevus of Ota, Café-au-lait spots, tattoos, and laser hair removal.

The Alexandrite Laser is similar to the Ruby Laser and it contains a rod of synthetic chrysoberyl, a gemstone discovered in Russia in 1830 on Czar Alexander II's 13th birthday. It emits a deep red light at 755 nm, and has properties similar to that of the ruby laser. It is slightly longer in wavelength, which permits slightly deeper penetration

into the skin. It has slightly less absorption by melanin and its uses include laser hair removal and tattoo removal.

The Pulsed Dye Laser produces a yellow light at 577-585 nm and because it coincides with the peak absorption of hemoglobin of the blood, the Pulsed Dye Laser is useful to treat vascular lesions. A lasing medium of rhodamine dye is excited by flash lamps, which emits a pulse in the range of 450 microseconds in the older models and 1500 microseconds in the newer models, which is less than the thermal relaxation time of minute blood vessels. It is the preferred laser for the treatment of vascular lesions, including spider veins, strawberry birthmarks and port wine stains. It replaced the Argon Laser because it produces less heat damage and decreased the chance of scarring. The Pulse Dye Laser does has a drawback, however; the short pulse and high absorption ruptures the targeted blood vessels, causing unsightly purpura (a black or blue mark due to ruptured blood vessels), which can last up to two weeks. Pulsed Dye lasers are used for the laser treatment of thick, red scars and port wine stains, especially in infants and children.

The Copper Vapor Laser uses vaporized copper bromide as the lasing medium and emits yellow light at 577 nm and green light at 511 nm through a fiber optic cable. Unlike the Pulse Dye laser, it does not tend to produce purpura, because of the longer pulse duration. However, the long warm up time and short laser cavity life make the Copper Vapor Laser a less popular choice than the Pulse Dye Laser for vascular lesions.

Diode Lasers are solid state devices similar in construction to LED's. The familiar "laser pointers" are in fact diode lasers. They are used clinically to emit near-

infrared light in the 800-900 nm range. Currently their principal application is in millisecond range pulsed mode for laser hair removal, and for periodontal surgery. Diode lasers will be used more in the near future as more wavelengths become available.

Excimer Lasers emit invisible ultraviolet light that triggers a photochemical reaction on the target tissue. This short wavelength is capable of high resolution and microscopic surgery. The most common medical application is the Argon:Fluorine laser at 193 nm. The laser beam is delivered through an operating microscope integrated with the laser housing and operating table.⁵

Low Level Laser Therapy:

LLLT is the application of red and near infrared light to injuries or lesions to improve wound and soft tissue healing. It also gives relief for acute and chronic pain. LLLT has been shown to reduce inflammation, relieve pain, shorten the duration of healing time, as well as improve the tensile strength and quality of tissue repair.⁶

The strength and intensity of low-level lasers is not like surgical lasers, in that there is no heating effect, and no destruction of tissues. Theoretically, the LLLT helps in the production of adenosine-tri-phosphate (ATP), which provides cells with energy. This is thought to occur when the laser energy that is emitted by the active medium as photons focused on the skin via a laser probe, are absorbed by photosensitive molecules which compose the melanin in the skin chromophores. A chromophore is an atom or group of atoms that absorbs light at a specific frequency and so imparts color to a molecule.⁷

Respiratory chain enzymes within the mitochondria and other chromophores buried in the

cell membrane absorb the photons, which causes the mitochondria to go into hyperactivity. Providing additional ATP is thought to aid in cellular healing.⁸ The analgesic effects of low-level laser therapy act on differing levels and are not always clearly defined. Some of the effects include increased levels of β -endorphin in spinal fluid, increased pain threshold through electrolytic block mechanism of nerve fibers (hyper polarization occurs due to the permeability of the membrane of the nerve cells for Na^+/K^+ decreasing), increased levels of serotonin in urinary excretion (central nervous system inhibitor), decreased release of bradykinin (analgesic agent that irritates the receptors of the nerve and causes pain), decrease in histamine release (inflammatory and analgesic agent), increased ATP production, decreased acetylcholine, increased local microcirculation, and increased lymphatic flow.⁹

Because of the inherent wave-particle dualism of electrons, it is appropriate to take into consideration radiation phenomena to help explain the cellular energy transfer. The classical biochemical models use only the particle aspect of the electrons as energy carriers. Depending on its wavelength, electromagnetic radiation in the form of light can stimulate macromolecules, can start conformation changes in proteins, or can transfer energy to electrons. Low-level laser from the red and the near infrared region corresponds well with the characteristic energy and absorption levels of the relevant components of the respiratory chain. This laser stimulation vitalizes the cell by increasing the mitochondrial ATP production.⁶

In January of 2002 the United States Food and Drug Administration gave clearance for the use of low level laser therapy in certain cases, for investigational purposes. Laser therapy is already available in the United States in the veterinary market.

This FDA clearance will cause this field to be studied very carefully in the United States. LLLT has been popularly used in other countries for soft tissue injuries, joint conditions, post-op pain, acupuncture, non-healing wounds and ulcers, and chronic pain. Treatment could be given by a nurse, physiologist, or the physical therapist. Since the skill is in the diagnosis and management of the condition, administering the treatment only involves where to point the laser and for how long.

Parameters:

One of the difficulties in studying low level laser therapy is that there are a large number of variables. There are numerous parameters, such as inclusion criteria, statistical quality, blinding, laser wavelength (nm), power at tissue, power (mW), pulse frequency (Hz), type of pulsing, power density, dosimetry (J/cm^2), treatment intervals, and treatment technique that have been neglected or misused in previous experiments. Mester suggested an optimal dose range for wound healing with HeNe lasers as early as 1971,⁹ but later studies; however, lower doses were used. This caused much confusion as well as some skepticism, because in some cases the doses were not stated, and have been derived indirectly.

Some of the studies that were conducted did not have a true control group. For example, Seichert used GaAs lasers and HeNe lasers in combination in the treatment group and HeNe lasers only in the “placebo” or control group. In that case, the treatment

group received 0.258 J/cm^2 , whereas the control group received 0.134 J/cm^2 , which cannot be regarded as a “placebo” light source.⁹

Treatment Parameters:

Both treatment technique and the subjects treated are important factors affecting outcome. There is often a difference between the total dose administered to the subject, and the local dose administered to the target tissue. This depends both on power, density, and on the method of application.

When studying wound healing, laser irradiations of the outer border of the wound, which is the active healing area, is thought to be much more effective than treatment of the open wound area as a whole. Low-level laser therapy has little effect on healthy tissue or on experimental wounds in healthy individuals, which may explain the difference between clinical and laboratory results.

Simunovic found that trigger points respond well to low level laser therapy, by HeNe 632.8nm visible red or infrared 820-830 nm continuous wave and 904 nm pulsed emission. Trigger points are myofascial zones that are particularly sensitive, have the highest projection of focal pain points due to ischemic conditions, and slow sensory and motor phenomena like pain, tenderness, increased motor unit activity, vasoconstriction, vasodilatation, and hyper secretion, some of which occur at a distance from the actual trigger point. Low-level laser therapy to the trigger points technique was applied in 243 patients in a blind controlled study, using sham irradiation as control. The conditions treated included headaches, facial pain, skeletomuscular ailments, myogenic neck pain,

shoulder and arm pain, epicondylitis, tenosynovitis, low back and radicular pain, and Achilles tendonitis. It was observed that the rigidity decreased, the mobility or the functional recovery was restored, and induced pain decreased or disappeared. In Acute cases, 64.52% of the patients achieved 100% pain relief and 14.52% of the patients achieved 60-90% pain relief. In chronic cases, 24.31% of the patients received 100% pain relief and 35.36% of the patients received 60-90% pain relief. The control group was not mentioned in the results. No negative effects on the human body were found and the use of analgesic drugs could be reduced or completely eliminated.¹⁰ The authors believed that low level laser therapy improved the local microcirculation and improved the oxygen supply to hypoxic cells in the trigger point areas, as well as removing collected waste products.

Acute Injuries:

Usuba, Akai, and Shirasaki compared the effect of low-level laser therapy with sham and whirlpool treatment on the contracted knee joint in Wistar rats. Forty-eight rats were operated on to immobilize the knee joint and one week after the operation they were randomly assigned to four different groups for treatment lasting two weeks. The first group was treated with a 40 mW laser (3.9 W/cm²) with a total dosage of 7.2 J, the second a 60 mW laser (5.8 W/cm²) with a total dosage of 10.8 J, the third were placed in a whirlpool at 42 degrees Celsius, in which the rats were forced to swim for 7 minutes with the help of a harness, and the fourth was treated with a sham laser during which the rats did not receive any active treatment. A tunable Ga-Al-As semiconductor laser was used with a wavelength of 810 nm. The preparation of the bilateral hind legs was done,

the degree of knee contracture was assessed by measuring the knee flexion angle, weight of the gastronemius muscle was recorded, and periarticular connective tissue viscoelasticity measuring phase-lag and stiffness was used. Of the 48 original rats that were entered into the study, 12 of them were eliminated for various reasons. Among the available 36 rats for the analysis, no significant differences were found in the body weight during the study. The stiffness varied widely ($P= 0.0050$) and failed to show any significant differences among the groups.¹¹

In a randomized, double blind, controlled clinical study by de Bie Ra on low level laser therapy in ankle sprains, the efficacy of low level laser therapy on lateral ankle sprains was tested as a complement to a standardized treatment regimen. The trial was conducted with a high-dose laser (5 J/cm^2), low-dose laser ($.5 \text{ J/cm}^2$), and a placebo laser (0 J/cm^2) at skin level. Two hundred and seventeen patients with acute lateral ankle sprains were randomized into the three groups in an ambulatory care setting. Twelve treatments of laser therapy with a wavelength of 904 nm within a four-week timeframe were given as an adjunct to a standardized treatment regimen of four weeks of brace therapy combined with a standardized program of home exercises and advice. The device used was a 904 nm GaAs laser, with 25-watt peak power and 500 Hz frequency, a pulse duration of 200 nanoseconds, and an irradiated area of 1 cm^2 . The primary method of measuring the outcome was pain and function as reported by the patient. de Bie Ra found that the placebo group had slightly less pain, and that the total days missed from work and sports were considerably lower in the placebo group than in the laser groups ($p= .02$).¹² The results of this study are in question because the technique used was not indicated. The study stated, “The probe was placed perpendicularly in the center of the

circumscribed area, directly on the skin.” However, this is not a sufficient description of the treatment method.

Wound healing is also an important aspect of athletic rehabilitation. Simunovic, Ivankovich, and Depolo studied wound healing in an animal model and in human sport and traffic accident injuries, using low-level laser therapy treatment. The main objective of the study was to assess the efficacy of low level-laser therapy on wound healing in rabbits and humans. In a randomized controlled study, the effects of laser irradiation were evaluated on the healing of surgical wounds on rabbits, but it was known that surgical wounds do not produce valid conclusions. The clinical study was performed on 74 patients with injuries to the ankle, knee, Achilles tendon, epicondyl, shoulder, wrist, interphalangeal joints of hands, both bilaterally and unilaterally. Two different lasers were used: an infrared diode laser (GaAlAs) 830 nm continuous wave for treatment of trigger points, and a HeNe 632.8 nm combined with diode laser 904 nm pulsed wave for scanning procedure. Both were applied separately during the study and the results were based on the following parameters: redness, pain, heat, swelling, and loss of function. It was found that the patients who were treated with low-level laser therapy had an accelerated healing time by approximately 25-35%. The main advantages claimed for low-level laser therapy for postoperative sport and traffic related injuries included prevention of side effects of drugs, significantly accelerated functional recovery, earlier return to work, cost benefit, and training and sport competition level compared to the control group of patients.¹³ The results of this study may be biased due to the fact that it was published in the *Journal of Clinical Laser Medicine & Surgery*. Potentially biased articles are used in this literature review mainly because of the sheer lack of information

in peer review journals on low level laser therapy and its potential widespread use in sports medicine.

Broken bones are a common occurrence in the athletic world today. Dortbudak, Hass, and Mialath-Pokorny studied low level laser irradiation on osteocytes and bone resorption at bony implant sites. The subjects chosen for this study were five male baboons with a mean age of 6.5 years. Four holes were drilled in each of the baboons' iliac crests. Sites on the left side were irradiated with a 100 mW low level laser with a wavelength of 690 nm for one minute, with a total dosage of 6 Joules. Immediately afterwards, four sandblasted and etched implants were inserted into the holes. Five days later, the bone was removed en bloc and was evaluated histomorphometrically. The study showed that osteocyte viability was significantly higher in the samples that had been subject to laser irradiation, in comparison to the control sites. However the bone resorption rate was not affected by the laser irradiation. Details of the treatment technique for this study were not given. The study stated, "radiation was applied to the holes in the left iliac crest for one minute with a 100mW low energy (690nm) laser," which is not a sufficient description of the treatment method. The exact type of laser that was used was not indicated, nor was the shape of the laser beam, nor the distance between the laser device and the wound.¹⁴

Chronic Conditions:

Low-level laser therapy may also benefit chronic conditions. For example, a number of sports can produce repetitive stress injuries, such as carpal tunnel syndrome. Rowing, golf, downhill skiing, tennis, archery, repetitive shooting, and rock climbing are

among the activities that stress the hand and wrist joints. Naeser, Hahn, Lieberman, and Branco studied whether real or sham low level laser therapy plus microampere transcutaneous electric nerve stimulation (TENS) applied to acupuncture points significantly reduced pain in carpal tunnel syndrome. It was a randomized, double blind, placebo control, cross over trial that was set in an outpatient, university affiliated Department of Veterans affairs medical center. The participants in the study were eleven mild to moderate carpal tunnel syndrome cases who failed standard medical or surgical treatment for 3 to 30 months. The patients were separated into groups and they received real and sham treatment series, each for a 3 to 4 week period and in a randomized order. Real treatments used continuous wave, 15 mW red beam lasers, with a wavelength of 632.8 nm on shallow acupuncture points on the affected hand. Deeper points on upper extremity and cervical paraspinal areas received a 9.4 watt pulsed infrared laser with a wavelength of 904 nm, and also microampere TENS on the affected wrist. The main outcome was calculated using the McGill Pain Questionnaire (MPQ) score, sensory and motor latencies, and Phalen and Tinel signs. The investigators found that the real treatment series gave significant decreases in MPQ score, median nerve sensory latency, and Phalen and Tinel signs. Patients could perform their previous work and were stable for 1 to 3 years after the treatment was given.¹⁵

Lateral epicondylitis is an overuse disorder that occurs from strenuous or repetitive tasks, and often leads to prolonged disability. Simunovic, T. Trobonjaca, and Z Trobonjaca treated medial and lateral epicondylitis with low level laser therapy. The main objective of the study was to assess the efficacy of low level laser therapy using trigger points and scanner application techniques. The clinical study was conducted at

two different laser centers (Locarno, Switzerland and Opatija, Croatia) as a double blind, placebo controlled, crossover clinical study. 50 of the patients had medial epicondylitis and 274 patients had lateral epicondylitis. The patients were separated into three groups. One group received the trigger point technique, another received the scanner technique, and the last received a combination of the two. A GaAlAs infrared diode laser with an 830 nm continuous wave for treatment of trigger points was used and HeNe 632.8 nm combined with an infrared diode laser with a wavelength of 830 nm pulsed wave was used for the scanner technique. Total energy doses were equally controlled and measured in Joules/cm² during the testing of all three groups. The outcome was measured with the short form of McGill's Pain Questionnaire (SF-MPQ), visual analogue scales (VAS), verbal rating scales (VRS), patient's pain diary, and hand dynamometer. The study found that the best results were obtained using combination treatment ($p < .001$). It also found that under- and over-irradiation dosage can result in the absence of positive therapy effects or even negative effects.¹⁶

Conclusion:

Low level laser therapy shows promise in the field of sports medicine. One of the difficulties in studying low level laser therapy is that there are a large number of variables and because of this, the extent of its applications in sports medicine have not been documented. Some parameters, such as inclusion criteria, statistical quality, blinding, laser wavelength (nm), power at tissue, power (mW), pulse frequency (Hz), type of pulsing, power density, dosimetry (J/cm²), control group, treatment intervals, and treatment technique have been neglected or misused in previous experiments.

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