Photontherapy and sports

Research abstracts in treating sport related disorders

Clinical intervention study's with photontherapy have been done for several sport related disorders, which are listed below. These studies have been done with different instruments which radiate laserlight with a great variability in the light parameters, such as wave length, intensity and pulsation. The effects of low intensity infrared laserlight depend on these specific parameters.

The parameters of the laser instruments of Medifoton and Medical Electronics are:

- **Wavelength: infrared laser 785 nm + red led 630 nm**
- **Intensity: very low 6 mW**
- **Pulsation: poly frequency spectrum 0,6 Hz – 600 kHz + Alpha brainfrequency 10,4 Hz**

Table of content

Introduction photontherapy and sports

An excellent solution

Benefits of photontherapy have been known for several decades. More recently, it's used in sport medicine, mostly with very good effect. Photontherapy applied in sports offers a special chance to support the performance and recovery. Increasingly complex physical activities and fierce competition in the world of sports generate a state of psycho-emotional and physical stress that can induce chronic fatigue syndrome, failure in physical training, predisposition to muscle damage, physical and emotional exhaustion etc., for which photontherapy could be an excellent solution.

Photontherapy is also an effective treatment for sports injuries because of it's alleviation of pain and inflammation and it's promotion of wound healing and tissue regeneration. Another reason to use photontherapy is the adverse effects of NSAIDs. Laboratory research shows that use of steroids and Non-Steroidal Anti-Inflammatories (NSAIDs) reduce healing, doubles the risk of sudden heart failure and is not tolerated by some people. Laser on the other hand improves healing, achieves better pain relief when compared in clinical trials and has no side effects. With over 200 randomised double blind placebo controlled clinical trials (RCTs) published in peer reviewed scientific journals, photontherapy has a very strong evidence base in rehabilitation medicine and should be used as the first therapeutic intervention after injury and instead of NSAIDs.

Terminology

Photontherapy research is hard to track down because authors use different names for this therapy. There is clearly a lack of consistency and consensus on terminology. The most frequently used term is low-level laser therapy (LLLT). The World Association for Laser Therapy advises the universal use of the new term Photobiomodulation therapy (PBMT).

A few of the other names previously used for this therapy have included:

- Soft Laser Therapy
- Low-Intensity Laser Therapy
- Cold Laser Therapy
- Photobiostimulation
- Low Energy Photon Therapy

MeSH term

Low Level Light Therapy is the often-cited Medical Subject Headings (MeSH) term contained in the National Library of Medicine's controlled vocabulary thesaurus. The term photobiomodulation therapy (PBMT) is added to the MeSH database since 2016. The term Low Level Laser Therapy generates the most results on PubMed: 8.918.

Other entry terms

- Light Therapies, Low-Level
- Light Therapy, Low-Level
- Low Level Light Therapy
- Low-Level Light Therapies
- Therapies, Low-Level Light
- Therapy, Low-Level Light
- Photobiomodulation Therapy
- Photobiomodulation Therapies
- Therapies, Photobiomodulation
- Therapy, Photobiomodulation
- LLLT
- Laser Therapy, Low-Level
- Laser Therapies, Low-Level
- Laser Therapy, Low Level
- Low-Level Laser Therapies
- Laser Irradiation, Low-Power
- Irradiation, Low-Power Laser
- Laser Irradiation, Low Power
- Low-Power Laser Therapy
- Low Power Laser Therapy
- Laser Therapy, Low-Power
- Laser Therapies, Low-Power
- Laser Therapy, Low Power
- Low-Power Laser Therapies
- Low-Level Laser Therapy
- Low Level Laser Therapy
- Low-Power Laser Irradiation
- Low Power Laser Irradiation
- Laser Biostimulation
- Biostimulation, Laser
- Laser Phototherapy
- Phototherapy, Laser

Introduction photontherapy and sports

Definitions Photobiomodulation therapy

"The therapeutic use of light [e.g. visible, near infrared (NIR), infrared (IR)] absorbed by endogenous chromophores, triggering non-thermal, non cytotoxic, biological reactions through photochemical or photophysical events, leading to physiological changes".

"A form of light therapy that utilizes non-ionizing forms of light sources, including lasers, LEDs, and broadband light, in the visible and infrared spectrum. It is a nonthermal process involving endogenous chromophores eliciting photophysical (i.e., linear and nonlinear) and photochemical events at various biological scales. This process results in beneficial therapeutic outcomes including but not limited to the alleviation of pain or inflammation, immunomodulation, and promotion of wound healing and tissue regeneration."

Mechanisms of action at cellular level

The nuts and bolts of low-level laser (light) therapy

Hoon Chung , Tianhong Dai, Sulbha K Sharma, Ying-Ying Huang, James D Carroll, Michael R Hamblin

Review Ann Biomed Eng. 2012 Feb;40(2):516-33.

Free PMC article

Abstract

Soon after the discovery of lasers in the 1960s it was realized that laser therapy had the potential to improve wound healing and reduce pain, inflammation and swelling. In recent years the field sometimes known as photobiomodulation has broadened to include light-emitting diodes and other light sources, and the range of wavelengths used now includes many in the red and near infrared. The term "low level laser therapy" or LLLT has become widely recognized and implies the existence of the biphasic dose response or the Arndt-Schulz curve. This review will cover the mechanisms of action of LLLT at a cellular and at a tissular level and will summarize the various light sources and principles of dosimetry that are employed in clinical practice. The range of diseases, injuries, and conditions that can be benefited by LLLT will be summarized with an emphasis on those that have reported randomized controlled clinical trials. Serious life-threatening diseases such as stroke, heart attack, spinal cord injury, and traumatic brain injury may soon be amenable to LLLT therapy.

Performance and endurance

Photobiomodulation and Sports: Results of a Narrative Review

Laura Marinela Ailioaie, Gerhard Litscher *Review Life (Basel). 2021 Dec 3;11(12):1339.*

Abstract

Benefits of photobiomodulation (PBM) have been known for several decades. More recently, PBM applied in sports offers a special chance to support the modeling of the performance and recovery. Increasingly complex physical activities and fierce competition in the world of sports generate a state of psycho-emotional and physical stress that can induce chronic fatigue syndrome, failure in physical training, predisposition to muscle damage, physical and emotional exhaustion etc., for which PBM could be an excellent solution. To evaluate and identify all risk factors and the influence of PBM on health and performance in sport and for a better understanding of its effects, we did a search for "Photobiomodulation and Sports" on PubMed, to update the PBM science applied in sports, and we retained for analysis the articles published from 2014 to date. The term "PBM" is recent, and we did not include previous studies with "low level laser therapy" or "LLLT" before 2014. In the present research, PBM has been shown to have valuable protective and ergogenic effects in 25 human studies, being the key to success for high performance and recovery, facts supported also by 22 animal studies. PBM applied creatively and targeted depending on sport and size of the level of physical effort could perfectly modulate the mitochondrial activity and thus lead to remarkable improvements in performance. PBM with no conclusive results or without effects from this review (14 studies from a total of 39 on humans) was analyzed and we found the motivations of the authors from the perspective of multiple causes related to technological limitations, participants, the protocols for physical activity, the devices, techniques and PBM parameters. In the near future, dose-response experiments on physical activity should be designed and correlated with PBM dose-response studies, so that quantification of PBM parameters to allow the energy, metabolic, immune, and neuro-endocrine modulation, perfectly coupled with the level of training. There is an urgent need to continuously improve PBM devices, delivery methods, and protocols in new ingenious future sports trials. Latest innovations and nanotechnologies applied to perform intracellular signaling analysis, while examining extracellular targets, coupled with 3D and 4D sports motion analysis and other high-tech devices, can be a challenge to learn how to maximize PBM efficiency while achieving unprecedented sports performance and thus fulfilling the dream of millions of elite athletes.

Performance and endurance

Photobiomodulation Therapy Improves Performance and Accelerates Recovery of High-Level Rugby Players in Field Test: A Randomized, Crossover, Double-Blind, Placebo-Controlled Clinical Study

Henrique D Pinto, Adriane A Vanin, Eduardo F Miranda, Shaiane S Tomazoni, Douglas S Johnson, Gianna M Albuquerque-Pontes, Ivo de O Aleixo Junior, Vanessa Dos S Grandinetti, Heliodora L Casalechi, Paulo de Tarso C de Carvalho, Ernesto Cesar Leal-Junior

Randomized Controlled Trial, J Strength Cond Res. 2016 Dec;30(12):3329-3338.

Abstract

Although growing evidence supports the use of photobiomodulation therapy (PBMT) for performance and recovery enhancement, there have only been laboratory-controlled studies. Therefore, the aim of this study was to analyze the effects of PBMT in performance and recovery of high-level rugby players during an anaerobic field test. Twelve male high-level rugby athletes were recruited in this randomized, crossover, double-blinded, placebo-controlled trial. No interventions were performed before the Bangsbo sprint test (BST) at familiarization phase (week 1); at weeks 2 and 3, pre-exercise PBMT or placebo were randomly applied to each athlete. Photobiomodulation therapy irradiation was performed at 17 sites of each lower limb, employing a cluster with 12 diodes (4 laser diodes of 905 nm, 4 light emitting diodes [LEDs] of 875 nm, and 4 LEDs of 640 nm, 30 J per site, manufactured by Multi Radiance Medical). Average time of sprints, best time of sprints, and fatigue index were obtained from BST. Blood lactate levels were assessed at baseline, and at 3, 10, 30, and 60 minutes after BST. Athletes' perceived fatigue was also assessed through a questionnaire. Photobiomodulation therapy significantly ($p \leq 0.05$) improved the average time of sprints and fatigue index in BST. Photobiomodulation therapy significantly decreased percentage of change in blood lactate levels ($p \leq 0.05$) and perceived fatigue ($p \leq 0.05$). Pre-exercise PBMT with the combination of super-pulsed laser (low-level laser), red LEDs, and infrared LEDs can enhance performance and accelerate recovery of high-level rugby players in field test. This opens a new avenue for wide use of PBMT in real clinical practice in sports settings.

Effects of photobiomodulation on sport performance in swimming para-athletes - a case series

Aguinaldo Garcez, Silvia C Nunez, Aguinaldo S Garcez, Edna M Garcez, Alessandra Baptista

Res Sports Med. Jan-Feb 2022;30(1):108-113.

Abstract

This study evaluates photobiomodulation (PBM) on cardio-respiratory function and swimming performance in parathletes. Ten swimming parathletes were tested before PBM, after PBM and placebo irradiation applied on upper musculature. After warmup, the parathletes rested for 1 min, and heart rate was recorded. Three sessions of 50 m free style swimming at maximum effort, with 5-min interval were performed and time, peak and recovery heart rate were recorded. After 1 week, biceps, deltoid, and trapezius received 108 J of energy from an LED array or sham-irradiation in a crossover study. After another week, the same protocol was repeated. All athletes improved time in 50 ms swimming. On average, time decreased 4 s after PBM and 1.5 s after placebo. Also, the peak heartbeat was 10% lower after PBM. A muscular pre-conditioning using PBM with an infrared LED could modulate upper musculature and cardio-respiratory function, leading tobetter swimming performance in parathletes.

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

Eduardo Foschini Miranda, Shaiane Silva Tomazoni, Paulo Roberto Vicente de Paiva, Henrique Dantas Pinto, Denis Smith, Larissa Aline Santos, Paulo de Tarso Camillo de Carvalho, Ernesto Cesar Pinto Leal-Junior

Randomized Controlled Trial Lasers Med Sci. 2018 May;33(4):719-727.

Abstract

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. Seventy-seven healthy volunteers completed the treadmill-training

protocol performed for 12 weeks, with 3 sessions per week. PBMT was performed before and/or after each training session (17 sites on each lower limb, using a cluster of 12 diodes: 4 × 905 nm super-pulsed laser diodes, 4 × 875 nm infrared LEDs, and 4 × 640 nm red LEDs, dose of 30 J per site). Volunteers were randomized in four groups according to the treatment they would receive before and after each training session: PBMT before + PBMT after, PBMT before + placebo after, placebo before + PBMT after, and placebo before + placebo after. Assessments were performed before the start of the protocol and after 4, 8, and 12 weeks of training. Primary outcome was time until exhaustion; secondary outcome measures were oxygen uptake and body fat. PBMT applied before and after aerobic exercise training sessions (PBMT before + PBMT after group) significantly increased ($p < 0.05$) the percentage of change of time until exhaustion and oxygen uptake compared to the group treated with placebo before and after aerobic exercise training sessions (placebo before + placebo after group) at 4th, 8th, and 12th week. PBMT applied before and after aerobic exercise training sessions (PBMT before + PBMT after group) also significantly improved ($p < 0.05$) the percentage of change of body fat compared to the group treated with placebo before and after aerobic exercise training sessions (placebo before + placebo after group) at 8th and 12th week. 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.

Effect of photobiomodulation therapy on performance and running economy in runners: A randomized double-blinded placebo-controlled trial

Fábio J Lanferdini, Edson S Silva, Francesco P Boeno, Francesca C Sonda, Rodrigo G Rosa, Rodrigo Quevedo, Bruno M Baroni, Álvaro Reischak-Oliveira, Marco A Vaz, Leonardo A Peyré-Tartaruga

Randomized Controlled Trial J Sports Sci. 2021 Jun;39(12):1348-1355.

Abstract

The objective of this study was to evaluate effects of photobiomodulation therapy (PBMT) on the 3000 m running performance (primary outcome), running economy (RE), metabolic cost and ratings of perceived exertion during running (secondary outcomes). Twenty male endurance athletes performed 4-min treadmill rectangular test at 12 km.h-1 monitored by a gas analyser. After that, PBMT or placebo in each lower limb was applied, followed performed a maximum test of 3000 m. Immediately after 3000 m test, the athletes repeated the treadmill test. Another application of PBMT/placebo was done after the treadmill test, and athletes went back to the laboratory 24 h later to repeat the treadmill test. After a 72 h interval, athletes repeated all procedures with another treatment intervention (PBMT/placebo). Athletes performed the 3000 m running test ~7s faster when treated with PBMT with similar effort score compared placebo condition. The RE remains unchanged immediately post 3000 m running test, nonetheless RE measured post-24 h improved by 5% with PBMT application without changes in metabolic cost. The PBMT pre- and post-conditioning enhanced the 3000 m running performance and improved RE 24 h following the 3000 m test. However, no changes on ratings of perceived exertion and metabolic cost with the application of PBMT.

Low-level phototherapy to improve exercise capacity and muscle performance: a systematic review and meta-analysis

Fernando Kenji Nampo, Vinícius Cavalheri, Francyelle Dos Santos Soares, Solange de Paula Ramos, Enilton Aparecido Camargo

Lasers. Med Sci. 2016 Dec;31(9):1957-1970.

Abstract

The aim of this study was to evaluate the effectiveness of pre-exercise low-level phototherapy (Light-Emitting Diode therapy [LEDtherapy] or Light Amplification by Stimulate Emission of Radiation therapy [LASERtherapy]) in increasing exercise capacity and muscle performance of people undergoing exercise when compared to placebo treatment. Randomized controlled trials and crossover studies were sought on CENTRAL, MEDLINE, EMBASE, SciELO, PEDro and LILACS from its inception up to February 2015. References lists of included studies were sought for additional relevant research. Two authors independently extracted data on study design, treatment parameters, exercise capacity (number of repetitions, time to exhaustion, blood lactate concentration and lactate dehydrogenase activity) and muscle performance (torque, power and strength) using an structured table. Agreement should be reached by consensus or by a third reviewer. Sixteen studies involving 297 participants

were included. Improvement of number of repetitions (mean difference [MD] [95 % confidence interval] = 3.51 repetitions [0.65-6.37]; P = 0.02), delay in time to exhaustion (MD = 4.01 s [2.10-5.91]; P < 0.0001), reduction in lactate levels (MD = 0.34 mmol/L [0.19-0.48]; P < 0.00001) and increased peak torque (MD = 21.51 Nm [10.01-33.01]; P < 0.00001) were observed when LASERtherapy was applied. LEDtherapy meta-analyses were performed with two studies and retrieved no between-group statistically significant difference in power, lactate levels or time to exhaustion. Although our results suggest that LASERtherapy is effective in improving skeletal muscle exercise capacity, the quality of the current evidence is limited.

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

Fábio J Lanferdini, Rodrigo R Bini, Bruno M Baroni, Kelli D Klein, Felipe P Carpes, Marco A Vaz,

Randomized Controlled Trial Int J Sports Physiol Perform. 2018 Jan 1;13(1):14-22.

Abstract

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. Twenty male competitive cyclists participated in a crossover, randomized, double-blind, placebo-controlled trial. They performed an incremental cycling test to exhaustion (on day 1) followed by 4 time-to-exhaustion tests (on days 2-5) at their individual maximal power output. Before each time-to-exhaustion test, different dosages of LLLT (135, 270, and 405 J/thigh, respectively) or placebo were applied at the quadriceps muscle bilaterally. Power output and muscle activation from both lower limbs were recorded throughout the tests. Increased performance in time-to-exhaustion tests was observed with the LLLT-135 J (~22 s; P < .01), LLLT-270 J (~13 s; P = .03), and LLLT-405 J (~13 s; P = .02) compared to placebo (149 ± 23 s). Although LLLT-270 J and LLLT-405 J did not show significant differences in muscle activation compared with placebo, LLLT-135 J led to an increased high-frequency content compared with placebo in both limbs at the end of the exhaustion test (P ≤ .03). In 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.

Muscular pre-conditioning using light-emitting diode therapy (LEDT) for high-intensity exercise: a randomized double-blind placebo-controlled trial with a single elite runner

Cleber Ferraresi, Thomas Beltrame, Fernando Fabrizzi, Eduardo Sanches Pereira do Nascimento, Marlus Karsten, Cristina de Oliveira Francisco, Audrey Borghi-Silva, Aparecida Maria Catai, Daniel Rodrigues Cardoso, Antonio Gilberto Ferreira, Michael R Hamblin, Vanderlei Salvador Bagnato, Nivaldo Antonio Parizotto

Randomized Controlled Trial Physiother Theory Pract. 2015 Jul;31(5):354-61.

Abstract

Recently, low-level laser (light) therapy (LLLT) has been used to improve muscle performance. This study aimed to evaluate the effectiveness of near-infrared light-emitting diode therapy (LEDT) and its mechanisms of action to improve muscle performance in an elite athlete. The kinetics of oxygen uptake (VO2), blood and urine markers of muscle damage (creatine kinase--CK and alanine), and fatigue (lactate) were analyzed. Additionally, some metabolic parameters were assessed in urine using proton nuclear magnetic resonance spectroscopy ((1)H NMR). A LED cluster with 50 LEDs (λ = 850 nm; 50 mW 15 s; 37.5 J) was applied on legs, arms and trunk muscles of a single runner athlete 5 min before a high-intense constant workload running exercise on treadmill. The athlete received either Placebo-1-LEDT; Placebo-2-LEDT; or Effective-LEDT in a randomized double-blind placebo-controlled trial with washout period of 7 d between each test. LEDT improved the speed of the muscular VO2 adaptation (~-9 s), decreased O2 deficit (~-10 L), increased the VO2 from the slow component phase (~+348 ml min(-1)), and increased the time limit of exercise (~+589 s). LEDT decreased blood and urine markers of muscle damage and fatigue (CK, alanine and lactate levels). The results suggest that a muscular pre-conditioning regimen using LEDT before intense exercises could modulate metabolic and renal function to achieve better performance.

Performance and endurance

Using Pre-Exercise Photobiomodulation Therapy Combining Super-Pulsed Lasers and Light-Emitting Diodes to Improve Performance in Progressive Cardiopulmonary Exercise Tests

Eduardo Foschini Miranda , Adriane Aver Vanin, Shaiane Silva Tomazoni, Vanessa dos Santos Grandinetti, Paulo Roberto Vicente de Paiva, Caroline dos Santos Monteiro Machado, Kadma Karênina Damasceno Soares Monteiro, Heliodora Leão Casalechi, Paulo de Tarso, Camillo de Carvalho, Ernesto Cesar Pinto Leal-Junior

J Athl Train. 2016 Feb;51(2):129-35.

Abstract

CONTEXT: Skeletal muscle fatigue and exercise performance are novel areas of research and clinical application in the photobiomodulation field, and positive outcomes have been reported in several studies; however, the optimal measures have not been fully established.

OBJECTIVE: To assess the acute effect of photobiomodulation therapy (PBMT) combining superpulsed lasers (low-level laser therapy) and light-emitting diodes (LEDs) on muscle performance during a progressive cardiopulmonary treadmill exercise test.

DESIGN: Crossover study.

SETTING: Laboratory.

PATIENTS or other participants: Twenty untrained male volunteers (age = 26.0 ± 6.0 years, height = 175.0 ± 10.0 cm, mass = 74.8 ± 10.9 kg).

INTERVENTIONS: Participants received PBMT with either combined superpulsed lasers and LED (active PBMT) or placebo at session 1 and the other treatment at session 2. All participants completed a cardiopulmonary test on a treadmill after each treatment. For active PBMT, we performed the irradiation at 17 sites on each lower limb (9 on the quadriceps, 6 on the hamstrings, and 2 on the gastrocnemius muscles), using a cluster with 12 diodes (four 905-nm superpulsed laser diodes with an average power of 0.3125 mW, peak power of 12.5 W for each diode, and frequency of 250 Hz; four 875-nm infrared LED diodes with an average power of 17.5 mW; and four 640-nm red LED diodes with an average power of 15 mW) and delivering a dose of 30 J per site.

MAIN OUTCOME MEASURES: Distance covered, time until exhaustion, pulmonary ventilation, and dyspnea score.

RESULTS: The distance covered (1.96 ± 0.30 versus 1.84 ± 0.40 km, t19 = 2.119, P < .001) and time until exhaustion on the cardiopulmonary test (780.2 ± 91.0 versus 742.1 ± 94.0 seconds, t19 = 3.028, P < .001) was greater after active PBMT than after placebo. Pulmonary ventilation was greater (76.4 ± 21.9 versus 74.3 ± 19.8 L/min, t19 = 0.180, P = .004) and the score for dyspnea was lower (3.0 [interquartile range = 0.5-9.0] versus 4.0 [0.0-9.0], U = 184.000, P < .001) after active PBMT than after placebo.

CONCLUSIONS: The combination of lasers and LEDs increased the time, distance, and pulmonary ventilation and decreased the score of dyspnea during a cardiopulmonary test.

Post-exercise recovery

Low-level laser therapy improves the VO 2 kinetics in competitive cyclists

Fábio J Lanferdini, Renata L Krüger, Bruno M Baroni, Caetano Lazzari, Pedro Figueiredo, Alvaro Reischak-Oliveira, Marco A Vaz,

Randomized Controlled Trial Lasers Med Sci. 2018 Apr;33(3):453-460.

Abstract

Some evidence supports that low-level laser therapy (LLLT) reduces neuromuscular fatigue, so incrementing sports performance. A previous randomized controlled trial of our group showed increased exercise tolerance in male competitive cyclists treated with three different LLLT doses (3, 6, and 9 J/diode; or 135, 270, and 405 J/thigh) before time-to-exhaustion cycling tests. Now, the present study was designed to evaluate the effects of these LLLT doses on the VO2 kinetics of athletes during cycling tests. Twenty male competitive cyclists (29 years) participated in a crossover, randomized, double-blind, and placebo-

controlled trial. On the first day, the participants performed an incremental cycling test to exhaustion to determine maximal oxygen uptake (VO2MAX) and maximal power output (POMAX), as well as a familiarization with the time-to-exhaustion test. In the following days (2 to 5), all participants performed time-to-exhaustion tests at POMAX. Before the exhaustion test, different doses of LLLT (3, 6, and 9 J/diode; or 135, 270, and 405 J/thigh, respectively) or placebo were applied bilaterally to the quadriceps muscle. All exhaustion tests were monitored online by an open-circuit spirometry system in order to analyze the VO2 amplitude, VO2 delay time, time constant (tau), and O2 deficit. Tau and O2 deficit were decreased with LLLT applications compared to the placebo condition ($p < 0.05$). No differences ($p > 0.05$) were found between the experimental conditions for VO2 amplitude and VO2 delay time. In conclusion, LLLT decreases tau and O2 deficit during time-to-exhaustion tests in competitive cyclists, and these changes in VO2 kinetics response can be one of the possible mechanisms to explain the ergogenic effect induced by LLLT.

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

Ernesto Cesar Pinto Leal Junior, Rodrigo Alvaro Brandão Lopes-Martins, Lucio Frigo, Thiago De Marchi, Rafael Paolo Rossi, Vanessa de Godoi, Shaiane Silva Tomazoni, Daniela Perin Silva, Maira Basso, Pedro Lotti Filho, Francisco de Valls Corsetti, Vegard V Iversen, Jan Magnus Bjordal

Randomized Controlled Trial J Orthop Sports Phys Ther. 2010 Aug;40(8):524-32.

Abstract

STUDY DESIGN: Randomized crossover double-blinded placebo-controlled trial.

OBJECTIVE: To investigate if low-level laser therapy (LLLT) can affect biceps muscle performance, fatigue development, and biochemical markers of postexercise recovery.

BACKGROUND: 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.

METHODS: Nine healthy male volleyball players participated in the study. They received either active LLLT (cluster probe with 5 laser diodes; lambda = 810 nm; 200 mW power output; 30 seconds of irradiation, applied in 2 locations over the biceps of the nondominant arm; 60 J of total energy) or placebo LLLT using an identical cluster probe. The intervention or placebo were applied 3 minutes before the performance of exercise. All subjects performed voluntary elbow flexion repetitions with a workload of 75% of their maximal voluntary contraction force until exhaustion.

RESULTS: Active LLLT increased the number of repetitions by 14.5% (mean +/- SD, 39.6 +/- 4.3 versus 34.6 +/- 5.6; P = .037) and the elapsed time before exhaustion by 8.0% (P = .034), when compared to the placebo treatment. The biochemical markers also indicated that recovery may be positively affected by LLLT, as indicated by postexercise blood lactate levels (P<.01), creatine kinase activity (P = .017), and C-reactive protein levels (P = .047), showing a faster recovery with LLLT application prior to the exercise.

CONCLUSION: We conclude that 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.

Immediate effects of photobiomodulation therapy combined with a static magnetic field on the subsequent performance: a preliminary randomized crossover triple-blinded placebo-controlled trial

Ivo de Oliveira Aleixo-Junior, Ernesto Cesar Pinto Leal-Junior, Heliodora Leão Casalechi, Adriane Aver Vanin, Paulo Roberto Vicente de Paiva, Caroline Dos Santos Monteiro Machado, Luana Barbosa Dias, Matheus Marinho Aguiar Lino, Adeilson Matias Teixeira, Douglas Scott Johnson, Shaiane Silva Tomazoni *Biomed Opt Express. 2021 Oct 15;12(11):6940-6953.*

Abstract

There is evidence about the effects of photobiomodulation therapy (PBMT) alone and combined with a static magnetic field (PBMT-sMF) on skeletal muscle fatigue, physical performance and post-exercise recovery in different types of exercise protocols and sports activity. However, the effects of PBMT-sMF to improve the subsequent performance after a first set of exercises are unknown. Therefore, the aim of this study was to investigate the effects of PBMT-sMF, applied between two sets of exercises, on the subsequent physical performance. A randomized, crossover, triple-blinded (assessors, therapist, and volunteers),

placebo-controlled trial was carried out. Healthy non-athlete male volunteers were randomized and treated with a single application of PBMT-sMF and placebo between two sets of an exercise protocol performed on isokinetic dynamometer. The order of interventions was randomized. The primary outcome was fatigue index and the secondary outcomes were total work, peak work, and blood lactate levels. Twelve volunteers were randomized and analyzed to each sequence. PBMT-sMF decreased the fatigue index compared to the placebo PBMT-sMF at second set of the exercise protocol (MD = -6.08, 95% CI -10.49 to -1.68). In addition, PBMT-sMF decreased the blood lactate levels post-intervention, and after the second set of the exercise protocol compared to placebo ($p<0.05$). There was no difference between PBMT-sMF and placebo in the remaining outcomes tested. Volunteers did not report adverse events. Our results suggest that PBMT-sMF is able to decrease skeletal muscle fatigue, accelerating post-exercise recovery and, consequently, increasing subsequent physical performance when applied between two sets of exercises.

Pre-Exercise Infrared Low-Level Laser Therapy (810 nm) in Skeletal Muscle Performance and Postexercise Recovery in Humans, What Is the Optimal Dose? A Randomized, Double-Blind, Placebo-Controlled Clinical Trial

Adriane Aver Vanin, Thiago De Marchi, S S Tomazoni, Olga Tairova, Heliodora Leão Casalech, Paulo de Tarso Camillo de Carvalho, Jan Magnus Bjordal, Ernesto Cesar Leal-Junior *Photomed Laser Surg. 2016 Oct;34(10):473-482.*

Abstract

AIM: This study aimed to evaluate the medium-term effects of low-level laser therapy (LLLT or photobiomodulation) in postexercise skeletal muscle recovery and performance enhancement and to identify the optimal dose of 810 nm LLLT.
MATERIALS AND METHODS: A randomized, double-blind, placebo-controlled trial was performed, with voluntary participation of 28 high-level soccer athletes. We analyzed maximum voluntary contraction (MVC), delayed onset muscle soreness (DOMS), creatine kinase (CK) activity, and interleukin-6 (IL-6) expression. The assessments were performed before exercise protocols, after 1 min, and 1, 24, 48, 72, and 96 h after the end of eccentric exercise protocol used to induce fatigue. LLLT was applied before eccentric exercise protocol with a cluster with five diodes, and dose of 10, 30, or 50 J (200 mW and 810 nm) in six sites of quadriceps.
RESULTS: LLLT increased ($p < 0.05$) MVC from immediately after exercise to 24 h with 50 J dose, and from 24 to 96 h with 10 J dose. Both 10 J then 50 J dose decreased ($p < 0.05$) CK and IL-6 with better results in favor of 50 J dose. However, LLLT had no effect in decreasing DOMS. No differences ($p > 0.05$) were found for 30 J dose in any of the outcomes measured.
CONCLUSIONS: Pre-exercise LLLT, mainly with 50 J dose, significantly increases performance and improves biochemical markers related to skeletal muscle damage and inflammation.

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

Adriano Rodrigues de Oliveira, Adriane Aver Vanin, Shaiane Silva Tomazoni, Eduardo Foschini Miranda, Gianna Móes Albuquerque-Pontes, Thiago De Marchi, Vanessa Dos Santos Grandinetti, Paulo Roberto Vicente de Paiva, Treice Beatriz Gonçalves Imperatori, Paulo de Tarso Camillo de Carvalho, Jan Magnus Bjorda, Ernesto Cesar Pinto Leal-Junior

Abstract

BACKGROUND: Photobiomodulation therapy (PBMT) has recently been used to alleviate postexercise muscle fatigue and enhance recovery, demonstrating positive results. A previous study by our research group demonstrated the optimal dose for an infrared wavelength (810 nm), but the outcomes could be optimized further with the determination of the optimal output power.
OBJECTIVE: 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.
MATERIALS AND METHOD: A randomized, placebo-controlled double-blind clinical trial was conducted with the participation of 28 high-level soccer players. PBMT was applied before the eccentric contraction protocol with a cluster with five diodes, 810 nm, dose of 10 J, and output power of 100, 200, 400 mW per diode or placebo at six sites of knee extensors. Maximum isometric voluntary contraction (MIVC), delayed onset muscle soreness (DOMS) and biochemical markers related to muscle damage (creatine kinase and lactate dehydrogenase), inflammation (IL-1β, IL-6, and TNF-α), and oxidative stress (catalase,

superoxide dismutase, carbonylated proteins, and thiobarbituric acid) were evaluated before isokinetic exercise, as well as at 1 min and at 1, 24, 48, 72, and 96 h, after the eccentric contraction protocol.
RESULTS: PBMT increased MIVC and decreased DOMS and levels of biochemical markers ($p < 0.05$) with the power output of 100 and 200 mW, with better results for the power output of 100 mW.
CONCLUSIONS: 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.

Muscle soreness, fatigue, damage and inflammation

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

Cleber Ferraresi, Ying-Ying Huang, Michael R Hamblin *Review J Biophotonics. 2016 Dec;9(11-12):1273-1299.*

Abstract

Photobiomodulation (PBM) describes the use of red or near-infrared (NIR) light to stimulate, heal, and regenerate damaged tissue. Both preconditioning (light delivered to muscles before exercise) and PBM applied after exercise can increase sports performance in athletes. This review covers the effects of PBM on human muscle tissue in clinical trials in volunteers related to sports performance and in athletes. The parameters used were categorized into those with positive effects or no effects on muscle performance and recovery. Randomized controlled trials and case-control studies in both healthy trained and untrained participants, and elite athletes were retrieved from MEDLINE up to 2016. Performance metrics included fatigue, number of repetitions, torque, hypertrophy; measures of muscle damage and recovery such as creatine kinase and delayed onset muscle soreness. Searches retrieved 533 studies, of which 46 were included in the review (n = 1045 participants). Studies used single laser probes, cluster of laser diodes, LED clusters, mixed clusters (lasers and LEDs), and flexible LED arrays. Both red, NIR, and red/NIR mixtures were used. PBM can increase muscle mass gained after training, and decrease inflammation and oxidative stress in muscle biopsies. We raise the question of whether PBM should be permitted in athletic competition by international regulatory authorities.

Infrared Low-Level Laser Therapy (Photobiomodulation Therapy) before Intense Progressive Running Test of High-Level Soccer Players: Effects on Functional, Muscle Damage, Inflammatory, and Oxidative Stress Markers-A Randomized Controlled Trial

Shaiane Silva Tomazoni, Caroline Dos Santos Monteiro Machado, Thiago De Marchi, Heliodora Leão Casalechi, Jan Magnus Bjordal, Paulo de Tarso Camillo de Carvalho, Ernesto Cesar Pinto Leal-Junior. *Oxid Med Cell Longev. 2019 Nov 16;2019:6239058.*

Abstract

The effects of preexercise photobiomodulation therapy (PBMT) to enhance performance, accelerate recovery, and attenuate exercise-induced oxidative stress were still not fully investigated, especially in high-level athletes. The aim of this study was to evaluate the effects of PBMT (using infrared low-level laser therapy) applied before a progressive running test on functional aspects, muscle damage, and inflammatory and oxidative stress markers in high-level soccer players. A randomized, triple-blind, placebo-controlled crossover trial was performed. Twenty-two high-level male soccer players from the same team were recruited and treated with active PBMT and placebo. The order of interventions was randomized. Immediately after the application of active PBMT or placebo, the volunteers performed a standardized high-intensity progressive running test (ergospirometry test) until exhaustion. We analyzed rates of oxygen uptake (VO2 max), time until exhaustion, and aerobic and anaerobic threshold during the intense progressive running test. Creatine kinase (CK) and lactate dehydrogenase (LDH) activities, levels of interleukin-1β (IL-1-β), interleukin-6 (IL-6), and tumor necrosis factor alpha (TNF-α), levels of thiobarbituric acid (TBARS) and carbonylated proteins, and catalase (CAT) and superoxide dismutase (SOD) activities were measured before and five

minutes after the end of the test. PBMT increased the VO2 max (both relative and absolute values-$p < 0.0467$ and $p < 0.0013$, respectively), time until exhaustion ($p < 0.0043$), time ($p < 0.0007$) and volume ($p < 0.0355$) in which anaerobic threshold happened, and volume in which aerobic threshold happened ($p < 0.0068$). Moreover, PBMT decreased CK ($p < 0.0001$) and LDH ($p < 0.0001$) activities. Regarding the cytokines, PBMT decreased only IL-6 ($p < 0.0001$). Finally, PBMT decreased TBARS ($p < 0.0001$) and carbonylated protein levels ($p < 0.01$) and increased SOD ($p < 0.0001$)and CAT ($p < 0.0001$) activities. The findings of this study demonstrate that preexercise PBMT acts on different functional aspects and biochemical markers. Moreover, preexercise PBMT seems to play an important antioxidant effect, decreasing exercise-induced oxidative stress and consequently enhancing athletic performance and improving postexercise recovery. This trial is registered with Clinicaltrials.gov NCT03803956.

Does the combination of photobiomodulation therapy (PBMT) and static magnetic fields (sMF) potentiate the effects of aerobic endurance training and decrease the loss of performance during detraining? A randomised, triple-blinded, placebo-controlled trial

Paulo Roberto Vicente de Paiva , Heliodora Leão Casalechi, Shaiane Silva Tomazoni, Caroline Dos Santos Monteiro Machado, Neide Firmo Ribeiro, Amanda Lima Pereira, Marcelo Ferreira Duarte de Oliveira, Marjury Nunes da Silva Alves, Maiara Conceição Dos Santos, Inti Ernesto Torrico Takara, Eduardo Foschini Miranda, Paulo de Tarso Camillo de Carvalho, Ernesto Cesar Pinto Leal-Junior

BMC Sports Sci Med Rehabil. 2020 Apr 10;12:23.

Abstract

BACKGROUND: Photobiomodulation (PBMT) is a therapy that uses non-ionising forms of light, including low-level lasers and light-emitting diodes (LEDs) that may be capable of modulating cellular activity. Some biological processes may also interact with static magnetic fields (sMF), leading to modulatory effects on cells. Previous studies have verified that the combination of PBMT and sMF (PBMT/sMF) enhances the performance of individuals during aerobic training programs. The detraining period can cause losses in aerobic capacity. However, there is no evidence of the existence of any recourse that can decrease the effects of detraining. We aimed to investigate the effects of PBMT/sMF application during training and detraining to assess the effectiveness of this treatment in reducing the effects of detraining.

METHODS: Sixty male volunteers were randomly allocated into four groups- participants who received PBMT/sMF during the training and detraining (PBMT/sMF + PBMT/sMF); participants who received PBMT/sMF during the training and a placebo in the detraining (PBMT/sMF + Placebo); participants who received a placebo during the training and PBMT/sMF in the detraining (Placebo+PBMT/sMF); and participants who received a placebo during the training and detraining (Placebo+Placebo). Participants performed treadmill training over 12 weeks (3 sessions/week), followed by 4 weeks of detraining. PBMT/sMF was applied using a 12-diode emitter (four 905 nm super-pulsed lasers, four 875 nm light-emitting diodes (LEDs), four 640 nm LEDs, and a 35 mT magnetic field) at 17 sites on each lower limb (dosage: 30 J per site). The data were analysed by two-way repeated measures analysis of variance (ANOVA, time vs experimental group) with post-hoc Bonferroni correction.

RESULTS: The percentage of change in time until exhaustion and in maximum oxygen consumption was higher in the PBMT/sMF + PBMT/sMF group than in the Placebo+Placebo group at all time-points ($p < 0.05$). Moreover, the percentage of decrease in body fat at the 16th week was higher in the PBMT/sMF + PBMT/sMF group than in the Placebo+Placebo group ($p < 0.05$).

CONCLUSIONS: PBMT/sMF can potentiate the effects of aerobic endurance training and decrease performance loss after a 4-week detraining period. Thus, it may prove to be an important tool for both amateur and high-performance athletes as well as people undergoing rehabilitation.

Does photobiomodulation therapy combined to static magnetic field (PBMT-sMF) promote ergogenic effects even when the exercised muscle group is not irradiated? A randomized, triple-blind, placebo-controlled trial

Caroline Dos Santos Monteiro Machado, Heliodora Leão Casalechi, Adriane Aver Vanin, Jônatas Bezerra de Azevedo, Paulo de Tarso Camillo de Carvalho, Ernesto Cesar Pinto Leal-Junior *BMC. Sports Sci Med Rehabil. 2020 Aug 26;12:49.*

Muscle soreness, fatigue, damage and inflammation

Abstract

BACKGROUND: The direct application of photobiomodulation therapy (PBMT) using low-level laser therapy (LLLT) and light emitting diodes (LEDs) combined with a static magnetic field (sMF) (PBMT-sMF) to target tissues is shown to improve muscle performance and recovery. Studies have reported possible PBMT effects when a local distant to the target tissue is irradiated. Notably, the extent of these effects on musculoskeletal performance and the optimal site of irradiation remain unclear, although this information is clinically important since these aspects could directly affect the magnitude of the effect. Therefore, we investigated the effects of local and non-local PBMT-sMF irradiations on musculoskeletal performance and post-exercise recovery before an eccentric exercise protocol.

METHODS: This randomized, triple-blind (participants, therapists and assessors), placebo-controlled trial included 30 healthy male volunteers randomly assigned to the placebo, local, and non-local groups. Active or placebo PBMT-sMF was applied to 6 sites of the quadriceps muscle of both legs. An eccentric exercise protocol was used to induce fatigue. The primary outcome was peak torque assessed by maximal voluntary contraction (MVC). The secondary outcomes were delayed onset muscle soreness (DOMS) measured by visual analogue scale (VAS), muscle injury assessed by serum creatine kinase activity (CK), and blood lactate levels. Evaluations were performed before the eccentric exercise protocol (baseline), as well as immediately after and 1, 24, 48, and 72 h upon protocol completion.

RESULTS: Ten volunteers were randomized per group and analysed for all outcomes. Compared to the placebo and non-local groups, irradiation with PBMT-SMF led to statistically significant improvement ($p < 0.05$) with regard to all variables in the local group. The outcomes observed in the non-local group were similar to those in the placebo group with regard to all variables. The volunteers did not report any adverse effects.

CONCLUSION: Our results support the current evidence that local irradiation of all exercised muscles promotes ergogenic effects. PBMT-sMF improved performance and reduced muscle fatigue only when applied locally to muscles involved in physical activity.

Phototherapy in skeletal muscle performance and recovery after exercise: effect of combination of super-pulsed laser and light-emitting diodes

Fernanda Colella Antonialli 1, Thiago De Marchi, Shaiane Silva Tomazoni, Adriane Aver Vanin, Vanessa dos Santos Grandinetti, Paulo Roberto Vicente de Paiva, Henrique Dantas Pinto, Eduardo Foschini Miranda, Paulo de Tarso Camillo de Carvalho, Ernesto Cesar Pinto Leal-Junior.

Lasers Med Sci. 2014 Nov;29(6):1967-76.

Abstract

Recent studies with phototherapy have shown positive results in enhancement of performance and improvement of recovery when applied before exercise. However, several factors still remain unknown such as therapeutic windows, optimal treatment parameters, and effects of combination of different light sources (laser and LEDs). The aim of this study was to evaluate the effects of phototherapy with the combination of different light sources on skeletal muscle performance and post-exercise recovery, and to establish the optimal energy dose. A randomized, double-blinded, placebo-controlled trial with participation of 40 male healthy untrained volunteers was performed. A single phototherapy intervention was performed immediately after pre-exercise (baseline) maximum voluntary contraction (MVC) with a cluster of 12 diodes (4 of 905 nm lasers-0.3125 mW each, 4 of 875 nm LEDs-17.5 mW each, and 4 of 670 nm LEDs-15 mW each- manufactured by Multi Radiance Medical™) and dose of 10, 30, and 50 J or placebo in six sites of quadriceps. MVC, delayed onset muscle soreness (DOMS), and creatine kinase (CK) activity were analyzed. Assessments were performed before, 1 min, 1, 24, 48, 72, and 96 h after eccentric exercise protocol employed to induce fatigue. Phototherapy increased ($p < 0.05$) MVC was compared to placebo from immediately after to 96 h after exercise with 10 or 30 J doses (better results with 30 J dose). DOMS was significantly decreased compared to placebo ($p < 0.05$) with 30 J dose from 24 to 96 h after exercise, and with 50 J dose from immediately after to 96 h after exercise. CK activity was significantly decreased ($p < 0.05$) compared to placebo with all phototherapy doses from 1 to 96 h after exercise (except for 50 J dose at 96 h). Pre-exercise phototherapy with combination of low-level laser and LEDs, mainly with 30 J dose, significantly increases performance, decreases DOMS, and improves biochemical marker related to skeletal muscle damage.

Muscle soreness, fatigue, damage and inflammation

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

Ernesto Cesar Pinto Leal-Junior, Adriane Aver Vanin, Eduardo Foschini Miranda, Paulo de Tarso Camillo de Carvalho, Simone Dal Corso, Jan Magnus Bjordal

Lasers Med Sci. 2015 Feb;30(2):925-39.

Abstract

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. A literature search was performed in Pubmed/Medline database for randomized controlled trials (RCTs) published from 2000 through 2012. Trial quality was assessed with the ten-item PEDro scale. Main outcome measures were selected as: number of repetitions and time until exhaustion for muscle performance, and creatine kinase (CK) activity to evaluate risk for exercise-induced muscle damage. The literature search resulted in 16 RCTs, and three articles were excluded due to poor quality assessment scores. From 13 RCTs with acceptable methodological quality (≥6 of 10 items), 12 RCTs irradiated phototherapy before exercise, and 10 RCTs reported significant improvement for the main outcome measures related to performance. The time until exhaustion increased significantly compared to placebo by 4.12 s (95% CI 1.21-7.02, $p < 0.005$) and the number of repetitions increased by 5.47 (95% CI 2.35-8.59, $p < 0.0006$) after phototherapy. Heterogeneity in trial design and results precluded meta-analyses for biochemical markers, but a quantitative analysis showed positive results in 13 out of 16 comparisons. 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.

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

Paul A Borsa, Kelly A Larkin, Jerry M True.

J Athl Train. Jan-Feb 2013;48(1):57-67.

Abstract

CONTEXT: 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: 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.

DATA SOURCES: We searched the electronic databases PubMed, SPORTDiscus, Web of Science, Scopus, and Rehabilitation & Physical Medicine without date limitations for the following key words: laser therapy, phototherapy, fatigue, exercise, circulation, microcirculation, and photobiomodulation.

STUDY SELECTION: Eligible studies had to be original research published in English as full papers, involve human participants, and receive a minimum score of 7 out of 10 on the Physiotherapy Evidence Database (PEDro) scale.

DATA EXTRACTION: Data of interest included elapsed time to fatigue, total number of repetitions to fatigue, total work performed, maximal voluntary isometric contraction (strength), electromyographic activity, and postexercise biomarker levels. We recorded the PEDro scores, beam characteristics, and treatment variables and calculated the therapeutic outcomes and effect sizes for the data sets.

DATA SYNTHESIS: In total, 12 randomized controlled trials met the inclusion criteria. However, we excluded data from 2 studies, leaving 32 data sets from 10 studies. Twenty-four of the 32 data sets contained differences between active phototherapy and sham (placebo-control) treatment conditions for the various outcome measures. 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.

CONCLUSIONS: Phototherapy administered before resistance exercise consistently has been found to provide ergogenic and prophylactic benefits to skeletal muscle.

The influence of photobiomodulation on the temperature of the brachial biceps during muscle fatigue protocol

Sadi Fernando Stamborowski, Bruna Moreira de Oliveira Spinelli, Fernanda Pupio Silva Lima, Davidson Ribeiro Costa, Gabriela Aparecida de Silveira Souza, Mario Oliveira Lima, Rodrigo Alvaro Brandão Lopes Martins

Clinical Trial Lasers Med Sci. 2021 Oct;36(8):1741-1749.

Abstract

Physical activity raises body temperature. However, the literature does not contain studies about whether the employment of Photobiomodulation (PMB) could significantly influence body temperature during a muscle fatigue (MF) protocol. Thus, the aim of this study was to evaluate the effects of PMB on the temperature of the biceps brachii muscle during the performance of a muscle fatigue protocol. The study consisted of 14 volunteers who were divided into two groups (placebo group and laser group) and all individuals rotated into all groups (crossover study). To induce muscle fatigue, three maximum voluntary isometric contractions (MVIC) were performed for 50 s with a 50-s interval. During the MVIC, the muscle strength was assessed using surface electromyography and infrared temperature at 0, 5, 10, and 15 min after the tests. The laser group presented a less accentuated decrease in muscle strength, evidencing a lower rate of muscle fatigue ($p > 0.05$) in relation to the other groups. In the temperature analysis, the control group exhibited the highest average temperature, with a significant difference only for the placebo. The results indicate that the control displayed the greatest physical degeneration and the PMB group had a positive effect on MF attenuation and body thermoregulation.

Photobiomodulation (PBM) therapy at 904 nm mitigates effects of exercise-induced skeletal muscle fatigue in young women

Renata Luri Toma, Murilo Xavier Oliveira, Ana Cláudia Muniz Renno, E-Liisa Laakso.

Randomized Controlled Trial Lasers Med Sci. 2018 Aug;33(6)

Abstract

Muscle fatigue is a process influenced by several mechanisms such as concentration of metabolic substrates, changes in blood flow, and increases in reactive oxygen species that impair contractile muscle function. In this context, photobiomodulation has been investigated for preventing muscle fatigue, with reports of positive effects on muscle performance. This study aimed to investigate the effects of 904-nm LASER photobiomodulation on rectus femoris muscle performance in young women. Eighteen young women participated in a randomized, participant and assessor-blinded crossover trial with placebo control. Active LASER (904 nm, 60 mW, 250 Hz, 3.6 J per diode, total dose of 129.6 J) intervention was applied prior to an isokinetic fatigue protocol consisting of a set of 60 concentric quadricep contractions at a constant dynamometer angular velocity of 180°/s. Compared to placebo, LASER photobiomodulation significantly reduced muscle fatigue across a range of indicators including reduced ratings of perceived exertion ($P = 0.0139$), and increased electromyographic fatigue index (EFI) ($P = 0.005$). The isokinetic dynamometer performance analysis demonstrated that LASER photobiomodulation increased peak torque ($P = 0.04$), time to peak torque ($P = 0.042$), total work ($P = 0.032$), average power ($P = 0.0007$), and average peak torque ($P = 0.019$) between both experimental conditions. No significant difference was observed for work fatigue index ($P = 0.29$) or for lactate concentration ($P > 0.05$). Photobiomodulation at 904 nm was effective in reducing fatigue levels and increasing muscle performance in young active women but had no effect on lactate levels.

What is the optimal time-response window for the use of photobiomodulation therapy combined with static magnetic field (PBMT-sMF) for the improvement of exercise performance and recovery, and for how long the effects last? A randomized, triple-blinded, placebo-controlled trial

Ernesto Cesar Pinto Leal-Junior, Marcelo Ferreira Duarte de Oliveira, Jon Joensen, Martin Bjørn Stausholm, Jan Magnus Bjordal, Shaiane Silva Tomazoni *BMC Sports Sci Med Rehabil. 2020 Oct 19;12:64.*

Muscle soreness, fatigue, damage and inflammation

Abstract

BACKGROUND: The optimal time-response window for photobiomodulation therapy (PBMT) using low-level laser therapy (LLLT) and/or light emitting diodes therapy (LEDT) combined with static magnetic fields (sMF) before physical activity still was not fully investigated. The aim of the present study was to investigate the better of four time-response windows for PBMT combined with sMF (PBMT-sMF) use before exercise in humans.

METHODS: A prospectively registered, randomized, triple-blinded (volunteers, therapists and assessors) placebo-controlled trial was carried out. Sixty healthy untrained male subjects were randomly allocated to six experimental groups (n = 10 per group): PBMT-sMF 5 mins, PBMT-sMF 3 h, PBMT-sMF 6 h, PBMT-sMF 1-day, placebo, and control. The control group performed all procedures, however did not receive any kind of intervention. PBMT-sMF active or PBMT-sMF placebo was applied precisely in different time points after baseline MVC test to ensure that both MVC tests and eccentric exercise protocol would occur at the same hour of the day in all groups. Then, after five minutes, 3 h, 6 h or 1-day (24 h) of PBMT-sMF treatment (active or placebo) the eccentric exercise protocol was performed. The primary outcome was peak torque obtained from maximum voluntary contraction (MVC). The secondary outcomes were creatine kinase (CK), and delayed onset muscle soreness (DOMS). The primary and secondary outcomes were measured at baseline, immediately after, 1 h, 24 h and 48 h after the eccentric exercise protocol.

RESULTS: Sixty patients were randomized and analyzed to each sequence. The outcomes in absolute values show that all active PBMT-sMF groups increased ($p < 0.05$) MVC from immediately after to 1 h after eccentric exercise, and decreased ($p < 0.05$) CK activity at all time points. However, PBMT-sMF 5 mins, 3 h and 6 h groups showed better results in MVC and CK analysis from 24 h to 48 h, and also to DOMS ($p < 0.05$) at all time points. Participants did not report any adverse events.

CONCLUSIONS: PBMT-sMF can be used from 5 min to 6 h before exercise, and the effects can last up to 54 h after treatment. However, the effects start to decrease when a 1-day (24 h) time-response window is used.

Use of low-level laser therapy (808 nm) to muscle fatigue resistance: a randomized double-blind crossover trial

Wouber Hérickson de Brito Vieira, Raphael Machado Bezerra, Renata Alencar Saldanha Queiroz, Nícia Farias Braga Maciel, Nivaldo Antonio Parizotto, Cleber Ferraresi

Randomized Controlled Trial Photomed Laser Surg. 2014 Dec;32(12):678-85.

Abstract

OBJECTIVE: The purpose of this study was to investigate whether low-level laser (light) therapy (LLLT) can provide fatigue resistance via maximum repetitions (RM) with an isokinetic dynamometer, and decrease electromyography fatigue index (EFI).

BACKGROUND: LLLT has been used to increase muscle performance when applied before or after intense exercises.

MATERIALS AND METHODS: This study was a randomized, double-blind, crossover trial with placebo. Seven young men (21±3 years of age) who were clinically healthy, were allocated into two groups: active laser (LLLT) and placebo laser (Placebo). Both groups were assessed at baseline, at one training session, and at the end of this study. Baseline and final assessments recorded the number of RM of knee flexion-extensions using an isokinetic dynamometer at 60 degrees/sec in conjunction with EFI recorded by median frequency. The training sessions consisted of three sets of 20 RM of knee flexion-extensions using an isokinetic dynamometer at 60 degrees/sec plus LLLT (808 nm, 100 mW, 4 J), or placebo, applied to quadriceps femoris muscles between sets, and after the last series of this exercise. After 1 week (washout period), all volunteers were exchanged among groups and then all assessments were repeated.

RESULTS: LLLT group increased RM (52%; p=0.002) with a small EFI for the vastus medialis (p=0.004) and rectus femoris (p=0.004).

Conclusions: These results suggest an increased muscle fatigue resistance when LLLT is applied during rest intervals, and after the last series of intense exercises.

Does Low-Level Laser Therapy Decrease Muscle-Damaging Mediators After Performance in Soccer Athletes Versus Sham Laser Treatment? A Critically Appraised Topic Jordan Bettleyon, Thomas W Kaminski, Review J Sport Rehabil. 2020 Nov *1;29(8):1210-1213.*

Muscle soreness, fatigue, damage and inflammation

Abstract

Clinical Scenario: Low-level laser therapy (LLLT) is a controversial topic for its use in athletic recovery, mainly due to inconsistency in research regarding the application of LLLT. Articles on LLLT have assessed its effectiveness in untrained humans through pain scales, functional scales, and blood draws, and it has been found capable in nonathletic rehabilitative use. The controversy lies with LLLT in the recovering athlete. Not only do athletes need to perform at high levels, but each sport is unique in the metabolic demands placed on the athletes' bodies. This modality can alter chemical mediators of the inflammatory process, specifically blood lactate (BL) and creatine kinase (CK). During soccer contests, it is a common problem for athletes to have an average CK level of 800 U/L and BL of 8 mmol·L, increasing delayed-onset muscle soreness and fatigue. Micro-CK level elevation is associated with cellular membrane damage, localized hypoxia, and electrolyte imbalances, hindering the recovery process. Clinical Question: Does LLLT decrease muscle-damaging mediators effecting player fatigue and delayed-onset muscle soreness after performance in soccer athletes versus sham treatment? Summary of Key Findings: In 3 studies, preperformance, postperformance, or preperformance and postperformance LLLT was performed and evaluated BL (2 of 3) and CK (2 of 3). In each article, BL and CK showed a significant decrease ($P < .05$) when performed either preperformance or postperformance versus the control group. The greatest decrease in these mediators was noticed when postperformance laser therapy was performed. Clinical Bottom Line: LLLT at 10, 30, or 50 J performed at a minimum of 2 locations on the rectus femoris, vastus lateralis, and vastus medialis bilaterally for 10 seconds each is significant in decreasing blood serum levels of BL and CK when performed postexercise. Strength of Recommendations: All 3 articles obtained a Physiotherapy Evidence Database score of ≥8/10.

Low-level laser therapy improves skeletal muscle performance, decreases skeletal muscle damage and modulates mRNA expression of COX-1 and COX-2 in a dose-dependent manner

Patrícia de Almeida, Rodrigo Álvaro Brandão Lopes-Martins, Shaiane Silva Tomazoni, José Antônio Silva Jr, Paulo de Tarso Camillo de Carvalho, Jan Magnus Bjordal, Ernesto Cesar Pinto Leal Junior, Photochem Photobiol. *Sep-Oct 2011;87(5):1159-63.*

Abstract

We tested if modulation in mRNA expression of cyclooxygenase isoforms (COX-1 and COX-2) can be related to protective effects of phototherapy in skeletal muscle. Thirty male Wistar rats were divided into five groups receiving either one of four laser doses (0.1, 0.3, 1.0 and 3.0 J) or a no-treatment control group. Laser irradiation (904 nm, 15 mW average power) was performed immediately before the first contraction for treated groups. Electrical stimulation was used to induce six tetanic tibial anterior muscle contractions. Immediately after sixth contraction, blood samples were collected to evaluate creatine kinase activity and muscles were dissected and frozen in liquid nitrogen to evaluate mRNA expression of COX-1 and COX-2. The 1.0 and 3.0 J groups showed significant enhancement ($P < 0.01$) in total work performed in six tetanic contractions compared with control group. All laser groups, except the 3.0 J group, presented significantly lower post-exercise CK activity than control group. Additionally, 1.0 J group showed increased COX-1 and decreased COX-2 mRNA expression compared with control group and 0.1, 0.3 and 3.0 J laser groups ($P < 0.01$). We conclude that pre-exercise infrared laser irradiation with dose of 1.0 J enhances skeletal muscle performance and decreases post-exercise skeletal muscle damage and inflammation.

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

Filipe Abdalla Dos Reis, Baldomero Antonio Kato da Silva, Erica Martinho Salvador Laraia, Rhaiza Marques de Melo, Patrícia Henrique Silva, Ernesto Cesar Pinto Leal-Junior, Paulo de Tarso Camillo de Carvalho, *Randomized Controlled Trial Photomed Laser Surg. 2014 Feb;32(2):106-12*

Abstract

OBJECTIVES: 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.

METHODS: The study was randomized, double blind, and placebo controlled.

PATIENTS: A sample of 27 healthy volunteers (male soccer players) were divided into three groups: placebo, pre-fatigue laser, and post-fatigue laser. The experiment was performed in two sessions, with a 1 week interval between them. Subjects performed two sessions of stretching followed by blood collection (measurement of lactate and CK) at baseline and after

fatigue of the quadriceps by leg extension. LLLT was applied to the femoral quadriceps muscle using an infrared laser device (830 nm), 0.0028 cm(2) beam area, six 60 mW diodes, energy of 0.6 J per diode (total energy to each limb 25.2 J (50.4 J total), energy density 214.28 J/cm(2), 21.42 W/cm(2) power density, 70 sec per leg. We measured the time to fatigue and number and maximum load (RM) of repetitions tolerated. Number of repetitions and time until fatigue were primary outcomes, secondary outcomes included serum lactate levels (measured before and 5, 10, and 15 min after exercise), and CK levels (measured before and 5 min after exercise).
RESULTS: The number of repetitions (p=0.8965), RM (p=0.9915), and duration of fatigue (p=0.8424) were similar among the groups. Post-fatigue laser treatment significantly decreased the serum lactate concentration relative to placebo treatment (p<0.01) and also within the group over time (after 5 min vs. after 10 and 15 min, p<0.05 both). The CK level was lower in the post-fatigue laser group (p<0.01).
CONCLUSIONS: 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.

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

Bruno Manfredini Baroni 1, Rodrigo Rodrigues, Bruno Bolla Freire, Rodrigo de Azevedo Franke, Jeam Marcel Geremia, Marco Aurélio Vaz, *Randomized Controlled Trial Eur J Appl Physiol. 2015 Mar;115(3):639-47.*

Abstract

PURPOSE: 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.
METHOD: Thirty healthy male subjects were randomized into three groups: Control Group (CG), Training Group (TG) and Training + LLLT Group (TLG). CG received no intervention, while TG and TLG were engaged on an 8-week knee extensor isokinetic eccentric training program. Only subjects from TLG were treated with LLLT (wavelength = 810 nm; power output = 200 mW; total dosage = 240 J) before each training session. Knee extensor muscle thickness and peak torque were assessed through ultrasonography and isokinetic dynamometry, respectively.
RESULTS: CG presented no changes in any variable throughout the study, while eccentric training led to significant increases in muscle thickness and peak torque in TG and TLG. Subjects from TLG reached significantly higher percent changes compared to subjects from TG for sum of muscles' thicknesses (15.4 vs. 9.4%), isometric peak torque (20.5 vs. 13.7%), and eccentric peak torque (32.2 vs. 20.0%).
CONCLUSION: LLLT applied before eccentric training sessions seems to improve the hypertrophic response and muscular strength gain in healthy subjects.

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

Thiago De Marchi, Ernesto Cesar Pinto Leal Junior, Celiana Bortoli, Shaiane Silva Tomazoni, Rodrigo Alvaro Brandão Lopes-Martins, Mirian Salvador, *Randomized Controlled Trial Lasers Med Sci. 2012 Jan;27(1):231-6.*

Abstract

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. LLLT (810 nm, 200 mW, 30 J in each site, 30 s of irradiation in each site) using a multi-diode cluster (with five spots - 6 J from each spot) at 12 sites of each lower limb (six in quadriceps, four in hamstrings, and two in gastrocnemius) was performed 5 min before a standardized progressive-intensity running protocol on a motor-drive treadmill until exhaustion. We analyzed exercise performance (VO(2 max), time to exhaustion, aerobic threshold and anaerobic threshold), levels of oxidative damage to lipids and proteins, the activities of the antioxidant enzymes superoxide dismutase (SOD) and catalase (CAT), and the markers of muscle damage creatine kinase (CK) and lactate dehydrogenase (LDH). Compared to placebo, active LLLT significantly increased exercise performance (VO(2 max) p = 0.01; time to exhaustion, p = 0.04) without changing the aerobic

and anaerobic thresholds. LLLT also decreased post-exercise lipid (p = 0.0001) and protein (p = 0.0230) damages, as well as the activities of SOD (p = 0.0034), CK (p = 0.0001) and LDH (p = 0.0001) enzymes. LLLT application was not able to modulate CAT activity. The use of LLLT before progressive-intensity running exercise increases exercise performance, decreases exercise-induced oxidative stress and muscle damage, suggesting that the modulation of the redox system by LLLT could be related to the delay in skeletal muscle fatigue observed after the use of LLLT.

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

Ernesto Cesar Pinto Leal Junior 1, Rodrigo Alvaro Brandão Lopes-Martins, Adriane Aver Vanin, Bruno Manfredini Baroni, Douglas Grosselli, Thiago De Marchi, Vegard V Iversen, Jan Magnus Bjordal

Randomized Controlled Trial Lasers Med Sci. 2009 May;24(3):425-31.

Abstract

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

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

Ernesto Cesar Pinto Leal Junior 1, Rodrigo Alvaro Brandão Lopes-Martins, Bruno Manfredini Baroni, Thiago De Marchi, Daiana Taufer, Débora Sgandella Manfro, Morgana Rech, Vanessa Danna, Douglas Grosselli, Rafael Abeche Generosi, Rodrigo Labat Marcos, Luciano Ramos, Jan Magnus Bjordal

Clinical Trial Lasers Med Sci. 2009 Nov;24(6):857-63.

Abstract

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. Twenty male athletes (nine professional volleyball players and eleven adolescent soccer players) participated. Active LLLT (830 nm wavelength, 100 mW, spot size 0.0028 cm(2), 3-4 J per point) or an identical placebo LLLT was delivered to five points in the rectus femoris muscle (bilaterally). The main outcome measures were the work performed in the Wingate test: 30 s of maximum cycling with a load of 7.5% of body weight, and the measurement of blood lactate (BL) and creatine kinase (CK) levels before and after exercise. There was no significant difference in the work performed during the Wingate test (P > 0.05) between subjects given active LLLT and those given placebo LLLT. For volleyball athletes, the change in CK levels from before to after the exercise test was significantly lower (P = 0.0133) for those given active LLLT (2.52 U l(-1) +/- 7.04 U l(-1)) than for those given placebo LLLT (28.49 U l(-1) +/- 22.62 U l(-1)). For the soccer athletes, the change in blood lactate levels from before exercise to 15 min after exercise was significantly lower (P < 0.01) in the group subjected to active LLLT (8.55 mmol l(-1) +/- 2.14 mmol l(-1)) than in the group subjected to placebo LLLT (10.52 mmol l(-1) +/- 1.82 mmol l(-1)). 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.

Muscle soreness, fatigue, damage and inflammation

Effect of 655-nm low-level laser therapy on exercise-induced skeletal muscle fatigue in humans

Ernesto Cesar Pinto Leal Junior 1, Rodrigo Alvaro Brandão Lopes-Martins, Francis Dalan, Maurício Ferrari, Fernando Montanari Sbabo, Rafael Abeche Generosi, Bruno Manfredini Baroni, Sócrates Calvoso Penna, Vegard V Iversen, Jan Magnus Bjordal *Randomized Controlled Trial Photomed Laser Surg. 2008 Oct;26(5):419-24.*

Abstract

OBJECTIVE: To investigate if development of skeletal muscle fatigue during repeated voluntary biceps contractions could be attenuated by low-level laser therapy (LLLT).

BACKGROUND: Previous animal studies have indicated that LLLT can reduce oxidative stress and delay the onset of skeletal muscle fatigue.

MATERIALS AND METHODS: Twelve male professional volleyball players were entered into a randomized double-blind placebo-controlled trial, for two sessions (on day 1 and day 8) at a 1-wk interval, with both groups performing as many voluntary biceps contractions as possible, with a load of 75% of the maximal voluntary contraction force (MVC). At the second session on day 8, the groups were either given LLLT (655 nm) of 5 J at an energy density of 500 J/cm2 administered at each of four points along the middle of the biceps muscle belly, or placebo LLLT in the same manner immediately before the exercise session. The number of muscle contractions with 75% of MVC was counted by a blinded observer and blood lactate concentration was measured.

RESULTS: Compared to the first session (on day 1), the mean number of repetitions increased significantly by 8.5 repetitions (+/- 1.9) in the active LLLT group at the second session (on day 8), while in the placebo LLLT group the increase was only 2.7 repetitions (+/- 2.9) ($p = 0.0001$). At the second session, blood lactate levels increased from a pre-exercise mean of 2.4 mmol/L (+/- 0.5 mmol/L), to 3.6 mmol/L (+/- 0.5 mmol/L) in the placebo group, and to 3.8 mmol/L (+/- 0.4 mmol/L) in the active LLLT group after exercise, but this difference between groups was not statistically significant.

CONCLUSION: We conclude that LLLT appears to delay the onset of muscle fatigue and exhaustion by a local mechanism in spite of increased blood lactate levels.

Light-emitting diode therapy (LEDT) before matches prevents increase in creatine kinase with a light dose response in volleyball players

Cleber Ferraresi 1, Ricardo Vinicius Dos Santos, Guilherme Marques, Marcelo Zangrande, Roberley Leonaldo, Michael R Hamblin, Vanderlei Salvador Bagnato, Nivaldo Antonio Parizotto *Randomized Controlled Trial Lasers Med Sci. 2015 May;30(4):1281-7.*

Abstract

Low-level laser (light) therapy (LLLT) has been applied over skeletal muscles before intense exercise (muscular pre-conditioning) in order to reduce fatigue and muscle damage (measured by creatine kinase, CK) in clinical trials. However, previous exercise protocols do not exactly simulate the real muscle demand required in sports. For this reason, the aim of this randomized and double-blind placebo-controlled trial was to investigate whether light-emitting diode therapy (LEDT) applied over the quadriceps femoris muscles, hamstrings, and triceps surae of volleyball players before official matches could prevent muscle damage (CK) with a dose response, establishing a therapeutic window. A professional male volleyball team (12 athletes) was enrolled in this study, and LEDT was applied before 4 matches during a national championship. LEDT used an array of 200 light-emitting diodes (LEDs) arranged in 25 clusters of 4 infrared LEDs (850 ± 20 nm; 130 mW) and 25 clusters of 4 red LEDs (630 ± 10 nm; 80 mW). Athletes were randomized to receive one of four different total doses over each muscle group in a double-blind protocol: 105 J (20 s), 210 J (40 s), 315 J (60 s), and placebo (no light for 30 s). CK in blood was assessed 1 h before and 24 h after each match. LEDT at 210 J avoided significant increases in CK (+10 %; $P = 0.993$) as well as 315 J (+31 %, $P = 0.407$). Placebo (0 J) allowed a significant increase in CK (+53 %; $P = 0.012$) as well as LEDT at 105 J (+59 %; $P = 0.001$). LEDT prevented significant increases of CK in blood in athletes when applied before official matches with a light dose response of 210-315 J, suggesting athletes might consider applying LEDT before competition.

Muscle strength

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

Cleber Ferraresi 1, Taysa de Brito Oliveira, Leonardo de Oliveira Zafalon, Rodrigo Bezerra de Menezes Reiff, Vilmar Baldissera, Sérgio Eduardo de Andrade Perez, Euclides Matheucci Júnior, Nivaldo Antônio Parizotto

Randomized Controlled Trial Lasers Med Sci. 2011 May;26(3):349-58.

Abstract

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. The study involved 36 men (20.8±2.2 years old), clinically healthy, with a beginner and/or moderate physical activity training pattern. The subjects were randomly distributed into three groups: TLG (training with LLLT), TG (training only) and CG (control). The training for TG and TLG subjects involved the leg-press exercise with a load equal to 80% of one repetition maximum (1RM) in the leg-press test over 12 consecutive weeks. The LLLT was applied to the quadriceps muscle of both lower limbs of the TLG subjects immediately after the end of each training session. Using an infrared laser device (808 nm) with six diodes of 60 mW each a total energy of 50.4 J of LLLT was administered over 140 s. Muscle strength was assessed using the 1RM leg-press test and the isokinetic dynamometer test. The muscle volume of the thigh of the dominant limb was assessed by thigh perimetry. The TLG subjects showed an increase of 55% in the 1RM leg-press test, which was significantly higher than the increases in the TG subjects (26%, P = 0.033) and in the CG subjects (0.27%, P < 0.001). The TLG was the only group to show an increase in muscle performance in the isokinetic dynamometry test compared with baseline. The increases in thigh perimeter in the TLG subjects and TG subjects were not significantly different (4.52% and 2.75%, respectively; P = 0.775). Strength training associated with LLLT can increase muscle performance compared with strength training only.

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

Wouber Hérickson de Brito Vieira 1, Cleber Ferraresi, Sérgio Eduardo de Andrade Perez, Vilmar Baldissera, Nivaldo Antônio Parizotto

Randomized Controlled Trial Lasers Med Sci. 2012 Mar;27(2):497-504.

Abstract

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). Included in the study were 45 clinically healthy women (21 ± 1.78 years old) who were randomly distributed into three groups: CG (control group), TG (training group) and TLG (training with LLLT group). The training for the TG and TLG groups involved cycle ergometer exercise with load applied to the ventilatory threshold (VT) for 9 consecutive weeks. Immediately after each training session, LLLT was applied to the femoral quadriceps muscle of both lower limbs of the TLG subjects using an infrared laser device (808 nm) with six 60-mW diodes with an energy of 0.6 J per diode and a total energy applied to each limb of 18 J. VT was determined by ergospirometry during an incremental exercise test and muscle performance was evaluated using an isokinetic dynamometer at 240°/s. Only the TLG showed a decrease in FIext in the nondominant lower limb (P = 0.016) and the dominant lower limb (P = 0.006). Both the TLG and the TG showed an increase in TWext in the nondominant lower limb (P < 0.001 and P = 0.011, respectively) and in the dominant lower limb (P < 0.000 and P < 0.000, respectively). The CG showed no reduction in FIext or TWext in either lower limb. 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.

Muscle strength

Phototherapy for Improvement of Performance and Exercise Recovery: Comparison of 3 Commercially Available Devices

Thiago De Marchi, Vinicius Mazzochi Schmitt, Carla Danúbia da Silva Fabro, Larissa Lopes da Silva, Juliane Sene, Olga Tairova, Mirian Salvador

Randomized Controlled Trial J Athl Train. 2017 May;52(5):429-438.

Abstract

CONTEXT: Recent studies suggest the prophylactic use of low-powered laser/light has ergogenic effects on athletic performance and postactivity recovery. Manufacturers of high-powered lasers/light devices claim that these can produce the same clinical benefits with increased power and decreased irradiation time; however, research with high-powered lasers is lacking.

OBJECTIVE: To evaluate the magnitude of observed phototherapeutic effects with 3 commercially available devices.

DESIGN: Randomized double-blind placebo-controlled study.

SETTING: Laboratory.

PATIENTS or other participants: Forty healthy untrained male participants.

INTERVENTIONS: Participants were randomized into 4 groups: placebo, high-powered continuous laser/light, low-powered continuous laser/light, or low-powered pulsed laser/light (comprising both lasers and light-emitting diodes). A single dose of 180 J or placebo was applied to the quadriceps.

MAIN OUTCOME MEASURES: Maximum voluntary contraction, delayed-onset muscle soreness (DOMS), and creatine kinase (CK) activity from baseline to 96 hours after the eccentric exercise protocol.

RESULTS: Maximum voluntary contraction was maintained in the low-powered pulsed laser/light group compared with placebo and high-powered continuous laser/light groups in all time points ($P < .05$). Low-powered pulsed laser/light demonstrated less DOMS than all groups at all time points ($P < .05$). High-powered continuous laser/light did not demonstrate any positive effects on maximum voluntary contraction, CK activity, or DOMS compared with any group at any time point. Creatine kinase activity was decreased in low-powered pulsed laser/light compared with placebo ($P < .05$) and high-powered continuous laser/light ($P < .05$) at all time points. High-powered continuous laser/light resulted in increased CK activity compared with placebo from 1 to 24 hours ($P < .05$).

CONCLUSIONS: Low-powered pulsed laser/light demonstrated better results than either low-powered continuous laser/light or high-powered continuous laser/light in all outcome measures when compared with placebo. The increase in CK activity using the high-powered continuous laser/light compared with placebo warrants further research to investigate its effect on other factors related to muscle damage.

Sports injuries

Low level laser therapy for sports injuries

Yusuke Morimoto 1, Akiyoshi Saito, Yasuaki Tokuhashi

Laser Ther. 2013;22(1):17-20.

Abstract

BACKGROUND: Our hospital has used LLLT in the treatment of athletes since 1990. We had a good result about LLLT for sports injuries. However, few articles have attempted to evaluate the efficacy of LLLT for sports injuries. The aims of this study was to evaluate the efficacy of LLLT for sports injuries. Materials (Subjects) and Methods: Forty one patients underwent LLLT in our hospital. These patients included 22 men and 19 women with an average age of 38.9 years old. Patients were irradiated by diode laser at points of pain and/or acupuncture points. Patients underwent LLLT a maximum treatment of 10 times (mean 4.1 times). We evaluated the efficacy of LLLT using a Pain relief score (PRS). A score of 2 to 5 after treatment was regarded as very good, 6 to 8 as good, and 9 to 10 as poor. A PRS score of less than 5 was regarded as effective.

RESULTS: The rate of effectiveness (PRS of 5 or less) after LLLT was 65.9% (27/41 patients).

Sports injuries

DISCUSSION: In this study, the resulting rate of effectiveness was 65.9% for all sports injuries. However, we have a high rate of effectiveness for Jumper's knee, tennis elbow and Achilles tendinitis and cases that were irradiated laser by a physician.
CONCLUSIONS: LLLT is an effective treatment for sports injuries, particularly jumper's knee, tennis elbow and Achilles tendinitis.

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

John Foley, David B Vasily, Jeanna Bradle, Catharine Rudio, R Glen Calderhead
Laser Ther. 2016 Mar 31;25(1):35-42.

Abstract

BACKGROUND and AIMS: 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.
SUBJECTS and METHODS: Over a 15-month period, a total of 395 injuries including sprains, strains, ligament damage, tendonitis and contusions were treated with 1,669 sessions of 830 nm LED phototherapy (mean of 4.3 treatments per injury, range 2 - 6). Efficacy was measured with pain attenuation on a visual analog scale (VAS) and the RTP period compared with historically-based anticipated RTP with conventional therapeutic intervention.
RESULTS: A full set of treatment sessions and follow-up data was able to be recorded in 65 informed and consenting subjects who achieved pain relief on the VAS of up to 6 points in from 2-6 sessions. The average LED-mediated RTP in the 65 subjects was significantly shorter at 9.6 days, compared with the mean anticipated RTP of 19.23 days ($p = 0.0066$, paired two-tailed Student's t-test). A subjective satisfaction survey was carried out among the 112 students with injuries incurred from January to May, 2015. Eighty-eight (78.5%) were either very satisfied or satisfied, and only 8 (7.2%) were dissatisfied.
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.

Acute pain

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

A Takenori, M Ikuhiro, U Shogo, K Hiroe, S Junji, T Yasutaka, K Hiroya, N Miki
Randomized Controlled Trial J Sci Med Sport. 2016 Dec;19(12):980-983.

Abstract

OBJECTIVES: 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.
DESIGN: Double-blind, randomized, comparative clinical study.
METHODS: Participants were 32 college athletes with motion pain at a defined site. Participants were randomized into two groups in which the tested or placebo laser therapy was administered to determine pain intensity from painful action before and after laser irradiation, using the Modified Numerical Rating Scale. The post-therapeutic Modified Numerical Rating Scale score was subtracted from the pre-therapeutic Modified Numerical Rating Scale score to determine pain intensity difference, and the rate of pain intensity difference to pre-therapeutic Modified Numerical Rating Scale was calculated as pain relief rate.

RESULTS: Low-level laser therapy was effective in 75% of the laser group, whereas it was not effective in the placebo group, indicating a significant difference in favor of the laser group ($p<0.001$). Pain relief rate was significantly higher in the laser group than in the placebo group (36.94% vs. 8.20%, respectively, $p<0.001$), with the difference in pain relief rate being 28.74%.
CONCLUSIONS: 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.

The effect of low-level laser on postoperative pain after tibial fracture surgery: a double-blind controlled randomized clinical trial

Sholeh Nesioonpour, Soheila Mokmeli, Salman Vojdani, Ahmadreza Mohtadi, Reza Akhondzadeh, Kaveh Behaeen, Shahnam Moosavi, Sarah Hojjati

Anesth Pain Med. 2014 Jun 21;4(3):e17350.

Abstract

BACKGROUND: Postoperative pain is a common complication that can lead to serious morbidities and delayed recovery.
OBJECTIVES: The aim of this study was to investigate the effect of low-level laser therapy on acute pain after tibial fracture surgery.
PATIENTS and METHODS: In this randomized clinical trial, 54 patients who were candidate for tibial fracture surgery were allocated randomly to two groups, namely, control and laser therapy. Both groups had the same type of surgery and technique of spinal anesthesia. Patients in laser group were treated with the combination of two lasers (GaALAs, 808 nm; and GaALInP, 650 nm) at the end of the surgery while control group received laser in turn-off mode with the same duration as laser group. Patients were evaluated for pain intensity according to the visual analogue scale (VAS) and the amount of analgesic use during 24 hours after surgery.
RESULTS: Laser group experienced less pain intensity in comparison with control group at second, fourth, eighth, 12(th), and 24(th) hours after surgery (P Value < 0.05). In addition, the amount of consumed opioid in laser group was significantly less than the control group (51.62 ± 29.52 and 89.28 ± 35.54 mg, respectively; P Value, 0.008).
CONCLUSIONS: Low Level Laser Therapy is a proper method to reduce postoperative pain because it is painless, safe, and noninvasive and is easily accepted by patients.

Low-level laser therapy in acute pain: a systematic review of possible mechanisms of action and clinical effects in randomized placebo-controlled trials

Jan Magnus Bjordal, Mark I Johnson, Vegard Iversen, Flavio Aimbire, Rodrigo Alvaro Brandao Lopes-Martins

Review Photomed Laser Surg. 2006 Apr;24(2):158-68.

Abstract

OBJECTIVE: The aim of this study was to review the biological and clinical short-term effects of photoradiation in acute pain from soft-tissue injury.
BACKGROUND DATA: It is unclear if and how photoradiation can reduce acute pain.
METHODS: Literature search of (i) controlled laboratory trials investigating potential biological mechanisms for pain relief and (ii) randomized placebo-controlled clinical trials which measure outcomes within the first 7 days after acute soft-tissue injury.
RESULTS: There is strong evidence from 19 out of 22 controlled laboratory studies that photoradiation can modulate inflammatory pain by reducing levels of biochemical markers (PGE(2), mRNA Cox 2, IL-1beta, TNFalpha), neutrophil cell influx, oxidative stress, and formation of edema and hemorrhage in a dose-dependent manner (median dose 7.5 J/cm(2), range 0.3-19 J/cm(2)). Four comparisons with non-steroidal anti-inflammatory drugs (NSAIDs) in animal studies found optimal doses of photoradiation and NSAIDs to be equally effective. Seven randomized placebo-controlled trials found no significant results after irradiating only a single point on the skin overlying the site of injury, or after using a total energy dose below 5 Joules. Nine randomized placebo-controlled trials (n = 609) were of acceptable methodological quality, and irradiated three or more points and/or more than 2.5 cm(2) at site of injury or surgical incision, with a total energy of 5.0-19.5 Joules. Results in these nine trials were significantly in favor of photoradiation groups over placebo groups in 15 out of 18 outcome comparisons. Poor and heterogeneous data presentation hampered statistical pooling of continuous data. Categorical data of subjective improve-

ment were homogeneous (Q-value = 7.1) and could be calculated from four trials (n = 379) giving a significant relative risk for improvement of 2.7 (95% confidence interval [CI], 1.8-3.9) in a fixed effects model.
CONCLUSION: photoradiation can modulate inflammatory processes in a dose-dependent manner and can be titrated to significantly reduce acute inflammatory pain in clinical settings. Further clinical trials with adequate photoradiation doses are needed to precisely estimate the effect size for photoradiation in acute pain.

Tendinopathy

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

Steve Tumilty 1, Joanne Munn, Suzanne McDonough, Deirdre A Hurley, Jeffrey R Basford, G David Baxter *Review Photomed Laser Surg. 2010 Feb;28(1):3-16.*

Abstract

OBJECTIVES: To assess the clinical effectiveness of Low Level Laser Therapy (LLLT) in the treatment of tendinopathy. Secondary objectives were to determine the relevance of irradiation parameters to outcomes, and the validity of current dosage recommendations for the treatment of tendinopathy.
BACKGROUND: 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.
METHOD: The following databases were searched from inception to 1(st) August 2008: MEDLINE, PubMed, CINAHL, AMED, EMBASE, All EBM reviews, PEDro (Physiotherapy Evidence Database), SCOPUS. Controlled clinical trials evaluating LLLT as a primary intervention for any tendinopathy were included in the review. Methodological quality was classified as: high (> or =6 out of 10 on the PEDro scale) or low (<6) to grade the strength of evidence. Accuracy and clinical appropriateness of treatment parameters were assessed using established recommendations and guidelines.
RESULTS: Twenty-five controlled clinical trials met the inclusion criteria. There were conflicting findings from multiple trials: 12 showed positive effects and 13 were inconclusive or showed no effect. Dosages used in the 12 positive studies would support the existence of an effective dosage window that closely resembled current recommended guidelines. In two instances where pooling of data was possible, LLLT showed a positive effect size; in studies of lateral epicondylitis that scored > or =6 on the PEDro scale, participants' grip strength was 9.59 kg higher than that of the control group; for participants with Achilles tendinopathy, the effect was 13.6 mm less pain on a 100 mm visual analogue scale.
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.

The effects of laser treatment in tendinopathy: a systematic review

Adelmário Cavalcanti Nogueira Jr, Manoel de Jesus Moura Júnior
Review Acta Ortop Bras. Jan-Feb 2015;23(1):47-9.

Abstract

Tendons have as main function transmit forces from the muscle to the bones. Tendinopathy is an inflammatory process that occurs in and around the tendon, when these are affected by some injury. Low level laser therapy consists in a local application of a monochromatic, coherent and short wavelength light. Its use began in 60's and since then several benefits for tendon injuries have been reported. The objective of this study is to collect the most recent studies about the use of laser on the tendinopathy treatment. We performed searches on the following electronic databases PubMed, Medline, CAPES journals portal and LILACS. After the analysis, we selected three articles that showed that the use of low-level laser therapy, compared to placebo, is effective in treatment of tendinopathy. Despite the need for more studies about this theme, the low-level laser therapy demonstrates consistent results in the treatment of tendinopathy.

Tendinopathy

The Functions and Mechanisms of Low-Level Laser Therapy in Tendon Repair (Review)

Kexin Lyu, Xueli Liu 1, Li Jiang, Yixuan Chen, Jingwei Lu, Bin Zhu, Xinyue Liu, Yujie Li, Dingxuan Wang, Sen Li *Front Physiol. 2022 Feb 15;13:808374.*

Abstract

Tendon injury is a common disease of the musculoskeletal system, accounting for roughly 30%-40% of sports system disorder injuries. In recent years, its incidence is increasing. Many studies have shown that low-level laser therapy (LLLT) has a significant effect on tendon repair by firstly activating cytochrome C oxidase and thus carrying out the photon absorption process, secondly acting in all the three phases of tendon repair, and finally improving tendon recovery. The repair mechanisms of LLLT are different in the three phases of tendon repair. In the inflammatory phase, LLLT mainly activates a large number of VEGF and promotes angiogenesis under hypoxia. During the proliferation phase, LLLT increases the amount of collagen type III by promoting the proliferation of fibroblasts. Throughout the remodeling phase, LLLT mainly activates M2 macrophages and downregulates inflammatory factors, thus reducing inflammatory responses. However, it should also be noted that in the final phase of tendon repair, the use of LLLT causes excessive upregulation of some growth factors, which will lead to tendon fibrosis. In summary, we need to further investigate the functions and mechanisms of LLLT in the treatment of tendon injury and to clarify the nature of LLLT for the treatment of diverse tendon injury diseases.

Neck

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

Roberta T Chow, Mark I Johnson, Rodrigo A B Lopes-Martins, Jan M Bjordal

Review Lancet. 2009 Dec 5;374(9705):1897-908.

Abstract

BACKGROUND: Neck pain is a common and costly condition for which pharmacological management has limited evidence of efficacy and side-effects. Low-level laser therapy (LLLT) is a relatively uncommon, non-invasive treatment for neck pain, in which non-thermal laser irradiation is applied to sites of pain. We did a systematic review and meta-analysis of randomised controlled trials to assess the efficacy of LLLT in neck pain.

METHODS: We searched computerised databases comparing efficacy of LLLT using any wavelength with placebo or with active control in acute or chronic neck pain. Effect size for the primary outcome, pain intensity, was defined as a pooled estimate of mean difference in change in mm on 100 mm visual analogue scale.

FINDINGS: We identified 16 randomised controlled trials including a total of 820 patients. In acute neck pain, results of two trials showed a relative risk (RR) of 1.69 (95% CI 1.22-2.33) for pain improvement of LLLT versus placebo. Five trials of chronic neck pain reporting categorical data showed an RR for pain improvement of 4.05 (2.74-5.98) of LLLT. Patients in 11 trials reporting changes in visual analogue scale had pain intensity reduced by 19.86 mm (10.04-29.68). Seven trials provided follow-up data for 1-22 weeks after completion of treatment, with short-term pain relief persisting in the medium term with a reduction of 22.07 mm (17.42-26.72). Side-effects from LLLT were mild and not different from those of placebo.

INTERPRETATION: We show that LLLT reduces pain immediately after treatment in acute neck pain and up to 22 weeks after completion of treatment in patients with chronic neck pain.

Neck

The effect of 300 mW, 830 nm laser on chronic neck pain: a double-blind, randomized, placebo-controlled study

Roberta T Chow 1, Gillian Z Heller, Les Barnsley

Clinical Trial Pain. 2006 Sep;124(1-2):201-10.

Abstract

A randomized, double-blind, placebo-controlled study of low-level laser therapy (LLLT) in 90 subjects with chronic neck pain was conducted with the aim of determining the efficacy of 300 mW, 830 nm laser in the management of chronic neck pain. Subjects were randomized to receive a course of 14 treatments over 7 weeks with either active or sham laser to tender areas in the neck. The primary outcome measure was change in a 10 cm Visual Analogue Scale (VAS) for pain. Secondary outcome measures included Short-Form 36 Quality-of-Life questionnaire (SF-36), Northwick Park Neck Pain Questionnaire (NPNQ), Neck Pain and Disability Scale (NPAD), the McGill Pain Questionnaire (MPQ) and Self-Assessed Improvement (SAI) in pain measured by VAS. Measurements were taken at baseline, at the end of 7 weeks' treatment and 12 weeks from baseline. The mean VAS pain scores improved by 2.7 in the treated group and worsened by 0.3 in the control group (difference 3.0, 95% CI 3.8-2.1). Significant improvements were seen in the active group compared to placebo for SF-36-Physical Score (SF36 PCS), NPNQ, NPAD, MPQVAS and SAI. The results of the SF-36 - Mental Score (SF36 MCS) and other MPQ component scores (afferent and sensory) did not differ significantly between the two groups. Low-level laser therapy (LLLT), at the parameters used in this study, was efficacious in providing pain relief for patients with chronic neck pain over a period of 3 months.

The clinical efficacy of low-power laser therapy on pain and function in cervical osteoarthritis

F Ozdemir, M Birtane, S Kokino. Clinical Trial Clin *Rheumatol. 2001;20(3):181-4.*

Abstract

Pain is a major symptom in cervical osteoarthritis (COA). Low-power laser (LPL) therapy has been claimed to reduce pain in musculoskeletal pathologies, but there have been concerns about this point. The aim of this study was to evaluate the analgesic efficacy of LPL therapy and related functional changes in COA. Sixty patients between 20 and 65 years of age with clinically and radiologically diagnosed COA were included in the study. They were randomised into two equal groups according to the therapies applied, either with LPL or placebo laser. Patients in each group were investigated blindly in terms of pain and pain-related physical findings, such as increased paravertebral muscle spasm, loss of lordosis and range of neck motion restriction before and after therapy. Functional improvements were also evaluated. Pain, paravertebral muscle spasm, lordosis angle, the range of neck motion and function were observed to improve significantly in the LPL group, but no improvement was found in the placebo group. LPL seems to be successful in relieving pain and improving function in osteoarthritic diseases.

Shoulder

The efficacy of low-level laser therapy for shoulder tendinopathy: a systematic review and meta-analysis of randomized controlled trials

Sturla Haslerud, Liv Heide Magnussen, Jon Joensen, Rodrigo Alvaro Brandao Lopes-Martins, Jan Magnus Bjordal, *Physiother Res Int. 2015 Jun;20(2):108-25.*

BACKGROUND AND PURPOSE: Low-level laser therapy (LLLT) is proposed as a treatment for tendinopathies. This is the first systematic review focusing solely on LLLT treatment effects in shoulder tendinopathy.

METHODS: A systematic review with meta-analysis and primary outcome measures pain relief on 100-mm visual analogue scale (VAS) and relative risk for global improvement. Two independent assessors rated the included studies according to the PEDro scale. Intervention quality assessments were performed of LLLT dosage and treatment procedures according to World Association for Laser Therapy guidelines. The included trials were sub-grouped by intervention quality and use of other physiotherapy interventions.

RESULTS: Seventeen randomized controlled trials (RCTs) met the inclusion criteria, and 13 RCTs were of high and 4 RCTs of

moderate methodological quality. Significant and clinically important pain relief was found with weighted mean differences (WMD) over placebo, for LLLT as monotherapy at 20.41 mm (95% CI: 12.38 to 28.44) and as adjunct to exercise therapy at 16.00 mm (95% CI: 11.88 to 20.12). The WMD when LLLT was used in a multimodal physiotherapy treatment regime reached statistical significance over placebo at 12.80 (95% CI: 1.67-23.94) mm pain reduction on VAS. Relative risks for global improvement were statistically significant at 1.96 (95% CI: 1.25-3.08) and 1.51 (95% CI: 1.12-2.03), for laser as monotherapy or adjunctive in a physiotherapy regime, respectively.

Laser versus Ultrasound in the Treatment of Supraspinatus Tendinosis: Randomised controlled trial

Liz Saunders, *Physiotherapy Volume 89, Issue 6, June 2003, Pages 365-373*

Summary

Thirty-six patients were randomly assigned to three groups to compare the effectiveness of low power laser therapy, ultrasound and no therapy for supraspinatus tendinosis. All three groups were given the same advice and educational material. Measurements were taken before and after treatment for muscle weakness secondary to pain, pain, disability and tenderness. Treatment for the experimental groups comprised nine therapeutic doses over a three-week period of either laser therapy or ultrasound; the control group had no treatment for three weeks.

The degree of muscle weakness, pain, functional disability and tenderness for the three groups was similar before treatment. Comparisons after treatment showed that the laser group had less muscle weakness ($p < 0.01$) and pain ($p < 0.01$) than the ultrasound and control groups and had less disability ($p < 0.05$) and tenderness ($p < 0.01$) after treatment than the control group.

These data suggest that the dose of laser therapy used in the study, advice and education improve the symptoms of supraspinatus tendinosis. Ultrasound also improved the symptoms, but was not significantly different from the control group that received advice only. Based on these results laser therapy should be the treatment of choice for supraspinatus tendinosis rather than ultrasound.

Elbow

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

Jan M Bjordal 1, Rodrigo Ab Lopes-Martins, Jon Joensen, Christian Couppe, Anne E Ljunggren, Apostolos Stergioulas, Mark I Johnson

Review BMC Musculoskelet Disord. 2008 May 29;9:75.

Abstract

BACKGROUND: 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. Methods: Systematic review with meta-analysis, with primary outcome measures of pain relief and/or global improvement and subgroup analyses of methodological quality, wavelengths and treatment procedures.

RESULTS: 18 randomised placebo-controlled trials (RCTs) were identified with 13 RCTs (730 patients) meeting the criteria for meta-analysis. 12 RCTs satisfied half or more of the methodological criteria. Publication bias was detected by Egger's graphical test, which showed a negative direction of bias. Ten of the trials included patients with poor prognosis caused by failed steroid injections or other treatment failures, or long symptom duration or severe baseline pain. The weighted mean difference (WMD) for pain relief was 10.2 mm [95% CI: 3.0 to 17.5] and the RR for global improvement was 1.36 [1.16 to 1.60]. Trials which targeted acupuncture points reported negative results, as did trials with wavelengths 820, 830 and 1064 nm. In a subgroup of five trials with 904 nm lasers and one trial with 632 nm wavelength where the lateral elbow tendon insertions were directly irradiated, WMD for pain relief was 17.2 mm [95% CI: 8.5 to 25.9] and 14.0 mm [95% CI: 7.4 to 20.6] respectively, while RR for global pain improvement was only reported for 904 nm at 1.53 [95% CI: 1.28 to 1.83]. LLLT doses in this subgroup ranged

between 0.5 and 7.2 Joules. Secondary outcome measures of painfree grip strength, pain pressure threshold, sick leave and follow-up data from 3 to 8 weeks after the end of treatment, showed consistently significant results in favour of the same LLLT subgroup ($p < 0.02$). No serious side-effects were reported.
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.

Effects of 904-nm low-level laser therapy in the management of lateral epicondylitis: a randomized controlled trial

Liz Kit Yin Lam, Gladys LaiYing Cheing

Randomized Controlled Trial Photomed Laser Surg. 2007 Apr;25(2):65-71.

Abstract

OBJECTIVE: The aim of this study was to evaluate the effectiveness of 904-nm low-level laser therapy (LLLT) in the management of lateral epicondylitis.
BACGROUND DATA: Lateral epicondylitis is characterized by pain and tenderness over the lateral elbow, which may also result in reduction in grip strength and impairment in physical function. LLLT has been shown effective in its therapeutic effects in tissue healing and pain control.
METHODS: Thirty-nine patients with lateral epicondylitis were randomly assigned to receive either active laser with an energy dose of 0.275 J per tender point (laser group) or sham irradiation (placebo group) for a total of nine sessions. The outcome measures were mechanical pain threshold, maximum grip strength, level of pain at maximum grip strength as measured by the Visual Analogue Scale (VAS) and the subjective rating of physical function with Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.
RESULTS: Significantly greater improvements were shown in all outcome measures with the laser group than with the placebo group ($p < 0.0125$), except in the two subsections of DASH.
CONCLUSION: This study revealed that LLLT in addition to exercise is effective in relieving pain, and in improving the grip strength and subjective rating of physical function of patients with lateral epicondylitis.

Effects of low-level laser and plyometric exercises in the treatment of lateral epicondylitis

Apostolos Stergioulas

Randomized Controlled Trial Photomed Laser Surg. 2007 Jun;25(3):205-13.

Abstract

OBJECTIVE: This study was undertaken to compare the effectiveness of a protocol of combination of laser with plyometric exercises and a protocol of placebo laser with the same program, in the treatment of tennis elbow.
BACKGROUND DATA: The use of low-level laser has been recommended for the management of tennis elbow with contradictory results. Also, plyometric exercises was recommended for the treatment of the tendinopathy.
METHODS: Fifty patients who had tennis elbow participated in the study and were randomised into two groups. Group A (n = 25) was treated with a 904 Ga-As laser CW, frequency 50 Hz, intensity 40 mW and energy density 2.4 J/cm(2), plus plyometric exercises and group B (n = 25) that received placebo laser plus the same plyometric exercises. During eight weeks of treatment, the patients of the two groups received 12 sessions of laser or placebo, two sessions per week (weeks 1-4) and one session per week (weeks 5-8). Pain at rest, at palpation on the lateral epicondyle, during resisted wrist extension, middle finger test, and strength testing was evaluated using Visual Analogue Scales. Also it was evaluated the grip strength, the range of motion and weight test. Parameters were determined before the treatment, at the end of the eighth week course of treatment (week 8), and eighth (week 8) after the end of treatment.
RESULTS: Relative to the group B, the group A had (1) a significant decrease of pain at rest at the end of 8 weeks of the treatment ($p < 0.005$) and at the end of following up period ($p < 0.05$), (2) a significant decrease in pain at palpation and pain on isometric testing at 8 weeks of treatment ($p < 0.05$), and at 8 weeks follow-up ($p < 0.001$), (3) a significant decrease in pain

Elbow

during middle finger test at the end of 8 weeks of treatment ($p < 0.01$), and at the end of the follow-up period ($p < 0.05$), (4) a significant decrease of pain during grip strength testing at 8 weeks of treatment ($p < 0.05$), and at 8 weeks follow-up ($p < 0.001$), (5) a significant increase in the wrist range of motion at 8 weeks follow-up ($p < 0.01$), (6) an increase in grip strength at 8 weeks of treatment ($p < 0.05$) and at 8 weeks follow-up ($p < 0.01$), and (7) a significant increase in weight-test at 8 weeks of treatment ($p < 0.05$) and at 8 weeks follow-up ($p < 0.005$).
CONCLUSION: The results suggested that the combination of laser with plyometric exercises was more effective treatment than placebo laser with the same plyometric exercises at the end of the treatment as well as at the follow-up. Future studies are needed to establish the relative and absolute effectiveness of the above protocol.

Low back

Acute low back pain with radiculopathy: a double-blind, randomized, placebo-controlled study

Ljubica M Konstantinovic, Zeljko M Kanjuh, Andjela N Milovanovic, Milisav R Cutovic, Aleksandar G Djurovic, Viktorija G Savic, Aleksandra S Dragin, Nesa D Milovanovic

Randomized Controlled Trial Photomed Laser Surg. 2010 Aug;28(4):553-60.

Abstract

OBJECTIVE: The aim of this study was to investigate the clinical effects of low-level laser therapy (LLLT) in patients with acute low back pain (LBP) with radiculopathy.
BACKGROUND: Acute LBP with radiculopathy is associated with pain and disability and the important pathogenic role of inflammation. LLLT has shown significant anti-inflammatory effects in many studies.
MATERIALS AND METHODS: A randomized, double-blind, placebo-controlled trial was performed on 546 patients. Group A (182 patients) was treated with nimesulide 200 mg/day and additionally with active LLLT; group B (182 patients) was treated only with nimesulide; and group C (182 patients) was treated with nimesulide and placebo LLLT. LLLT was applied behind the involved spine segment using a stationary skin-contact method. Patients were treated 5 times weekly, for a total of 15 treatments, with the following parameters: wavelength 904 nm; frequency 5000 Hz; 100-mW average diode power; power density of 20 mW/cm(2) and dose of 3 J/cm(2); treatment time 150 sec at whole doses of 12 J/cm(2). The outcomes were pain intensity measured with a visual analog scale (VAS); lumbar movement, with a modified Schober test; pain disability, with Oswestry disability score; and quality of life, with a 12-item short-form health survey questionnaire (SF-12). Subjects were evaluated before and after treatment. Statistical analyses were done with SPSS 11.5.
RESULTS: Statistically significant differences were found in all outcomes measured ($p < 0.001$), but were larger in group A than in B ($p < 0.0005$) and C ($p < 0.0005$). The results in group C were better than in group B ($p < 0.0005$).
CONCLUSIONS: The results of this study show better improvement in acute LBP treated with LLLT used as additional therapy.

The effectiveness of low-level laser therapy for nonspecific chronic low back pain: a systematic review and meta-analysis

ZeYu Huang, Jun Ma, Jing Chen, Bin Shen, FuXing Pei, Virginia Byers Kraus

Review Arthritis Res Ther. 2015 Dec 15;17:360.

Abstract

BACKGROUND: In recent decades, low-level laser therapy (LLLT) has been widely used to relieve pain caused by different musculoskeletal disorders. Though widely used, its reported therapeutic outcomes are varied and conflicting. Results similarly conflict regarding its usage in patients with nonspecific chronic low back pain (NSCLBP). This study investigated the efficacy of low-level laser therapy (LLLT) for the treatment of NSCLBP by a systematic literature search with meta-analyses on selected studies.

METHOD: MEDLINE, EMBASE, ISI Web of Science and Cochrane Library were systematically searched from January 2000 to November 2014. Included studies were randomized controlled trials (RCTs) written in English that compared LLLT with placebo treatment in NSCLBP patients. The efficacy effect size was estimated by the weighted mean difference (WMD). Standard random-effects meta-analysis was used, and inconsistency was evaluated by the I-squared index (I(2)).
RESULTS: Of 221 studies, seven RCTs (one triple-blind, four double-blind, one single-blind, one not mentioning blinding, totaling 394 patients) met the criteria for inclusion. Based on five studies, the WMD in visual analog scale (VAS) pain outcome score after treatment was significantly lower in the LLLT group compared with placebo (WMD = -13.57 [95 % CI = -17.42, -9.72], I(2) = 0 %). No significant treatment effect was identified for disability scores or spinal range of motion outcomes.
CONCLUSIONS: Our findings indicate that LLLT is an effective method for relieving pain in NSCLBP patients. However, there is still a lack of evidence supporting its effect on function.

Evaluation of the Therapeutic Effect of Low Level Laser in Controlling Low Back Pain: A Randomized Controlled Trial

Leyla Kholoosy, Dariush Elyaspour, Mohammad Reza Akhgari, Zahra Razzaghi, Zeinab Khodamardi, Masume Bayat. J Lasers *Med Sci. Spring 2020;11(2):120-125.*

Abstract

INTRODUCTION: Low back pain (LBP) is a very common musculoskeletal disorder. The big burden of disease necessitates investigating a more effective modality of treatments with more persistence and also fewer side effects. Low power laser has been proved as a pain reducing modality, but there is a lack of studies comparing it with other treatments and also among the Iranian race and society. The purpose of this study was to evaluate the effect of low-level laser on patients with LBP.
METHODS: Our study was a single-blind, randomized controlled trial. Forty subjects, aged between 20 to 70 with LBP participated in the study. Their pain severity scale was 3-10 according to the visual analogue scale of pain (VAS). They were randomly assigned to two groups, a case group (true laser) and a control group (sham laser). Naproxen was prescribed with a free dose (250-1000 mg/ daily) to both groups. We evaluated patients' subjective pain, functional status (using the Roland Morris disability questionnaire), spinal range of motion (ROM) and spinal tenderness at the basic time, one month and 3 months after treatment. The true laser group received 12 sessions of laser (160 mW) and the control group took 12 sessions of sham laser (the same laser instrument in off status). An infrared laser GaAlAs, wavelength 808 nm, power 160 mw and spot size 1 cm2 and power density 0.16 J/cm2 in continuous mode was used in treatment. We applied the laser to articular spaces of vertebral column, adjacent paravertebral points, pain radiating areas, tender points and also pain-controlling acupuncture points.
RESULTS: Of the 40 participants in the study, 6 persons were excluded and thus the data obtained from 34 participants were statistically analyzed. There was significant improvement in pain ($P<0.001$ for both groups), functional status (Case group: $P<0.001$; control group: $P=0.004$) and spinal ROM (Case group: $P<0.001$; control group: $P=0.007$) in both groups at the end of the first month, but these gains persisted for 3 months only in the case group ($P<0.001$). Regarding spinal tenderness, it was disappeared in 89.47% of the patients in the true laser group at the end of one month but remained unchanged in 73.33% of the subjects of the sham laser group.
CONCLUSION: We concluded that laser therapy (in combination with NSAIDs) is an effective and long-lasting therapeutic strategy in bringing relief from LBP without any significant side effect.

Efficacy of low power laser therapy and exercise on pain and functions in chronic low back pain

Ali Gur, Mehmet Karakoc, Remzi Cevik, Kemal Nas, Aysegul Jale Sarac, Meral Karakoc
Clinical Trial Lasers Surg Med. 2003;32(3):233-8

Abstract

BACKGROUND AND OBJECTIVES: The aim of this study was to determine whether low power laser therapy (Gallium-Arsenide) is useful or not for the therapy of chronic low back pain (LBP).
MATERIALS AND METHODS: This study included 75 patients (laser + exercise-25, laser alone-25, and exercise alone-25) with LBP. Visual analogue scale (VAS), Schober test, flexion and lateral flexion measures, Roland Disability Questionnaire (RDQ) and

Low back

Modified Oswestry Disability Questionnaire (MODQ) were used in the clinical and functional evaluations pre and post therapeutically. A physician, who was not aware of the therapy undertaken, evaluated the patients.
RESULTS: Significant improvements were noted in all groups with respect to all outcome parameters, except lateral flexion $P < 0.05$).
CONCLUSIONS: Low power laser therapy seemed to be an effective method in reducing pain and functional disability in the therapy of chronic LBP.

Hamstring

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

Maurício Pinto Dornelles, Carolina Gassen Fritsch, Francesca Chaida Sonda, Douglas Scott Johnson, Ernesto Cesar Pinto Leal-Junior, Marco Aurélio Vaz, Bruno Manfredini Baroni
Randomized Controlled Trial Lasers Med Sci. 2019 Aug;34(6):1177-1184.

Abstract

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. Twelve male amateur soccer players (~ 25 years) participated in this randomized, crossover, double-blinded, placebo-controlled trial. The volunteers were evaluated in two sessions, with a minimum 7-day interval. At each session, volunteers received either PBMT (300 J per thigh) or placebo treatment on the hamstrings prior to the simulated soccer match. Muscle strength and functional capacity were evaluated through isokinetic dynamometry and countermovement jump (CMJ) tests, respectively, before and immediately after the simulated soccer match. Players had lower reductions on hamstring eccentric peak torque [4.85% (ES = 0.31) vs. 8.72% (ES = 0.50)], hamstring-to-quadriceps torque ratio [3.60% (ES = 0.24) vs. 7.75% (ES = 0.50)], and CMJ height [1.77% (ES = 0.09) vs. 5.47% (ES = 0.32)] when treated with PBMT compared to placebo. 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. In conclusion, 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.

Knee

Low-level laser therapy in meniscal pathology: a double-blinded placebo-controlled trial

Nikolaos Malliaropoulos, Olga Kiritsi, Kostantinos Tsitas, Dimitris Christodoulou, A Akritidou, Angelo Del Buono, Nicola Maffulli
Randomized Controlled Trial, Lasers Med Sci. 2013 Jul;28(4):1183-8.

Abstract

We performed a randomized, double-blinded, placebo-controlled study (ISRCTN24203769) to assess the effectiveness of low-level laser therapy (LLLT) in patients with meniscal pathology, including only symptomatic patients with tiny focus of grade 3 attenuation (seen only on 0.7 thickness sequences) or intrasubstance tears with spot of grade 3 signal intensity approaching the articular surface. None of the patients in the study group underwent arthroscopy or new magnetic resonance imaging investigation. Paired-samples t test was used to detect significant changes in subjective knee pain over the experimental period within groups, and ANOVA was used to detect any significant differences between the two groups. Pain was significantly im-

proved for the LLLT group than for the placebo group (F = 154, p < 0.0001). Pain scores were significantly better after LLLT. Four (12.5 %) patients did not respond to LLLT. At baseline, the average Lysholm score was 77 ± 4.6 for the LLLT group and 77.2 ± 2.6 for the placebo group (p > 0.05). Four weeks after LLLT or placebo therapy, the laser group reported an average Lysholm score of 82.5 ± 4.6, and the placebo group scored 79.0 ± 1.9. At 6 months, the laser group had an average Lysholm score of 82.2 ± 5.7, and after 1 year, they scored 81.6 ± 6.6 (F = 14.82923, p = 0.002). Treatment with LLLT was associated with a significant decrease of symptoms compared to the placebo group: it should be considered in patients with meniscal tears who do not wish to undergo surgery.

Adjunctive use of combination of super-pulsed laser and light-emitting diodes phototherapy on nonspecific knee pain: double-blinded randomized placebo-controlled trial

Ernesto Cesar Pinto Leal-Junior 1, Douglas Scott Johnson, Anita Saltmarche, Timothy Demchak

Randomized Controlled Trial Lasers Med Sci. 2014 Nov;29(6):1839-47.

Abstract

Phototherapy with low-level laser therapy (LLLT) and light-emitting diode therapy (LEDT) has arisen as an interesting alternative to drugs in treatments of musculoskeletal disorders. However, there is a lack of studies investigating the effects of combined use of different wavelengths from different light sources like lasers and light-emitting diodes (LEDs) in skeletal muscle disorders. With this perspective in mind, this study aimed to investigate the effects of phototherapy with combination of different light sources on nonspecific knee pain. It was performed a randomized, placebo-controlled, double-blinded clinical trial. Eighty-six patients rated 30 or greater on the pain visual analogue scale (VAS) were recruited and included in study. Patients of LLLT group received 12 treatments with active phototherapy (with 905 nm super-pulsed laser and 875 and 640 nm LEDs, Manufactured by Multi Radiance Medical, Solon, OH, USA) and conventional treatment (physical therapy or chiropractic care), and patients of placebo group were treated at same way but with placebo phototherapy device. Pain assessments (VAS) were performed at baseline, 4th, 7th, and 10th treatments, after the completion of treatments and at 1-month follow-up visit. Quality of life assessments (SF-36®) were performed at baseline, after the completion of treatments and at 1-month follow-up visit. Our results demonstrate that phototherapy significantly decreased pain (p < 0.05) from 10th treatment to follow-up assessments and significantly improved (p < 0.05) SF-36® physical component summary at posttreatments and follow-up assessments compared to placebo. We conclude that combination of super-pulsed laser, red and infrared LEDs is effective to decrease pain and improve quality of life in patients with knee pain.

Lower leg

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

Cheng-Chiang Chang, Chih-Hung Ku, Wei-Chun Hsu, Yu-An Hu, Jia-Fwu Shyu, Shin-Tsu Chang

Randomized Controlled Trial Lasers Med Sci. 2014 Jul;29(4):1485-94.

Abstract

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). All medical data were gathered from enrolled adults with sports-related lower leg pain. A total of 54 patients underwent triple-phase bone scans using skeletal nuclear scintigraphy, which confirmed periostitis in their lower limbs. The patients were then randomly divided into two groups: one group received laser therapy (N = 29) and the other group (N = 25) received an equivalent placebo treatment (a drug or physical therapy). Treatment protocol commenced with rehabilitation intervention and LLLT was performed three times daily for 5 days at a dosage of 1.4 J/cm(2). A Likert-type pain scale was used to evaluate the severity of pain. Balance function, including postural stability testing (PST) and limits of stability (LOS), was also performed to evaluate

the function outcome. Patients experienced a significant improvement in pain by day 2 or day 5 after starting LLLT, but here was no significant difference in pain scale between the measurements before (baseline) and after LLLT. Comparing the PST, the group differences of dynamic vs. static testings ranged from -18.54 to -50.22 (compared 12, 8, 4, 3, 2, 1 to 0, all $p < 0.0001$), and the PST after LLLT were 3.73 units ($p = 0.0258$) lower than those of before LLLT. Comparing the LOS, the group differences of dynamic vs. static testing were similar to those in PST, and the relationship between LOS and groups only varied with the direction control during dynamic testing in direction at backward/right vs. right ($p < 0.0001$). LLLT had a positive effect on proprioception in patients with lower limb periostitis. Larger, better controlled studies are needed to determine what specific effects LLLT has on the function of proprioception.

Achilles tendon

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

J M Bjordal 1, R A B Lopes-Martins, V V Iversen

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

Abstract

BACKGROUND: Low level laser therapy (LLLT) has gained increasing popularity in the management of tendinopathy and arthritis. Results from in vitro and in vivo studies have suggested that inflammatory modulation is one of several possible biological mechanisms of LLLT action.

Objective: To investigate in situ if LLLT has an anti-inflammatory effect on activated tendinitis of the human Achilles tendon.

SUBJECTS: Seven patients with bilateral Achilles tendinitis (14 tendons) who had aggravated symptoms produced by pain inducing activity immediately before the study.

METHOD: Infrared (904 nm wavelength) LLLT (5.4 J per point, power density 20 mW/cm2) and placebo LLLT (0 J) were administered to both Achilles tendons in random blinded order.

RESULTS: Ultrasonography Doppler measurements at baseline showed minor inflammation through increased intratendinous blood flow in all 14 tendons and measurable resistive index in eight tendons of 0.91 (95% confidence interval 0.87 to 0.95). Prostaglandin E2 concentrations were significantly reduced 75, 90, and 105 minutes after active LLLT compared with concentrations before treatment ($p = 0.026$) and after placebo LLLT ($p = 0.009$). Pressure pain threshold had increased significantly ($p = 0.012$) after active LLLT compared with placebo LLLT: the mean difference in the change between the groups was 0.40 kg/cm2 (95% confidence interval 0.10 to 0.70).

CONCLUSION: 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.

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

Apostolos Stergioulas, Marianna Stergioula, Reidar Aarskog, Rodrigo A B Lopes-Martins, Jan M Bjordal, *Randomized Controlled Trial, Am J Sports Med. 2008 May;36(5):881-7.*

Abstract

BACKGROUND: Eccentric exercises (EEs) are recommended for the treatment of Achilles tendinopathy, but the clinical effect from EE has a slow onset.

HYPOTHESIS: The addition of low-level laser therapy (LLLT) to EE may cause more rapid clinical improvement.

STUDY DESIGN: Randomized controlled trial; Level of evidence, 1.

METHODS: A total of 52 recreational athletes with chronic Achilles tendinopathy symptoms were randomized to groups receiving either EE + LLLT or EE + placebo LLLT over 8 weeks in a blinded manner. Low-level laser therapy (lambda = 820 nm) was

administered in 12 sessions by irradiating 6 points along the Achilles tendon with a power density of 60 mW/cm(2) and a total dose of 5.4 J per session.
RESULTS: The results of the intention-to-treat analysis for the primary outcome, pain intensity during physical activity on the 100-mm visual analog scale, were significantly lower in the LLLT group than in the placebo LLLT group, with 53.6 mm versus 71.5 mm (P = .0003) at 4 weeks, 37.3 mm versus 62.8 mm (P = .0002) at 8 weeks, and 33.0 mm versus 53.0 mm (P = .007) at 12 weeks after randomization. Secondary outcomes of morning stiffness, active dorsiflexion, palpation tenderness, and crepitation showed the same pattern in favor of the LLLT group.
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.

Photobiomodulation and eccentric exercise for Achilles tendinopathy: a randomized controlled trial

Steve Tumilty, Ramikrishnan Mani, George D Baxter. *Randomized Controlled Trial, Lasers Med Sci. 2016 Jan;31(1):127-35.*

Abstract

BACKGROUND: The common regime of eccentric exercise in use for Achilles tendinopathy is somewhat arduous and compliance issues can arise. This is the first study to investigate the effectiveness of a regime of fewer exercise sessions combined with photobiomodulation for the treatment of Achilles tendinopathy.
METHODS: A double blind randomized controlled trial and intention-to-treat analysis were performed. Eighty participants, 18-65 years with Achilles tendinopathy and symptoms for longer than 3 months, were included in the trial. Participants randomized into one of four groups; 1 (Placebo + Ex Regime 1) or 2 (Laser + Ex Regime 1) or 3 (Placebo + Ex Regime 2) or 4 (Laser + Ex Regime 2). The primary outcome measure was the Victorian Institute of Sports Assessment-Achilles (VISA-A) questionnaire. Outcomes were collected at baseline, week 4 and week 12.
RESULTS: Sixteen participants were lost to follow-up at 12 weeks, 4 of which due to adverse reactions. As per intention to treat, missing data were imputed, 80 participants were included in the final analysis. For VISA-A at 12 weeks, group 4 achieved significant gains over the other 3 groups: group 1 (18.5 [9.1, 27.9]), group 2 (10.4 [1.5, 19.2]), group 3 (11.3 [3.0, 19.6]). There was a moderate effect size in favour of exercise twice per week (7.2 [-1.8, 16.2], ES .7).
CONCLUSIONS: Twice-daily exercise sessions are not necessary as equivalent results can be obtained with two exercise sessions per week. The addition of photobiomodulation as adjunct to exercise can bring added benefit.

Ankle

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

Apostolos Stergioulas Clinical Trial, J *Clin Laser Med Surg. 2004 Apr;22(2):125-8.*

Abstract

OBJECTIVE: 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.
MATERIALS AND METHODS: Forty-seven soccer players with second degree ankle sprains, selected at random, were divided into the following groups: The first group (n = 16) was treated with the conventional initial treatment (RICE, rest, ice, compression, elevation), the second group (n = 16) was treated with the RICE method plus placebo laser, and the third group (n = 15) was treated with the RICE method plus an 820-nm GaA1As diode laser with a radiant power output of 40 mW at 16 Hz. Before the treatment, and 24, 48, and 72 h later, the volume of the edema was measured.
RESULTS: A three by three repeated measures ANOVA with a follow up post hoc test revealed that the group treated with the RICE and an 820-nm GaA1As diode laser presented a statistically significant reduction in the volume of the edema after 24 h

(40.3 +/- 2.4 mL, p < 0.01), 48 h (56.4 +/- 3.1 mL, p < 0.002), and 72 h (65.1 +/- 4.4 mL, p < 0.001).
CONCLUSIONS: LLLT combined with RICE can reduce edema in second-degree ankle sprains.

Musculoskeletal pain

Low-intensity LASER and LED (photobiomodulation therapy) for pain control of the most common musculoskeletal conditions: a literature review

Marcelo F DE Oliveira, Douglas S Johnson, Timothy Demchak, Shaiane S Tomazoni, Ernesto C Leal-Junior *Eur J Phys Rehabil Med. 2021 Dec 16.*

Abstract

Pain is the most common reason for physician consultations and the number one reason for missed work or school days is musculoskeletal pain. Pain management is utilized for easing the suffering and improving the quality of life of those living with chronic pain. Over the past several decades, physicians have become increasingly willing to prescribe opioids to manage pain. However, the opioid use can cause side effects as poor coordination, sedation, mood swings, depression, and anxiety combined with a dependence on the drugs. In the rehabilitation setting, patients benefit most when their health providers utilize a multimodal approach combining different types of therapies and when patients take on a significant role in optimal management of their own pain. The use of light as a therapeutic alternative form of medicine to manage pain and inflammation has been proposed to fill this void. Photobiomodulation therapy applied in the form of low-intensity light amplification by the stimulated emission of radiation (LASER) and lightemitting diode (LED) has been shown to reduce inflammation and swelling, promote healing, and reduce pain for an array of musculoskeletal conditions. There is evidence that photobiomodulation therapy reduces pain intensity in non-specific knee pain, osteoarthritis, pain post-total hip arthroplasty, fibromyalgia, temporomandibular diseases, neck pain, and low back pain. Therefore, the purpose of this review was to presented the up-to-dated evidence about the effects of lowintensity LASER and LED (photobiomodulation therapy) on pain control of the most common musculoskeletal conditions. We observed that the photobiomodulation therapy offers a noninvasive, safe, drug-free, and side-effect-free method for pain relief of both acute and chronic musculoskeletal conditions as well as fibromyalgia.

The Use of Low Level Laser Therapy (LLLT) For Musculoskeletal Pain

Howard B Cotler, Roberta T Chow, Michael R Hamblin, James Carroll

MOJ Orthop Rheumatol. 2015;2(5):00068.

Abstract

Pain is the most common reason for physician consultation in the United States. One out of three Americans is affected by chronic pain annually. The number one reason for missed work or school days is musculoskeletal pain. Currently accepted therapies consist of non-steroidal anti-inflammatory drugs, steroid injections, opiate pain medications and surgery, each of which carries their own specific risk profiles. What is needed are effective treatments for pain which have an acceptably low risk-profile. For over forty years, low level laser (light) therapy (LLLT) and LED (light emitting diode) therapy (also known as photobiomodulation) has been shown to reduce inflammation and edema, induce analgesia, and promote healing in a range of musculoskeletal pathologies. The purpose of this paper is to review the use of LLLT for pain, the biochemical mechanisms of action, the dose response curves, and how LLLT may be employed by orthopedic surgeons to improve outcomes and reduce adverse events. With the predicted epidemic of chronic pain in developed countries, it is imperative to validate cost-effective and safe techniques for managing painful conditions which would allow people to live active and productive lives. Moreover the acceptance of LLLT (which is currently being used by many specialties around the world) into the armamentarium of the American health care provider would allow for additional treatment options for patients. A new cost-effective therapy for pain could elevate quality of life while reducing financial strains.

Musculoskeletal pain

Effects of low-level laser therapy on pain in patients with musculoskeletal disorders: a systematic review and meta-analysis

Ron Clijsen, Anina Brunner, Marco Barbero, Peter Clarys, Jan Taeymans

Review Eur J Phys Rehabil Med. 2017 Aug;53(4):603-610.

Abstract

INTRODUCTION: This meta-analysis investigated the effectiveness of low-level laser therapy (LLLT) on pain in adult patients with musculoskeletal disorders.

EVIDENCE AQUISITION: A systematic literature search was conducted in the Medline and PEDro databases. Two researchers independently screened titles and abstracts of the retrieved studies for eligibility. Quality assessment of the eligible studies was conducted using the PEDro rating scale. Studies that scored ≥4 were included. A random-effects model was used for this meta-analysis. Subgroup meta-analyses were conducted to evaluate the influence of the adherence of the applied LLLT to the World Association of Laser Therapy (WALT) guidelines, the anatomical site under investigation and the study design on the overall weighted mean effect size. Meta regression was used to assess the possible influence of the study quality on the individual study effect sizes.

EVIDENCE SYNTHESIS: Eighteen studies allowing for 21 head-to-head comparisons (totaling N.=1462 participants) were included. The pooled raw mean difference (D) in pain between LLLT and the control groups was -0.85 (95% CI: -1.22 to -0.48). There was high (I^2=85.6%) and significant between study heterogeneity (Cochran's Q =139.2; df=20; P<0.001). The subgroup meta-analysis of the comparisons not following the WALT guidelines revealed a D=-0.68 (95% CI: -1.09 to -0.27). In this group, heterogeneity decreased to I^2=72.6% (Q=51.2; df=14; P<0.001). In the WALT subgroup D equaled -1.52 (95% CI: -2.34 to -0.70). This between groups difference was clinically relevant although statistically not significant (Q=3.24; df=1; P=0.072).

CONCLUSIONS: This meta-analysis presents evidence that LLLT is an effective treatment modality to reduce pain in adult patients with musculoskeletal disorders. Adherence to WALT dosage recommendations seems to enhance treatment effectiveness.

Wounds

Wound healing of animal and human body sport and traffic accident injuries using low-level laser therapy treatment: a randomized clinical study of seventy-four patients with control group

Z Simunovic 1, A D Ivankovich, A Depolo,

Clinical Trial, J Clin Laser Med Surg. 2000 Apr;18(2):67-73.

Abstract

BACKGROUND AND OBJECTIVE: The main objective of current animal and clinical studies was to assess the efficacy of low level laser therapy (LLLT) on wound healing in rabbits and humans.

STUDY DESIGN/MATERIALS AND METHODS: In the initial part of our research we conducted a randomized controlled animal study, where we evaluated the effects of laser irradiation on the healing of surgical wounds on rabbits. The manner of the application of LLLT on the human body are analogous to those of similar physiologic structure in animal tissue, therefore, this study was continued on humans. Clinical study was performed on 74 patients with injuries to the following anatomic locations: ankle and knee, bilaterally, Achilles tendon; epicondylus; shoulder; wrist; interphalangeal joints of hands, unilaterally. All patients had had surgical procedure prior to LLLT. Two types of laser devices were used: infrared diode laser (GaAlAs) 830 nm continuous wave for treatment of trigger points (TPs) and HeNe 632.8 nm combined with diode laser 904-nm pulsed wave for scanning procedure. Both were applied as monotherapy during current clinical study. The results were observed and measured according to the following clinical parameters: redness, heat, pain, swelling and loss of function, and finally postponed to statistical analysis via chi2 test.

RESULTS: After comparing the healing process between two groups of patients, we obtained the following results: wound

healing was significantly accelerated (25%-35%) in the group of patients treated with LLLT. Pain relief and functional recovery of patients treated with LLLT were significantly improved comparing to untreated patients.
CONCLUSION: In addition to accelerated wound healing, the main advantages of LLLT for postoperative sport- and traffic-related injuries include prevention of side effects of drugs, significantly accelerated functional recovery, earlier return to work, training and sport competition compared to the control group of patients, and cost benefit.

Bone fracture

Therapeutic outcomes of low-level laser therapy for closed bone fracture in the human wrist and hand

Wen-Dien Chang, Jih-Huah Wu, Hui-Ju Wang, Joe-Air Jiang
Randomized Controlled Trial Photomed Laser Surg. 2014 Apr;32(4):212-8.

Abstract

OBJECTIVE: The therapeutic outcomes of low-level laser therapy (LLLT) on closed bone fractures (CBFs) in the wrist and hand were investigated in this controlled study.
BACKGROUND: Animal research has confirmed that LLLT increases osteocyte quantity; however, little research has been conducted to determine the effect of LLLT on the treatment of human bone fractures.
METHODS: In this study, the therapeutic outcomes of administering 830 nm LLLT to treat CBFs in the wrist or hand were examined. Fifty patients with CBFs in the wrist and hand, who had not received surgical treatment, were recruited and randomly assigned to two groups. The laser group underwent a treatment program in which 830 nm LLLT (average power 60 mW, peak power 8 W, 10 Hz, 600 sec, and 9.7 J/cm(2) per fracture site) was administered five times per week for 2 weeks. Participants in a placebo group received sham laser treatment. The pain, functional disability, grip strength, and radiographic parameters of the participants were evaluated before and after treatment and at a 2-week follow-up.
RESULTS: After treatment and at the follow-up, the laser group exhibited significant changes in all of the parameters compared with the baseline ($p<0.05$). The results of comparing the two groups after treatment and at the follow-up indicated significant between-group differences among all of the parameters ($p<0.05$).
CONCLUSIONS: LLLT can relieve pain and improve the healing process of CBFs in the human wrist and hand.

The effect of light-emitting diode (590/830 nm)-based low-level laser therapy on posttraumatic edema of facial bone fracture patients

Woo Yeol Baek, Il Hwan Byun, In Sik Yun, Jae Yoon Kim, Tai Suk Roh, Dae Hyun Lew, Young Seok Kim *J Craniomaxillofac Surg. 2017 Nov;45(11):1875-1877.*

Abstract

PURPOSE: Posttraumatic edema in facial bone fracture patients may interfere with the operation field and delay the schedule. Thus, swiftly reducing the edema alleviates patient discomfort and advances the operation date. Ice packing and compression bandages are often used for such a purpose, but such methods are often inconvenient for the face. In this study, we aim to analyze the effect of light-emitting diode (LED) (590/830 nm)-based low-level laser therapy (LLLT) in posttraumatic edema in facial bone fracture patients.
MATERIALS AND METHODS: We conducted a prospective cohort study of 40 patients who were admitted to a single institution for facial bone fracture. The patients were divided into two groups of 20 each, treated either with LLLT or with sham treatment light. We used an LLLT device that consists of planar LED-based arrays with double wavelengths 590 nm and 830 nm. The patients were treated with either true or sham light from posttraumatic day 1-5, twice a day. After each treatment, the volume of a patient's face was measured with a 3-dimensional camera. We analyzed and compared the changes in facial edema. The Wilcoxon rank sum test was conducted for statistical comparison of the two groups, and significance was set to the level of $p < 0.05$.

RESULTS: The sex ratio and mean age of the two groups were of little difference. The fracture sites included the nasal bone, orbital wall, zygomaticomaxillary bone, mandible, and frontal sinus. Mechanisms of injury included fall, assault, traffic accident, sports, and gunshot. The total operation rate of both groups was equal to 85%. Our analysis showed a 16.5% reduction of edema in the LLLT group and 7.3% in the sham light group. The edema reduction was statistically significantly greater in the LLLT group than in the sham light group ($p < 0.047$).
CONCLUSION: LED-based LLLT is recently receiving attention worldwide for its cost-effectiveness and large coverage area compared to traditional laser therapy. Recent studies support its effectiveness in various areas such as wound healing, skin rejuvenation, and pain alleviation. In this study, we treated facial bone fracture patients with LED-based LLLT, and showed its effectiveness in reducing posttraumatic ede

Laser acupuncture for refractory coccydynia after traumatic coccyx fracture: A case report

Chien-Hung Lin, Szu-Ying Wu, Wen-Long Hu, Chia-Hung Hung, Yu-Chiang Hung, Chun-En Aurea Kuo

Case Reports Medicine (Baltimore). 2020 Feb;99(6):e18860.

Abstract

RATIONALE: Coccyx fracture is an injury usually caused by trauma. In most cases, the fractures recover after conservative therapy. For refractory cases that exhibit coccydynia after more than 2 months of conservative treatment, coccygectomy is indicated. However, limited information about the efficacy of this procedure is available, and it is known to have a high complication rate. As such, other therapeutic approaches are needed. Here, we report our experience using another conservative treatment option, low-level laser therapy, to successfully reduce refractory coccydynia in a patient with coccyx fracture.
PATIENT CONCERNS: A 23-year-old woman had refractory coccydynia and increased pain after a traffic accident-induced coccyx fracture.
DIAGNOSES: Initially, the patient reported transient improvement after conservative treatment with non-steroidal anti-inflammatory drugs. However, the pain increased in severity (numerical rating scale score of 8) soon after she resumed work in her office, and progressed in the following 2 months. Surgical intervention was suggested owing to the prolonged coccydynia following the failure of conservative treatment and difficulties in performing daily life activities. However, she sought other conservative therapy options, because she was concerned about the risks associated with the coccygectomy surgery.
INTERVENTIONS: The patient received low-level laser therapy once a week, for 24 weeks.
OUTCOMES: After 11 weeks of treatment, the patient reported significant improvements in her symptoms; her pain was reduced to a numerical rating scale score of 2 and bone healing was noted on radiographs. The patient could eventually perform her daily activities satisfactorily, without coccydynia, after 24 weeks of treatment.
LESSONS: Laser acupuncture produced analgesic effects in this patient with refractory coccydynia after traumatic coccyx fracture. This is the first case report to apply laser acupuncture for refractory coccydynia after traumatic coccyx fracture. Our findings imply that laser acupuncture may be a good conservative therapy option for coccyx fracture.

Medifoton

Gezond door licht