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Bioceramic materials emitting infrared radiation for musculoskeletal pain relief

Bill Giannakopoulos, Mohamed Amessou and Eva Koscova

Musculoskeletal (MSK) disorders are the leading cause of chronic pain, physical, functional impairment and loss of quality of life. About one in three people worldwide is suffering from MSK pain. The biological effects of bioceramic materials as Infrared-C emitters on body tissues and their benefits to the self-management of MSK disorders, are the subject of current interest.

Musculoskeletal disorders are the most common cause of disability and represent an enormous burden to society, leading to lost productivity and overburdening the health care system [1, 2]. MSK disorders have different triggers and range from overuse or traumatic injuries during sports to neuropathies or myalgias. MSK disorders are often treated with symptom-oriented strategies such as non-pharmacological medical devices, e.g. physical modalities, or pharmacological interventions, e.g. analgesics, NSAIDs (non-steroidal anti-inflammatory drugs), glucocorticoids or opioids. These treatment options can relieve distressing symptoms but do not alleviate the underlying cause of pain. To avoid the side effects of pharmacological therapies, new drug-free, often non-invasive solutions for pain management have been introduced.

A recent review describes the current state of bioceramic materials emitting infrared C-radiation for relieving musculoskeletal (MSK) pain [2].

Biological effects of infrared therapy

While shorter wavelength IR-A or IR-B (near infrared) penetrates deep into the skin and can cause tissue damage, long wavelength IR-C (mid and far infrared) is completely absorbed in the epidermal layers (see **Fig. 1**). In several studies, IR-C light (far infrared) showed positive therapeutic

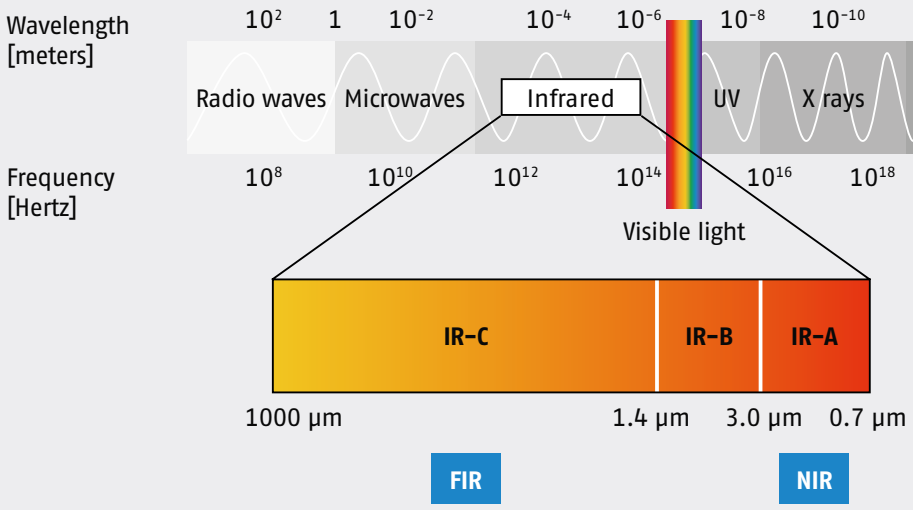

Fig. 1. Electromagnetic spectrum and infrared radiation; FIR: Far infrared; NIR: Near infrared

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Affiliation/Correspondence: Bill Giannakopoulos, PharmD, Sanofi, Athens, Greece; Mohamed Amessou, PhD, MBA, Sanofi, Neuilly-sur-Seine, France (Mohamed.Amessou@sanofi.com); Eva Koscova MD, PhD, MBA, CVTI SR, Bratislava, Slovakia

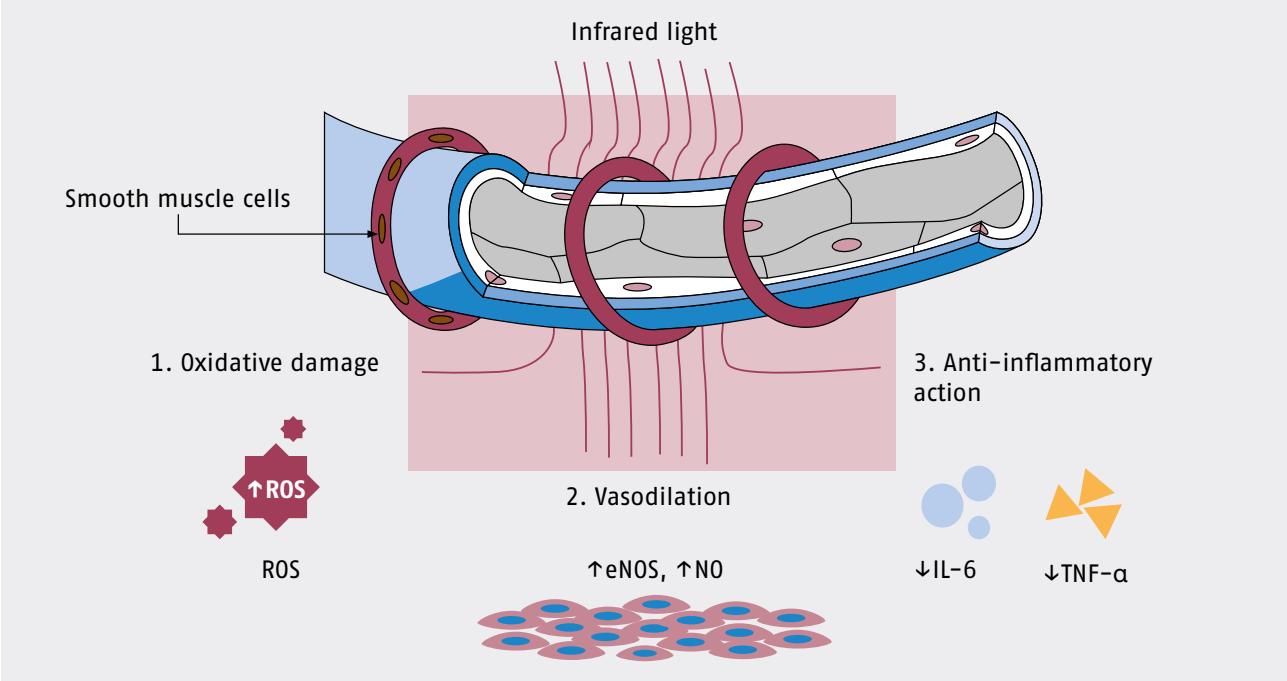

Fig. 2. Cellular signaling pathways affected by IR-C (far infrared) [2]. Thus, by increasing NO levels and reducing oxidative stress and inflammatory mediators, infrared can indirectly relieve pain.

effects in deep tissue layers that were not accessible to direct radiation (see **Fig. 1**): The authors describe an energy transfer through pathways other than direct radiation and propose water as a dynamic biomolecule and possible transmitter of energy [2].

Based on the current findings, the biological effects of IR-C on MSK disorders can be divided into three categories as indicated in **Figure 2**. Infrared radiation can relieve pain by increasing NO levels and reducing oxidative stress and inflammatory mediators.

1. Oxidative damage: Oxidative stress is defined as an excess production of reactive oxygen species (ROS) that can lead to oxidative damage to cells. Oxidative stress can cause tissue damage and inflammation, which in turn can alter nociception via stimulation of sensory neurons and lead to hyperalgesia. Indeed, in studies, IR radiation has been shown to decrease oxidative stress and relieve pain and inflammation at the muscular level [2].

2. Vasodilation: IR radiation can upregulate endothelial nitric oxide synthase (eNOS), increasing the bioavailability of nitroxide (NO). NO has a relaxing, vasodilator effect on vessels, as well as other beneficial effects on the body, such as inhibiting platelet aggregation and preventing leukocyte adhesion. It promotes muscle repair. Via inhibiting the migration of inflammatory cells, it may protect muscle from damage and inflammatory responses. An antinociceptive effect via hyperpolarization of nociceptors is discussed [2].

3. Anti-inflammatory action: Inflammation can increase the pain response via sensitization of sensory nerves. During inflammation or tissue injury, damaged cells and immune cells release inflammatory mediators. Increased serum levels of IL-6 and IL-8 lead to hyperalgesia, fatigue, and pain. TNF-α can promote sensitization of nociceptors, leading to chronic pain and muscle fatigue. IR-C radiation inhibits the expression of inflammatory cytokines [2].

Bioceramics as infrared radiators

Bioceramics are mineral materials that emit IR-C (far infrared) radiation after absorbing body heat and can produce positive biological effects on tissues. Compared to electrically powered IR sources, the emitted power density is low, but is compensated by the longer time bioceramic materials are worn in close contact with the skin surface as wearables. Several studies have demonstrated that infrared-emitting bioceramics can increase blood flow without increasing skin temperature [2]. The degradation of microcirculation is linked to the chronification of pain and can increase the risk of neck/shoulder and low back pain [3]. The increase of microcirculation supplies oxygen and nutrients to the tissue and helps to remove metabolism byproducts. An increase in microcirculation may promote healing and reduce pain [4].

Other studies investigated the use of bioceramics to relieve various pain conditions. For example, in a randomized, placebo-controlled trial, an IR-C-emitting patch significantly improved pain scores in knee osteoarthritis. Athletes benefited from less muscle soreness by wearing IR-C-emitting pants. Patients with foot pain reported pain reduction by wearing IR-C-emitting socks. IR-C treatment also appears to be beneficial in the longer term, as shown in women with dysmenorrhea, as the pain score in the verum group also proved to be better than in the control group during the follow-up period of two follow-up cycles [2].

The tolerance of IR-C emitting materials is good, which is not surprising because the radiation intensity achieved by

IR-C emitting ceramics and tissues is too low to raise safety concerns.

Summary

The use of IR-C (far infrared) is one way to treat musculoskeletal pain by reducing pain and inflammation, potentially reducing usage of pharmacotherapy which might cause side effects, while promoting the body's natural healing mechanisms [5, 6]. Infrared emitting materials are safe due to low radiation intensity and are considered well tolerated. The authors recommend further research to evaluate and validate current theories [2].

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