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Low Level Laser Therapy Research – Sports Medicine

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A summary of
Low Level Lase r Therapy Research
Sports Medicine

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Introduction

Types of laser

Medical professionals will be familiar with the wide range of lasers that are used in modern medicine. These include Erbium:YAG, Argon and the Nd:YAG most often used in surgical situations. These lasers use or have the potential to use “high powers” ranging from fractions of a watt to 25 watts or more.

This document will help introduce evidence for the clinical use of a different type of medical laser – the low level laser.

Low level lasers terminology

Lasers that operate below about 3W are known as "low level lasers" (LLL) and are generally smaller and less expensive than those used in a surgical setting.

The therapy performed with such lasers is often called "Low Level Laser Therapy" (LLLT) or sometimes just “laser therapy” and the lasers are called "therapeutic lasers".

Other treatment terms used include “photobiomodulation”,”laser acupuncture” “biostimulation” and “biomodulation . At other times the equipment can be referred to as a "soft laser", "low intensity level laser", “cold laser”, and “low-power laser”.

These therapeutic lasers generally operate in the visible and the infrared spectrum, 600-900 nm wavelength. However, other wavelengths have been successfully used in laser therapy.

History

Not long after the invention of the laser in 1960, interest in its use in medicine started and reports appeared suggesting beneficial physiological effects of low level laser light. The use of lasers specifically designed for medical use began in 1967 but commercial LLL were very low powered and results were inconsistent. As models with higher powers have appeared the results have improved and the treatment times reduced.

Interpreting the scientific literature

The scientific literature contains thousands of published studies and reports in the domain of laser therapy in healthcare. These include double blind clinical trials. Even with the large range of modalities, experiment design, patient numbers and treatments investigated, 90% report a positive effect of laser therapy.

However, there are a large number of parameters that can be selected when designing these studies (time, intensity, wavelength, area, pulse or continuous, pulse frequency, number of applications). This can help explain a number of negative studies that have also been released. These should not necessarily be taken to mean that LLL therapy in ineffective but that the parameters chosen in those studies were not successful.

This document will highlight significant areas of treatment indications for modern podiatry practice. While some studies are hard to evaluate given the lack of standardisation of parameters in use and their reporting, an overall foundation for clinical use is presented.

In all cases, proper clinical assessment and judgment should be used no matter how impressive the results described – LLLT is not a universal remedy and has specific indications for use. Always use care to select the most appropriate treatment technique and interval with an appropriate dosage for a desirable result.

Sports Medicine

Low level laser therapy can provide several benefits to muscle tissue as evidenced by a plethora of studies. The effects that LLLT exert on muscle tissues are explained by the increased levels of adenosine tri-phosphate ATP, which is the biological source of energy for muscles to work. Several other mechanisms are used to explain the effects on muscle tissue and improvement in sports performance. The effects of LLLT on muscle performance had been assessed in several studies.

Performance

Improvement of Performance and Reduction of Fatigue with Low-Level Laser Therapy in Competitive Cyclists.

Introduction: Evidence indicates that low-level laser therapy (LLLT) minimizes fatigue effects on muscle performance. However, the ideal LLLT dosage to improve athletes'performance during sports activities such as cycling is still unclear. Therefore, the goal of this study was to investigate the effects of different LLLT dosages on cyclists'performance in time-to-exhaustion tests. In addition, the effects of LLLT on the frequency content of the EMG signals to assess fatigue mechanisms were examined.

Conclusion: LLLT increased time to exhaustion in competitive cyclists, suggesting this intervention as a possible nonpharmacological ergogenic agent in cycling. Among the different dosages, LLLT-135 J seems to promote the best effects.

Int J Sports Physiol Perform. 2018 Jan 1;13(1):14-22. doi: 10.1123/ijspp.2016-0187. Epub 2017 Dec 28.

Lanferdini FJ, Bini RR, Baroni BM, Klein KD, Carpes FP, Vaz MA.

Photobiomodulation Therapy on Physiological and Performance Parameters During Running Tests: Dose-Response Effects.

Introduction: This study was aimed at verifying effects of photobiomodulation therapy (PBMT) with different energy doses (15, 30, and 60 J per site) on physiological and performance parameters during running tests.

Conclusion: All PBMT doses positively affected physiological and/or performance parameters; however, magnitude-based inference reported that PBMT applied with 30 J led to more beneficial effects than 15 and 60 J.

Lasers Med Sci. 2018 Oct;32(10):2807-2815. doi: 10.1519/JSC.0000000000002488.

Dellagrana RA, Rossato M, Sakugawa RL, Baroni BM, Diefenthaeler F

Effects of low level laser therapy (808 nm) on physical strength training in humans.

Introduction: Recent studies have investigated whether low level laser therapy (LLLT) can optimize human muscle performance in physical exercise. This study tested the effect of LLLT on muscle performance in physical strength training in humans compared with strength training only.

Conclusion: The TLG was the only group to show an increase in muscle performance in the isokinetic dynamometry test compared with baseline.

Lasers Med Sci. 2011 May;26(3):349-58. doi: 10.1007/s10103-010-0855-0. Epub 2010 Nov 18.

Ferraresi C, de Brito Oliveira T, de Oliveira Zafalon L, de Menezes Reiff RB, Baldissera V, de Andrade Perez SE, Matheucci Júnior E, Parizotto NA.

When is the best moment to apply photobiomodulation therapy (PBMT) when associated to a treadmill endurance-training program? A randomized, triple-blinded, placebo-controlled clinical trial.

Introduction: Photobiomodulation therapy (PBMT) employing low-level laser therapy (LLLT) and/or light emitting diode therapy (LEDT) has emerged as an electrophysical intervention that could be associated with aerobic training to enhance beneficial effects of aerobic exercise. However, the best moment to perform irradiation with PBMT in aerobic training has not been elucidated. The aim of this study was to assess the effects of PBMT applied before and/or after each training session and to evaluate outcomes of the endurance-training program associated with PBMT.

Conclusion: PBMT applied before and after sessions of aerobic training during 12 weeks can increase the time-to-exhaustion and oxygen uptake and also decrease the body fat in healthy volunteers when compared to placebo irradiation before and after exercise sessions. Our outcomes show that PBMT applied before and after endurance-training exercise sessions lead to improvement of endurance three times faster than exercise only.

Lasers Med Sci. 2018 May;33(4):719-727. doi: 10.1007/s10103-017-2396-2. Epub 2017 Nov 29.

Miranda EF, Tomazoni SS, de Paiva PRV, , Pinto HD, Smith D, Santos LA, de Tarso Camillo de Carvalho P, Leal-Junior ECP

Low-level laser therapy (LLLT) in human progressive-intensity running: effects on exercise performance, skeletal muscle status, and oxidative stress.

Introduction: The aim of this work was to evaluate the effects of low-level laser therapy (LLLT) on exercise performance, oxidative stress, and muscle status in humans. A randomized double-blind placebo-controlled crossover trial was performed with 22 untrained male volunteers.

Conclusion: The application of LLT 5 minutes before a progressive-intensity running protocol significantly increased exercise performance, post-exercise and decreased biomarkers of muscular damage compared to placebo. Overall the effect of LLLT application before exercise reduced oxidative stress and muscle damage and improved exercise performance. One possible explanation for the improved post-exercise muscular recovery to the reduction of the exercise induced oxidative stress at muscular level.

Lasers Med Sci. 2012 Jan;27(1):231-6. doi: 10.1007/s10103-011-0955-5. Epub 2011 Jul 8.

De Marchi T, Leal Junior EC, Bortoli C, Tomazoni SS, Lopes-Martins RA, Salvador M.

Effects of low-level laser therapy (808 nm) on isokinetic muscle performance of young women submitted to endurance training: a randomized controlled clinical trial.

Introduction: Low-level laser therapy (LLLT) has shown efficacy in muscle bioenergetic activation and its effects could influence the mechanical performance of this tissue during physical exercise. This study tested whether endurance training associated with LLLT could increase human muscle performance in isokinetic dynamometry when compared to the same training without LLLT. The primary objective was to determine the fatigue index of the knee extensor muscles (FIext) and the secondary objective was to determine the total work of the knee extensor muscles (TWext).

Conclusion: The results suggest that an endurance training program combined with LLLT leads to a greater reduction in fatigue than an endurance training program without LLLT. This is relevant to everyone involved in sport and rehabilitation.

Vieira WH, Ferraresi C, Perez SE, Baldissera V, Parizotto NA.

Lasers Med Sci. 2012 Mar;27(2):497-504. doi: 10.1007/s10103-011-0984-0. Epub 2011 Aug 26.

Effect of phototherapy (low-level laser therapy and light-emitting diode therapy) on exercise performance and markers of exercise recovery: a systematic review with meta-analysis.

Introduction: Recent studies have explored if phototherapy with low-level laser therapy (LLLT) or narrow-band light-emitting diode therapy (LEDT) can modulate activity-induced skeletal muscle fatigue or subsequently protect against muscle injury. We performed a systematic review with meta-analysis to investigate the effects of phototherapy applied before, during and after exercises.

Conclusion: The most significant and consistent results were found with red or infrared wavelengths and phototherapy application before exercises, power outputs between 50 and 200 mW and doses of 5 and 6 J per point (spot). We conclude that phototherapy (with lasers and LEDs) improves muscular performance and accelerate recovery mainly when applied before exercise. Positive doses were observed for the use of LLLT and LEDT, both separately or in combination.

Lasers Med Sci. 2015 Feb;30(2):181-214. doi: 10.1007/s10103-017-2368-6. Epub 2017 Oct 31.

Vanin AA, Verhagen E, Barboza SD, Costa LOP, Leal-Junior ECP

Photobiomodulation in human muscle tissue: an advantage in sports performance?

Introduction: A systematic review investigating the role of photo biomodulation on sport performance. 46 studies were analyzed comprising randomized control trials and case-control studies in healthy trained and untried participants or elite athletes.

Conclusion: All types of photo biomodulation therapies including LLLT, can decrease inflammation and oxidative stress after training and increase muscle mass gain after training. Considering its efficacy as an ergogenic agent the question raised is if this therapy should be permitted in athletic competitions by authorities.

J Biophotonics. 2016 Dec;9(11-12):1273-1299. doi: 10.1002/jbio.201600176. Epub 2016 Nov 22.

Ferraresi C, Huang YY, Hamblin MR

Photobiomodulation therapy for the improvement of muscular performance and reduction of muscular fatigue associated with exercise in healthy people: a systematic review and meta-analysis.

Introduction: Studies have been performed to investigate the effects of phototherapy on improving performance and reduction of muscular fatigue. However, a great variability in the light parameters and protocols of the trials are a concern to establish the efficacy of this therapy to be used in sports or clinic. The aim of this study is to investigate the effectiveness, moment of application of phototherapy

within an exercise protocol, and which are the parameters optimally effective for the improvement of muscular performance and the reduction of muscular fatigue in healthy people.

Conclusion: Most of positive results were observed with an energy dose range from 20 to 60 J for small muscular groups and 60 to 300 J for large muscular groups and maximal power output of 200 mW per diode.

Lasers Med Sci. 2018 Jan;33(1):181-214. doi: 10.1007/s10103-017-2368-6. Epub 2017 Oct 31. Review.

Vanin AA, Verhagen E, Barboza SD, Costa LOP, Leal-Junior ECP.

Recovery

Pre-Exercise Infrared Photobiomodulation Therapy (810 nm) in Skeletal Muscle Performance and Postexercise Recovery in Humans: What Is the Optimal Power Output?

Introduction: Photobiomodulation therapy (PBMT) has recently been used to alleviate postexercise muscle fatigue and enhance recovery, demonstrating positive results. The aim of the present study was to evaluate the effects of PBMT (through low-level laser therapy) on postexercise skeletal muscle recovery and identify the best output power.

Conclusion: PBMT with 100 mW power output per diode (500 mW total) before exercise achieves best outcomes in enhancing muscular performance and postexercise recovery. Another time it has been demonstrated that more power output is not necessarily better.

Photomed Laser Surg. 2017 Nov;35(11):595-603. doi: 10.1089/pho.2017.4343.

de Oliveira AR, Vanin AA, Tomazoni SS, Miranda EF, Albuquerque-Pontes GM, De Marchi T, Dos Santos Grandinetti V, de Paiva PRV, Imperatori TBG, de Carvalho PTC, Bjordal JM, Leal-Junior ECP

Effects of pre- or post-exercise low-level laser therapy (830 nm) on skeletal muscle fatigue and biochemical markers of recovery in humans: double-blind placebo-controlled trial.

Introduction: The purpose of this study was to investigate the effect of low-level laser therapy (LLLT) before and after exercise on quadriceps muscle performance, and to evaluate the changes in serum lactate and creatine kinase (CK) levels.

Conclusion: Laser application either before or after fatigue reduced the post-fatigue concentrations of serum lactate and CK. The results were more pronounced in the post-fatigue laser group.

Photomed Laser Surg. 2014 Feb;32(2):106-12. doi: 10.1089/pho.2013.3617. Epub 2014 Jan 23.

Dos Reis FA, da Silva BA, Laraia EM, de Melo RM, Silva PH, Leal-Junior EC, de Carvalho Pde T

Does photobiomodulation therapy is better than cryotherapy in muscle recovery after a high-intensity exercise? A randomized, double-blind, placebo-controlled clinical trial.

Introduction: Cryotherapy is often used as a technique for muscle recovery. This study aimed to determine the effectiveness of photobiomodulation therapy (PBMT) and cryotherapy, in isolated and combined forms, as muscle recovery techniques after muscle fatigue-inducing protocol.

Conclusion: Phototherapy alone proved to be more effective than the use of cryotherapy for muscle recovery. A significant increase in the Muscular Isometric voluntary contraction and a decrease in the blood biomarkers of oxidative damage was observed when phototherapy was applied in the post-training session period.

Lasers Med Sci. 2017 Feb;32(2):429-437. doi: 10.1007/s10103-016-2139-9. Epub 2017 Jan 5.

De Marchi T, Schmitt VM, Machado GP, de Sene JS, de Col CD, Tairova O, Salvador M, Leal-Junior EC

Photobiomodulation therapy (PBMT) and/or cryotherapy in skeletal muscle restitution, what is better? A randomized, double-blinded, placebo-controlled clinical trial.

Introduction: Photobiomodulation therapy (PBMT) studies (with both low-level laser therapy and light-emitting diode therapy) have demonstrated positive scientific evidence to suggest its use. The study aims to evaluate PBMT and cryotherapy as a single or combined treatment on skeletal muscle recovery after eccentric contractions of knee extensors.

Conclusion: PBMT used as single treatment is the best modality for enhancement of post-exercise restitution, leading to complete recovery to baseline levels from 24 h after high-intensity eccentric contractions.

Lasers Med Sci. 2016 Dec;31(9):1925-1933. Epub 2016 Sep 13.

de Paiva PR, Tomazoni SS, Johnson DS, Vanin AA, Albuquerque-Pontes GM, Machado CD, Casalechi HL, de Carvalho PT, Leal-Junior EC

Effect of 830 nm low-level laser therapy applied before high-intensity exercises on skeletal muscle recovery in athletes.

Introduction: Levels of different biochemical markers such as lactate, creatine kinase and c-reactive protein are measured in the blood to evaluate the effect of exercise on muscle fatigue/recovery. Low levels of these biomarkers after a training session indicate a faster muscle recovery and consequently improved athletic performance. In vitro and animal studies have suggested that the use of LLLT can reduce oxidative stress and inflammatory response in muscle tissues. This evidence has supported its use before training to enhance recovery. Our aim was to investigate the immediate effects of bilateral, 830 nm, low-level laser therapy (LLLT) on high-intensity exercise and biochemical markers of skeletal muscle recovery, in a randomised, double-blind, placebo-controlled, crossover trial set in a sports physiotherapy clinic.

Conclusion: LLLT irradiation before the Wingate test seemed to inhibit an expected post-exercise increase in CK level and to accelerate post-exercise lactate removal without affecting test performance. These findings suggest that LLLT may be of benefit in accelerating post-exercise recovery.

Lasers Med Sci. 2009 Nov;24(6):857-63. doi: 10.1007/s10103-008-0633-4. Epub 2008 Dec 5.

Leal Junior EC, Lopes-Martins RA, Baroni BM, De Marchi T, Taufer D, Manfro DS, Rech M, Danna V, Grosselli D, Generosi RA, Marcos RL, Ramos L, Bjordal JM.

Effects of low-level laser therapy (LLLT) in the development of exercise-induced skeletal muscle fatigue and changes in biochemical markers related to postexercise recovery.

Introduction: Cell and animal studies have suggested that LLLT can reduce oxidative stress and inflammatory responses in muscle tissue. But it remains uncertain whether these findings can translate into humans in sport and exercise situations. The objective of this study was to investigate if low-level laser therapy (LLLT) can affect biceps muscle performance, fatigue development, and biochemical markers of postexercise recovery.

Conclusion: Pre-exercise irradiation of the biceps with an LLLT dose of 6 J per application location, applied in 2 locations, increased endurance for repeated elbow flexion against resistance and decreased postexercise levels of blood lactate, creatine kinase, and C-reactiveprotein.

J Orthop Sports Phys Ther. 2010 Aug;40(8):524-32. doi: 10.2519/jospt.2010.3294.

Leal Junior EC, Lopes-Martins RA, Frigo L, De Marchi T, Rossi RP, de Godoi V, Tomazoni SS, Silva DP, Basso M, Filho PL, de Valls Corsetti F, Iversen VV,, Bjordal JM.

The effect of MLS Laser Therapy in élite football players affected by muscles injuries: a controlled clinical trial

Introduction: Muscle injuries are frequent in élite football players, with a percentage of 30-40% of all injuries. The 22% of total injuries are muscular relapses. The focus of this study was to evaluate how the laser therapy could modify the recovery time in élite football player. The treatments have been performed with a Multiwave Locked System (MLS) laser. The sample group of football players was divided into two groups: the first group has been subjected to the standard rehabilitation program without MLS laser irradiation, the second group has been treated with the new rehabilitation program that included laser therapy.
Conclusion: We compared the average injury's duration in the two groups to establish the efficacy of the MLS laser treatment in accelerating rehabilitation. In spite of a positive trend observed in the laser-treated group, which showed a decrease of the recovery time on the basis of the lesions considered, the difference in comparison with the control group was not statistically significant, also due to the low number of patients considered. Therefore, the results suggest that laser therapy could be useful to shorten the recovery time after muscle injury, but further studies with a larger number of cases are required to statistically demonstrate the efficacy of the MLS laser therapy.

Energy for Health [10] 2013
Galanti G., Stefani L., Iacchi A., Lonero L., Moretti A.

Does phototherapy enhance skeletal muscle contractile function and postexercise recovery? A systematic review.

Introduction: Recently, researchers have shown that phototherapy administered to skeletal muscle immediately before resistance exercise can enhance contractile function, prevent exercise-induced cell damage, and improve postexercise recovery of strength and function. Objective being to critically evaluate original research addressing the ability of phototherapeutic devices, such as lasers and light-emitting diodes (LEDs), to enhance skeletal muscle contractile function, reduce exercise-induced muscle fatigue, and facilitate postexercise recovery. In total, 12 randomized controlled trials met the inclusion criteria.

Conclusion: Exposing skeletal muscle to single-diode and multidiode laser or multidiode LED therapy was shown to positively affect physical performance by delaying the onset of fatigue, reducing the fatigue response, improving postexercise recovery, and protecting cells from exercise-induced damage. Phototherapy administered before resistance exercise consistently has been found to provide ergogenic and prophylactic benefits to skeletal muscle.

J Athl Train. 2013 Jan-Feb;48(1):57-67. doi: 10.4085/1062-6050-48.1.12.

Borsa PA, Larkin KA, True JM.

Effects of low-level laser therapy on skeletal muscle repair: a systematic review

Introduction: A review of the literature was performed to demonstrate the most current applicability of low-level laser therapy (LLLT) for the treatment of skeletal muscle injuries, addressing different lasers, irradiation parameters, and treatment results in animal models. A systematic review critically evaluated results from 17 studies about the effects of LLLT on muscle repair.

Conclusion: The analyzed studies demonstrated positive effects of LLLT on muscle repair process considering different parameters such reduction of inflammatory process, increased angiogenesis and modulation of growth factors and myogenic regulatory factors.

Am J Phys Med Rehabil. 2014 Dec;93(12):1073-85. doi: 10.1097/PHM.0000000000000158.

Alves AN, Fernandes KP, Deana AM, Bussadori SK, Mesquita-Ferrari RA.

Physiological

Low-level laser therapy improves the VO2 kinetics in competitive cyclists.

Introduction: This study was designed to explain possible mechanism for the improved performance of observed with the use of LLLT. This study involved competitive cyclists who performed a cycling test to exhaustion.

Conclusion: In conclusion, LLLT decreases tau and O_2 deficit during time-to-exhaustion tests in competitive cyclists, and these changes in VO_2 kinetics response can be one of the possible mechanisms to explain the ergogenic effect induced by LLLT.

Lasers Med Sci. 2018 Apr;33(3):453-460. doi: 10.1007/s10103-017-2347-y. Epub 2017 Nov 9.

Lanferdini FJ, Krüger RL, Baroni BM, Lazzari C, Figueiredo P, Reischak-Oliveira A, Vaz MA

Acute effects of low-level laser therapy on physiologic and electromyographic responses to the cardiopulmonary exercise testing in healthy untrained adults.

Introduction: Despite the positive effects of low-level laser therapy (LLLT) on muscle fatigue before exercises using a single muscle group, the acute effects of LLLT on performance in cardiopulmonary exercise testing (CPET) are poorly understood. We aimed to assess the acute effects of LLLT on physiologic and electromyographic responses to the CPET in healthy adults.

Conclusion: The LLLT acutely increases exercise performance in healthy untrained adults probably due to increased O2 extraction by peripheral muscles without causing a significant impact on muscle fatigue.

Lasers Med Sci. 2014 Nov;29(6):1945-51. doi: 10.1007/s10103-014-1595-3. Epub 2014 Jun 13.

da Silva Alves MA, Pinfildi CE, Neto LN, Lourenço RP, de Azevedo PH, Dourado VZ.

Muscle fatigue

Effect of pre-exercise phototherapy applied with different cluster probe sizes on elbow flexor muscle fatigue

Introduction: Phototherapy has been used for reducing muscle fatigue. In view of the various types of phototherapy cluster probes available in the market, the purpose of this study was to compare the effects of a similar phototherapy dosage with two different cluster probes on elbow flexor muscle fatigue: small cluster probe (SC = 9 diodes; 7.5 cm(2)) vs. large cluster probe (LC = 33 diodes; 30.2 cm(2)).

Conclusion: The effect of pre-exercise application of large and small phototherapy probes on elbow flexor muscle fatigue was measured resulting in a higher time to exhaustion for both types of probes. A significant reduction in fatigue parameters in elbow muscle flexor was observed without difference between two types of probes.

Lasers Med Sci. 2016 Aug;31(6):1237-44. doi: 10.1007/s10103-016-1973-0. Epub 2016 Jun 6.

Rossato M, Dellagrana RA,Lanferdini FJ, Sakugawa RL, Lazzari CD, Baroni BM, Diefenthaeler F

Time Response of Photobiomodulation Therapy on Muscular Fatigue in Humans.

Introduction: The aim of this study was to identify the effects of 2 different time responses on fatigue of knee extensor.

Conclusion: When phototherapy was applied to knee extensor using different time protocols, muscular fatigue evaluated using different parameters such as peak torque during maximal isometric voluntary contraction were significatively reduced on the test group with respect to placebo, and this was particularly when phototherapy was applied 6 hours +immediately before exercise protocol.

J Strength Cond Res. 2018 Nov;32(11):3285-3293. doi: 10.1519/JSC.0000000000002339.

Rossato M, Dellagrana RA, Sakugawa RL, Lazzari CD, Baroni BM, Diefenthaeler F

Application of MLS laser on muscular contracture caused by functional overload in a young athlete - case report

Introduction: Myalgic fatigue (or muscular contracture caused by functional overload) is clinically detected as an unpleasant feeling of one or more muscles, that appears within 24 hours after exercise and disappears in 5-7 days.

Results: The athlete was available to work with the team after 3 days of treatment. We joined the athlete to the team according to subjective symptoms and to the clinical examination negative for pain and muscle contracture.

Discussion: The prognosis of a muscle contracture is 5-7 days as usually found in clinical experience. The athlete treated according to the new protocol was cured in just 3 days of therapies with no recurrence or new muscle injury. We should note that the injury occurred during the preseason, so the athlete was subjected to treatment twice a day rather than once, as often happens during the season. However, the result is very encouraging. Studies are in progress to confirm our findings increasing the number of cases and also evaluating the efficacy of MLS laser therapy on different the types of injury

G. Galanti, A. Moretti, L. Lo Nero

Energy For Health Vo 8 (2012)

Effect of 830 nm low-level laser therapy in exercise-induced skeletal muscle fatigue in humans.

Introduction: This study aimed to investigate the effect of 830 nm low-level laser therapy (LLLT) on skeletal muscle fatigue. Ten healthy male professional volleyball players entered a crossover randomized double-blinded placebo-controlled trial. Active LLLT (830 nm wavelength, 100 mW output, spot size 0.0028 cm(2), 200 s total irradiation time) or an identical placebo LLLT was delivered to four points on the biceps humeri muscle immediately before exercises. All subjects performed voluntary biceps humeri contractions with a load of 75% of the maximum voluntary contraction (MVC) force until exhaustion. After active LLLT the mean number of repetitions was significantly higher than after placebo irradiation [mean difference 4.5, standard deviation (SD) +/- 6.0, P = 0.042], the blood lactate levels increased after exercises, but there was no significant difference between the treatments.

Conclusion: We conclude that 830nm LLLT can delay the onset of skeletal muscle fatigue in high-intensity exercises, inspite of increased blood lactate levels.

Leal Junior EC, Lopes-Martins RA, Vanin AA, Baroni BM, Grosselli D, De Marchi T, Iversen VV, Bjordal JM.

Lasers Med Sci. 2009 May;24(3):425-31. doi: 10.1007/s10103-008-0592-9. Epub 2008 Jul 23.

Effect of cluster multi-diode light emitting diode therapy (LEDT) on exercise-induced skeletal muscle fatigue and skeletal muscle recovery in humans.

Introduction: There are some indications that low-level laser therapy (LLLT) may delay the development of skeletal muscle fatigue during high-intensity exercise. There have also been claims

that LED cluster probes may be effective for this application however there are differences between LED and laser sources like spot size, spectral width, power output, etc. In this study we wanted to test if light emitting diode therapy (LEDT) can alter muscle performance, fatigue development and biochemical markers for skeletal muscle recovery in an experimental model of biceps humeri muscle contractions.

Conclusion: We conclude that this particular procedure and dose of LEDT immediately before exhastive biceps humeri contractions, causes a slight delay in the development of skeletal muscle fatigue, decreases post-exercise blood lactate levels and inhibits the release of Creatine Kinase and C-Reactive protein.

Leal Junior EC, Lopes-Martins RA, Rossi RP, De Marchi T, Baroni BM, de Godoi V, Marcos RL, Ramos L, Bjordal JM.

Lasers Surg Med. 2009 Oct;41(8):572-7. doi: 10.1002/lsm.20810.

Prevention

Effect of low-level laser therapy on muscle adaptation to knee extensor eccentric training.

Introduction: Eccentric training has been popularized for physical conditioning and prevention/rehabilitation of musculoskeletal disorders, especially due to the expressive responses in terms of muscular strength gain. In view of evidence that low-level laser therapy (LLLT) is able to increase exercise performance and accelerate post-exercise recovery, the aim of this study was to verify the effect of LLLT on hypertrophy and strengthening of knee extensor muscles submitted to eccentric training.

Conclusion: LLLT applied before eccentric training sessions seems to improve the hypertrophic response and muscular strength gain in healthy subjects.

Eur J Appl Physiol. 2015 Mar;115(3):639-47. doi: 10.1007/s00421-014-3055-y. Epub 2014 Nov 23.

Baroni BM, Rodrigues R, Freire BB, Franke Rde A, Geremia JM, Vaz MA.

Photobiomodulation therapy as a tool to prevent hamstring strain injuries by reducing soccer-induced fatigue on hamstring muscles.

Introduction: Muscle fatigue is a potential risk factor for hamstring strain injuries in soccer players. The aim of this study was to verify the effect of photobiomodulation therapy (PBMT) on the hamstrings' muscle fatigue of soccer players during a simulated match.

Conclusion: Magnitude-based inference supports that PBMT promoted 75%, 69%, and 53% chances for beneficial effects on hamstring eccentric peak torque, hamstring-to-quadriceps torque ratio, and CMJ height, respectively, compared to placebo treatment. PBMT applied before a simulated soccer match proved to be effective in attenuating the hamstrings' muscle fatigue. These findings support PBMT as a promising tool to prevent hamstring strain injury in soccer players.

Lasers Med Sci. 019 Aug;34(6):1177-1184. doi: 10.1007/s10103-018-02709-w. Epub 2019 Jan 3.

Dornelles MP, Fritsch CG, Sonda FC, Johnson DS, Leal-Junior ECP, Vaz MA, Baroni BM

Effects of Low-Level Laser Therapy Applied Before Treadmill Training on Recovery of Injured Skeletal Muscle in Wistar Rats.

Introduction: The aim of this study was to analyze the effects of low-level laser therapy (LLLT) when associated with treadmill training on the recovery of skeletal muscle, during two periods of rest after muscle injury in rats.

CONCLUSIONS: The LLLT applied before the physical exercise on the treadmill stimulated the angiogenesis and accelerated the process of muscle recovery.

Photomed Laser Surg. 2016 May;34(5):187-93. doi: 10.1089/pho.2015.4031. Epub 2016 Apr 8.

Adabbo M, Paolillo FR, Bossini PS, Rodrigues NC, Bagnato VS, Parizotto NA.

Sport Injuries

Based on data from several published studies LLLT has shown promising results for the treatment of sport injuries. When administered at proper intensity and for an adequate length of time LLLT relives pain for many of these conditions.

Low level laser therapy for sports injuries

Introduction: The aims of this study was to evaluate the efficacy of LLLT for sports injuries. 124 patients involved in different sport disciplines were treated for several sport injuries using LLLT. Patients were irradiated at points of pain and/or acupuncture points, mean treatment 4.1 times, administered in a single week.

Conclusion: Authors of this study evaluated efficacy of treatment using a pain relief score and concluded that LLLT is clinically useful for pain relive. The rate of effectiveness, in the case of irradiation by a physician, was reported to be 100%.

Laser Ther 2013; 22(1): 17–20. doi: 10.5978/islsm.13-OR-01

Yusuke Morimoto, Akiyoshi Saito, Yasuaki Tokuhashi

Immediate pain relief effect of low level laser therapy for sports injuries: Randomized, double-blind placebo clinical trial.

Introduction: The efficacy of LLLT for pain relief due to different sport injuries has been demonstrated in Randomized Clinical Trials. Objectives being to determine the immediate pain relief effect of low-level laser therapy on sports injuries in athletes and degree of pain relief by the therapy.

Conclusion: Low-level laser therapy provided an immediate pain relief effect, reducing pain by 28.74%. It was effective for pain relief in 75% of participants.

J Sci Med Sport. 2016 Dec;19(12):980-983. doi: 10.1016/j.jsams.2016.03.006. Epub 2016 Mar 24.

Takenori A, Ikuhiro M, Shogo U, Hiroe K, Junji S, Yasutaka T, Hiroya K, Miki N

830 nm light-emitting diode (led) phototherapy significantly reduced return-to-play in injured university athletes: a pilot study.

Introduction: For any committed athlete, getting back to conditioning and participation post-injury (return to play [RTP]) needs to be as swift as possible. The effects of near-infrared light-emitting diode (LED) therapy on pain control, blood flow enhancement and relaxation of muscle spasm (all aspects in the treatment of musculoskeletal injury) have attracted attention. The present pilot study was undertaken to assess the role of 830 nm LED phototherapy in safely accelerating RTP in injured university athletes.

CONCLUSIONS: For any motivated athlete, RTP may be the most important factor postinjury based on the resolution of pain and inflammation and repair to tissue trauma. 830 nm LED phototherapy significantly and safely reduced the RTP in dedicated university athletes over a wide range of injuries with no adverse events. One limitation of the present study was the subjective nature of the assessments, and the lack of any control groups. However, further controlled studies are warranted to enable confirmation and generalization of the very good results in the present study.

Laser Ther. 2016 Mar 31;25(1):35-42. doi: 10.5978/islsm.16-OR-03.

Foley J, Vasily DB, Bradle J, Rudio C, Calderhead RG.

Low-level laser treatment can reduce edema in second degree ankle sprains.

Introduction: Low-level laser therapy (LLLT) has been used for the last few years to treat sports injuries. The purpose of this study was to compare three therapeutic protocols in treating edema in second degree ankle sprains that did not require immobilization with a splint, under placebo-controlled conditions.

Conclusion: LLLT combined with RICE can reduce edema in second-degree ankle sprains.

Stergioulas A.

J Clin **Laser** Med Surg. 2004 Apr;22(2):125-8.

Five-day, low-level laser therapy for sports-related lower extremity periostitis in adult men: a randomized, controlled trial.

Introduction: Periostitis in the lower leg caused by overexercise is a universal problem in athletes and runners. The purpose of this study was to observe the functional improvement of the lower limbs upon rehabilitation low-level laser therapy (LLLT).

Conclusion: LLLT had a positive effect on propriorception in patients with lower limb periostitis. Larger, better controlled studies are needed to determine what specific effects LLLT has on the function of proprioception

Lasers Med Sci. 2014 Jul;29(4):1485-94. doi: 10.1007/s10103-014-1554-z. Epub 2014 Mar 13.

Chang CC[1], Ku CH, Hsu WC, Hu YA, Shyu JF, Chang ST.

Tendinopathy

Considering LLLT benefit not only pain relief but can aid the treatment of injuries resulting from sport practice. One sub-area researchers are investigating is the effectiveness of LLLT for the treatment of tendinopathy. Among these conditions Achilles tendonitis is a painful condition, occurring commonly among recreational runners. It is quite debilitating, causing great difficulty walking especially in the acute phase. Some studies have evaluated the added effect of LLLT to the Eccentric exercise, in treatment of these condition.

Effects of low-level laser therapy and eccentric exercises in the treatment of recreational athletes with chronic achilles tendinopathy.

Introduction: This was a double blinded randomized control trial. Authors evaluated pain at different time intervals, up to 8 week and other clinical parameters.

Conclusion: Low-level laser therapy, with the parameters used in this study, accelerates clinical recovery from chronic Achilles tendinopathy when added to an EE regimen. For the LLLT group, the results at 4 weeks were similar to the placebo LLLT group results after 12 weeks.

Am J Sports Med. 2008 May;36(5):881-7. doi: 10.1177/0363546507312165. Epub 2008 Feb 13.

Stergioulas A, Stergioula M, Aarskog R, Lopes-Martins RA, Bjordal JM.

A systematic review with procedural assessments and meta-analysis of low level laser therapy in lateral elbow tendinopathy (tennis elbow)

Introduction: Recent reviews have indicated that low level level laser therapy (LLLT) is ineffective in lateral elbow tendinopathy (LET) without assessing validity of treatment procedures and doses or the influence of prior steroid injections.

Conclusion: LLLT administered with optimal doses of 904 nm and possibly 632 nm wavelengths directly to the lateral elbow tendon insertions, seem to offer short-term pain relief and less disability in LET, both alone and in conjunction with an exercise regimen. This finding contradicts the conclusions of previous reviews which failed to assess treatment procedures, wavelengths and optimal doses.

BMC Musculoskelet Disord 2008 May 29; 9:75. doi: 10.1186/1471-2474-9-75.

Bjordal JM, Lopes-Martins RA, Joensen J, Couppe C, Ljunggren AE, Stergioulas A, Johnson MI.

Low level laser treatment of tendinopathy: a systematic review with meta-analysis.

Introduction: LLLT is proposed as a possible treatment for tendon injuries. However, the clinical effectiveness of this modality remains controversial, with limited agreement on the most efficacious dosage and parameter choices.

Conclusion: LLLT can potentially be effective in treating tendinopathy when recommended dosages are used. The 12 positive studies provide strong evidence that positive outcomes are associated with the use of current dosage recommendations for the treatment of tendinopathy.

Photomed Laser Surg. 2010 Feb;28(1):3-16. doi: 10.1089/pho.2008.2470

Tumilty S, Munn J, McDonough S, Hurley DA, Basford JR, Baxter GD.

MLS® Laser Therapy in the treatment of patients affected by Tendinopathies

The results obtained in this study show that the treatment with a high power, dual wavelength NIR laser source is effective in inducing inhibition of pain referred by patients affected by tendinopathies.

Energy for Health [16] (2017)

L. Vignali, G. Caruso, S. Gervasi, F. Cialdai

A randomised, placebo controlled trial of low level laser therapy for activated Achilles tendinitis with microdialysis measurement of peritendinous prostaglandin E2 concentrations.

LLLT at a dose of 5.4 J per point can reduce inflammation and pain in activated Achilles tendinitis. LLLT may therefore have potential in the management of diseases with an inflammatory component.

Br J Sports Med. 2006 Jan;40(1):76-80; discussion 76-80.

Bjordal JM[1], Lopes-Martins RA, Iversen VV.

Comparing the effects of exercise program and low-level laser therapy with exercise program and polarized polychromatic non-coherent light (bioptron light) on the treatment of lateral elbow tendinopathy.

The results suggest that the combination of an exercise program with LLLT or polarized polychromatic non-coherent light is an adequate treatment for patients with LET. Further research to establish the relative and absolute effectiveness of such a treatment approach is needed.

Photomed Laser Surg. 2009 Jun;27(3):513-20. doi: 10.1089/pho.2008.2281.

Stasinopoulos D[1], Stasinopoulos I, Pantelis M, Stasinopoulou K.