



RESEARCH ARTICLE

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APPLICATIONS AND BENEFITS OF THE INFRARED RAYS AND INFRARED-BASED DEVICES IN SPORTS AND REHABILITATION

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ARTICLE INFO

Article History:

Received 17th September, 2019
Received in revised form
05th October, 2019
Accepted 23rd November, 2019
Published online 31st December, 2019

Key Words:

Infrared, Athletic performance,
Muscle recovery, Rehabilitation,
Physio-aesthetic

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ABSTRACT

Background: Infrared rays, that comprise NIR, MIR and FIR rays, are increasingly used for enhancing athletic performance and muscle recovery but also for neuromuscular rehabilitation and in sports medicine. Infrared-based devices frequently used on athletes include infrared thermal blankets, infrared lipo laser paddles (soft-laser), infrared heat lamps, infrared bands, infrared saunas, infrared pens, far infrared-emitting ceramic or stone beads and far infrared-emitting apparel (technical sportswear). **Methods:** A literature analysis of the last twenty years was made regards the application of infrared rays on athletes. **Results:** Although the mechanisms of action of infrared rays are still unclearly, they develop endogenous heat and show many interesting heat-related effects and non-heat-related effects on the human tissues included skeletal muscles, tendons and ligaments. **Conclusions:** Infrared has a positive effect on all disorders of the locomotor system and concurs to the improvement of skeletal muscle performance, decreases exercise-induced oxidative stress, delays of muscle fatigue, reduces pain (also chronic pain) and inflammatory responses of muscles, protects against muscle injuries and stimulates general psychophysical well-being.

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Citation: *Luigi Cristiano*. 2019. "Applications and benefits of the infrared rays and infrared-based devices in sports and rehabilitation", *International Journal of Development Research*, 09, (12), 32728-32731.

INTRODUCTION

Infrared (IR) rays are increasingly used and applied in human life, so much so that various types of infrared-based devices are becoming increasingly widespread both in the medical field, especially in non-invasive aesthetic medicine, in beauty salons, in slimming centers and gyms. The use of infrared-based devices is very simple, safe and totally noninvasive so these devices can be used on humans. More recently, thanks to the development of the modern field of physio-aesthetic, the use of IR has also become more widespread in the practice of physiotherapists, not only as a medical-type practice for treating blemishes or various types of ailments but above all as a complementary tool for preparation athletics, post-workout recovery and a better and faster neuromuscular rehabilitation following pathologies, traumas or accidents of various type. IR rays, perceived as heat (Schieke, 2003), are an invisible form of electromagnetic radiation that is well absorbed by living organisms (Xiao-Feng, 2010), through various kinds of photoacceptor molecules (endogenous chromophores) (Cristiano, 2019). IR has wavelengths between visible light and microwave ranges, in particular between 780 nm and 1000

µm and, according to standard ISO20473:2007, they are generally divided into three different bands, i.e. near-infrared (NIR), with wavelengths between 0.78 µm and 3.0 µm, mid-infrared (MIR), with wavelength between 3.0 µm and 50.0 µm, and far-infrared rays (FIR), with wavelengths between 50.0 µm and 1000.0 µm (Cristiano, 2019 and Cristiano, 2019). IR shows numerous photophysical, photochemical and photobiological responses when its wavelengths enter into contact with the biological tissues. The nature of these interactions is due to both heat-related effects and non-heat-related effects of IR rays (Xiao-feng, 2004; Xiao-feng, 2003 and Xiao-feng, 2002), although their mechanisms of action are still unclearly. This review, for the first time, collects and summarizes the investigations and applications of infrared and the main infrared-based devices that are currently used in the sportive field both for preparation athletics and injury prevention and for muscle recovery in post-workout sessions and in neuromuscular rehabilitation.

Athletic training and injury prevention: The muscular performance enhancement is of fundamental importance for carrying out an athletic activity as it allows both to improve performance during the sports activity and to delay muscle

fatigue. In fact, it is well-known that skeletal muscles are subject to muscle fatigue (Allen, 2008) that it consists of a progressive decline of performance during vigorous athletic activity or strenuous and prolonged physical exercises and that this process predisposes to skeletal muscle damage (Aver Vanin, 2016 and Clarkson, 2002). The use of IR-based devices in pre-exercise of athletes, i.e. before any type of high-intensity activity, can improve skeletal muscle performance during exercises, as it prepares the muscles for athletic effort thanks to the development of heat within the human tissues (endogenous heat) which bring to vasodilatation and so improves the perfusion of skeletal muscles with a greater flow of blood, oxygen and nutrients. This delays muscle fatigue development, enhances performance during sport activity and consequently protects more against muscle injuries both in athletes and non-athletes (de Oliveira, 2017; Pinto, 2016; Dos Reis, 2014; Baroni, 2010 and Leal Junior, 2009). In addition, has been highlighted that IR rays can decrease exercise-induced oxidative stress and so they have also an antioxidant effect (Tomazoni, 2019 and De Marchi, 2012). In this context, it is useful to report not only the infrared-based devices that can be used before sport but also the clothing that emits FIR rays that can be worn by athletes during physical performance. In fact, FIR sportswear worn during exercises, that is all types of body apparel including socks and gloves, is useful to increase sweating and remove lactic acid and toxins. Unlike traditional textiles made of various type of fibres and used during the athletic effort, that have various kind of adverse effects, including skin irritation, FIR-emitting textiles products can maximize body heat and have a positive physiological effect on athletes muscles during sport effort that includes a less oxygen consumption, permits to retard muscles fatigue, concurs to improve muscle tone, gets to reduce muscular pain and, finally, allows to prevent injuries (Worobets, 2015; Dyer, 2011 and Babu, 2008).

Muscle recovery in post-workout sessions: IR finds very interesting applications as a passive modality to improve and speed-up skeletal muscle recovery and to reduce inflammatory responses in post-exercise of athletes, i.e. after training performance or sports activities (Leal-Junior, 2015 and Miranda, 2014), especially when it is applied immediately after high-intensity physical exercise. This has been verified in studies conducted both in animal models (Leung, 2011; Sussai, 2010 and Liu, 2009) and humans (Borges, 2014) and it has also been observed that it is useful for stimulating a general state of well-being and relaxation. The most frequently used infrared-based devices include the IR thermal blankets (also called sauna blankets or FIR blankets or infrared bags), the IR lipo laser paddles (called also soft-laser (Hamblin, 2007)), the IR heat lamps and the IR saunas (Cristiano, 2019; Cristiano, 2019; Aragane, 2019; Mero, 2015; Noponen, 2015; de Almeida, 2012 and Vatansever, 2012). In addition, also FIR-emitting textiles products are frequently used (Dyer, 2011). IR heat lamps and IR lipo laser paddles are used for applications on specific areas of the body, for example, a thigh, an arm, the lumbar area or the abdomen. In particular, IR lipo laser paddles, used in what is commonly called light-emitting diodes therapy (LEDT), are applied directly or a short distance to the skin and allowed to act for a variable time depending on the area of the body and the results that it is want to obtain. Each pad is constituted by a variable number of light-emitting diodes (LEDs), that are low-power light sources that emit wavelengths in the red-to-NIR optical region, typically between 635 nm and 650–680 nm (red light) however, there

are also devices that emits between 760 nm and 1200 nm, i.e. between the red light tail and NIR rays (Cristiano, 2019). IR saunas, including FIR saunas, and IR thermal blankets are used for whole-body applications to reduce fatigue, relaxing muscles and improve muscle recovery. In addition, they have been shown to have a general detoxifying effect, an anti-inflammatory effect and a general relaxation effect (Cristiano, 2019 and Miyazaki, 2010). The rehydration of athletes who undergo the use of these devices is essential, therefore it would be good practice to drink water before undergoing treatment and also after the conclusion of the treatment (Wahjuni, 2019). FIR textiles, including FIR-emitting clothes, can be helpful to give relief to various kind of muscle-skeletal injuries, further that to the muscles also to tendons and ligaments. They are able to promote the microcirculation and to accelerate recovery of muscle pain but not only: in fact, they are also useful to give relief of various kind of chronic pain (Dyer, 2011; Nunes, 2019; Ismail, 2018 and Loturco, 2016).

Neuromuscular rehabilitation

There is a large number of investigations and applications about the use of IR in the medical treatment of various blemishes, diseases, disorders, including chronic pain, and in reducing wound healing times (Hsu, 2017; Tsai, 2017; Shui, 2015 and Gale, 2006) but IR finds application as a complementary treatment also in rehabilitation medicine with the aim of counteracting muscle contractures and pains, improve muscle performance and muscle repair in the rehabilitation of athletes, especially elite athletes, and preparing muscles for massages and subsequent physiotherapy treatments (Cristiano, 2009; Ribeiro, 2016 and dos Santos Maciel, 2014). Generally, IR rays shown positive effects on general disorders of the locomotor system (Lai, 2017 and Putowski, 2016). The application of IR rays (and the devices that generate them), in this case, falls into what is most known with the term of thermotherapy. The devices often used in these treatments include FIR dry sauna cabins, FIR sauna blankets, IR bands, FIR heat lamps, IR pens (Vatansever, 2012) and FIR-emitting ceramic or stone beads (Cao, 2013). These devices are used both for general treatments and for localized treatments in specific areas of the body or face. IR pens are used for spot applications on the pain trigger points of the body or directly on the acupuncture points (Cristiano, 2019). FIR-emitting ceramic or stone beads, forming by various types of small particles of FIR-emitting ceramic material, strongly improve human blood microcirculation and local metabolism (Vatansever, 2012 and Cao, 2013) and they can be used alone, i.e. incorporated into fiber textile products, or in more complex systems as the Enseki sandbath (Aragane, 2019).

Physio-aesthetic applications

Physio-aesthetic arises from the union of physiotherapy with aesthetic medicine and uses various kind of non-invasive and painless techniques and devices mostly, but not exclusively, with the aim of remodelling the body, through slimming, firming, tissue toning, but also through reducing cellulite, the removal of lymphatic stasis and edemas and with the fighting of tissue ageing. Physio-aesthetic also finds application in various types of post-surgical treatments to facilitate the reabsorption of edemas, hematomas and accelerate the cicatrization and wounds healing. Physio-aesthetic, non-invasive aesthetic medicine and beauty care share together the

use of IR for the same purposes that are: body toning, slimming and non-surgical body remodeling (Cristiano, 2019). The infrared-based devices more frequently used are IR thermal blankets, for whole-body applications, and IR lipo laser paddles, that are used for localized applications.

Conclusion

IR and, in general, any type of IR-based devices are increasingly used as a non-invasive complementary tool and passive modality of enhancing performance or recovery both in sports pre-exercise and in athletic post-workout but also for neuromuscular rehabilitation and in sports medicine, physiotherapy and physio-aesthetic. IR, that comprise NIR, MIR and FIR rays, is perceived as heat and although its mechanisms of action are still unclearly, it develops endogenous heat and shows many interesting heat-related effects and non-heat-related effects on the human tissues included skeletal muscles, tendons and ligaments. In general, IR rays have a positive effect on all disorders of the locomotor system and concur to the improvement of skeletal muscle performance, decrease exercise-induced oxidative stress, delay of muscle fatigue, reduce pain (also chronic pain) and inflammatory responses of muscles, protect against muscle injuries and stimulate general psychophysical well-being. Infrared-based devices frequently used include IR thermal blankets, IR lipo laser paddles (soft-laser), IR heat lamps, IR bands, IR saunas, IR pens, FIR-emitting ceramic or stone beads and FIR-emitting apparel (technical sportswear).

Conflicts of interest

The author is employed in the Prestige Company and has received a salary also for the research activities for the preparation of this review.

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