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ORIGINAL RESEARCH

Effect of low-level laser therapy (LLLT) and light-emitting diodes (LEDT) applied during combined training on performance and post-exercise recovery: protocol for a randomized placebo-controlled trial

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Abstract
Background: Previous studies have shown positive results of phototherapy for improving performance and accelerating recovery; however, the effects of phototherapy during training and after a primary adaptation remain unclear. The aim of this randomized controlled trial is to analyze the effects of phototherapy and combined training on clinical, functional, and psychological outcomes and on vascular endothelial growth factor.
Methods: This randomized placebo-controlled trial by stratified sample will involve 45 healthy male participants. In phase 1, the participants will undergo six weeks of combined training (sprints and squats). In phase 2, participants will be allocated through stratified randomization (based on adaptation capacity) into three groups: active phototherapy group (AG), placebo group (PG), and non-treatment control group (CG). A new six-week training program will then start and the participants will receive the recovery strategy between sprints and squats. The primary outcome will be maximal isometric contraction. The secondary outcomes include strength and power testing, maximal incremental test, squat jump, sprint test, muscle soreness, pain

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threshold, perceptions of exertion and recovery, psychological questionnaire, and vascular endothelial growth factor.
Conclusions: This will be the first trial to include phototherapy during training. We believe that this strategy will combine the ergogenic and prophylactic effects in the same session. Furthermore, an application protocol performed after primary adaptation may reflect the real effect of the technique.

Introduction

Phototherapy has been the focus of important research in sports science in recent years.[1] Also known as the phenomenon of photobiomodulation or photobiostimulation,[2] this technique is the application of monochromatic light that can influence cellular activity through inhibition or stimulation of chemical and biological functions.[3] Phototherapy has two main light sources, i.e., laser and LED (light emitting diode), that are applied separately and, in recent years, in combination, and has demonstrated a significant therapeutic advance with subsequent clinical improvement.[4]

Experimental studies and clinical trials have identified the possible physiological effects of this technique on muscle tissue undergoing structural or metabolic stress.[5] The main findings showed the formation of giant mitochondria able to provide high respiratory rates, a higher volume of energy, and greater mitochondrial density in the tissues[6] with consequent synthesis of adenosine triphosphate (ATP),[7] modulation of gene expression with regeneration of musculoskeletal tissue,[5] increases in local microcirculation[8] and modulation of endothelial function with angiogenesis upregulated by the technique with vascular endothelial growth factor (VEGF) as mediator.[9,10] These interactions have repercussions in exercise and its mechanisms of action are related to two main effects, i.e., ergogenic and protective or prophylactic.[11] Borsa et al.[11] relate the ergogenic effects of changes in microcirculation, reduction in lactic acid production,[12–14] improvement in mitochondrial function, and increase in antioxidant capacity.[15–17] The protective effect is closely related to muscle cell protection against muscle damage,[17] producing anti-inflammatory and antioxidant effects.[11]

From these mechanisms, positive results can be observed in a range of outcomes, as discussed in recent systematic reviews[3,11] and clinical trials.[4,12,14–23] The magnitude of the effects of phototherapy can be influenced by the different application techniques, such as wavelength, energy density, and power, as well as the type of damage and time of application.[3,24] Recent studies[3,4] have aimed to eliminate these potential biases by identifying the best management application. Regarding the time of application, Leal-Junior et al.[3] emphasize that 92% of the studies included in a systematic review opted to apply the technique before exercise. However, studies have shown positive effects on different markers from application both before and after exercise, although no justification for such a choice is given other than author preference.

Thus, investigation into the management of phototherapy adjusted to a model of training (between structural and metabolic exercise), could combine the ergogenic and protective effects in the same session. In addition, phototherapy applied after control of the primary adaptation to exercise may reflect the real effect of the technique. Thus, the objective of the study is to analyze the effect of phototherapy with different light sources (low-level laser therapy and light-emitting diodes) and combined training on clinical, functional, and psychological outcomes and on vascular endothelial growth factor. Accordingly, the study hypothesis is that the use of a phototherapy protocol, adjusted to a specific time of physical stress, will lead to significant improvements in the recovery process and in damage prevention.

Methods

Study design and settings

We will conduct a randomized, placebo-controlled clinical trial with parallel groups at Universidade Estadual Paulista (UNESP), Presidente Prudente, SP, Brazil. The trial has been prospectively registered at ClinicalTrials.gov (NCT02918916) and approved by Human Research Ethics Committee of UNESP, Presidente Prudente, SP, Brazil (1.389.046/2016). The study follows the SPIRIT 2013 checklist (Standard Protocol Items: Recommendations for International Trials)[25] and TIDieR (Template for Intervention Description and Replication)[26] to improve the information and quality of intervention reporting.[27] Prior to the procedures, the participants will receive oral and written instructions and sign a consent form agreeing to participate in the study. All personal data will be confidential.

Participants will undergo a 12-week training program divided into two phases. In phase 1 (six weeks), participants will undergo training consisting of sprints and squats in the same session. After this period, the participants will undergo new tests and be randomly allocated into the groups that comprise the study. In phase 2, a new six-week training period will begin. In this phase, the participants will train normally with the adjusted loads and between sprints and squats will receive the recovery strategy related to the group to which they belong.

A flowchart of the design, composition of the groups, and phases is presented in Fig. 1.