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Efficacy of photobiomodulation in reducing pain in cases of Tendonitis: A systematic review

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ABSTRACT

Pain is a sensation that arises after potential or actual tissue damage, and can be classified as somatic or visceral, and often results from tissue damage common in inflammatory, traumatic, invasive or ischemic situations. Tendonitis is an inflammation resulting from mechanical overload or repetitive movements, generating inflammation and local pain. This study aims to review articles that report the efficacy of photobiomodulation on tendon pain and inflammation. **Methodology:** This is a systematic review study, carried out by searching articles in the following databases: Virtual Health Library, PubMed, Scielo and Revista Estima. National and international articles in Portuguese, English and Spanish were included. **Conclusion:** In this systematic review, it is concluded that the action of photobiomodulation reduces the inflammatory effects induced by thermal, chemical or mechanical actions, as in cases of tendinitis. Photobiomodulation inhibits the action peak generated by the lesion stimulus and by the signaling to the nociceptors, preventing the information of pain in the dorsal horn and promoting pain control. However, the need for further studies in this area is highlighted, as well as the standardization of time, dosage, and wavelength parameters to be used for a more effective treatment.

Keywords: Nociceptive Pain, Nociceptors, Low Intensity Light Therapy, Biostimulation, Photobiomodulation.

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BACKGROUND

Pain is a subjective and multidimensional phenomenon, which involves unpleasant sensory experiences, associated with emotional, social, environmental and cognitive aspects of everyone. To understand and explain pain, several theories have been developed. The International Association for the Study of Pain (IASP), in 1979, and accepted by the World Health Organization, defines pain as "an unpleasant sensory or emotional experience, associated with, or similar to that associated with, an actual or potential tissue injury", emphasizing the subjective nature of the experience, which does not necessarily require an identifiable tissue injury.[1.2]

Historically, understanding pain has been essential to human psychological development. The Incas, for example, interpreted pain as a supernatural element, relieved through the surgical removal of the spirit of malignancy or through sacrifices. During the Middle Ages and early modernity, the Judeo-Christian doctrine advocated that self-flagellation and punishments could achieve divine forgiveness, promoting justice and purification of the soul. With the advancement of the Middle Ages, science began to incorporate knowledge of human anatomy and physiology, which had been deeply studied by Leonardo da Vinci in the sixteenth century. In the twentieth century, pain began to be approached from a more robust scientific perspective, encompassing social and environmental aspects, and benefiting from advances in neurology, psychoanalysis and psychiatry, consolidating the understanding that pain has a significant emotional dimension and that it can be relieved, eliminating the need for permanent coexistence with it.[2]

Nociception is the phenomenon that transmits information about mechanical, thermal, or chemical stimuli to the Central Nervous System (CNS) through receptors located in various body regions. In the pain process, nociceptors, found in muscles, blood vessels, skin, joints, tendons, viscera, fascia, and dura mater, generate action potentials that may or may not result in pain perception. The sequence of events that allows the perception of the painful stimulus involves transduction, transmission, modulation, and perception. During transduction, the stimulus generates an electrical potential in the nociceptor, which is transmitted to the dorsal horn of the spinal cord, where the signal can be modulated – amplified or attenuated – influenced by emotional factors present in the somatosensory cortex, hypothalamus, gray matter and reticular formation, affecting the perception of pain, which is understood as a subjective and individual experience.[2]

Pain pathways are categorized into ascending and descending. After activation of the nociceptors, the stimulus is conducted to the CNS via the afferent pathway. These pathways are

divided into Aδ fibers, which transmit pain signals quickly, either by mechanical or thermal stimuli, and type C unmyelinated fibers, which transmit slowly and are more related to chemical stimuli, such as those present in chronic pain that intensifies over time, leading the person to seek relief from the cause of the pain.[2]

Pain can be classified as acute, defined as a response of the body to an aggression (generated by trauma, surgeries, medical procedures, acute diseases and inflammatory processes), with a short duration and an important role in signaling the extent of the damage, promoting a rapid pain response. This pain is transmitted to the CNS and has a physiological function of alertness, which can be modified by emotions or cognition, which influences perception and can favor the chronicity of pain, requiring appropriate treatment to prevent its persistence. Chronic pain, on the other hand, persists for a prolonged time, interrupts the individual's sleep and functional capacity, and can be nociceptive or neuropathic. It can result from an ongoing injury (due to trauma, surgery, or conditions such as arthritis and fibromyalgia) or arise without an apparent cause, affecting up to 20% of the world's population and corresponding to the main complaint in 15% to 20% of medical consultations.[2]

In tendonitis, there is an injury to the tendon — well-organized and fibrous connective tissue, located between muscles and bones, composed of intertwined collagen fibers that allow the transmission of muscle forces. Characteristically, this condition involves both inflammatory processes and tissue degeneration, often caused by mechanical overload or repetitive movements. This condition results in pain, edema, and functional limitation, affecting both active and sedentary individuals. It is associated with intrinsic and extrinsic factors, such as age, genetics, vascular supply, tendon adaptation to mechanical loads, and drug use.[3]

When a tendon injury occurs, the inflammatory process begins. For tissue repair to occur, an enzyme called phospholipase A2 is activated in the cell membrane, which degrades the membrane and releases arachidonic acid. This, in turn, is metabolized into prostacyclins, leukotrienes, and prostaglandins. The COX1 and COX2 cyclooxygenases are released by cells, with COX1 being responsible for exerting protective functions in some organs and COX2 acting in the inflammatory process, releasing prostaglandins that bind to nociceptors and stimulate afferent fibers (Aδ and type C), leading pain stimulation to the central nervous system (CNS). During this process, pro-inflammatory cytokines, such as tumor necrosis factor (TNFα), act as regulators of the immune and inflammatory system. These are released by macrophages to regulate the inflammatory process, while interleukins (IL1, IL2, IL6, IL8) aim to protect the body through the activation of leukocytes and cyclooxygenase.[12]

When this inflammatory process is regulated, the cytokine Interleukin 10 plays a key role in preventing an exacerbated immune response. It prevents the body from producing a defense against itself, interrupting the production of pro-inflammatory cytokines and chemokines, mediators secreted by macrophages and dendritic cells, in addition to blocking the production of matrix metalloproteases by macrophages and the differentiation and maturation of dendritic cells originating from monocytes.[12]

The most frequent causes of tendonitis, accounting for 16% and 21% of cases, respectively, are biceps tendonitis and rotator cuff tendonitis. These conditions are mainly characterized by pain, limitation of movement and strength, and loss of shoulder function.[12]

As an adjunct in tissue repair and in the relief of pain and inflammation, studies have explored photobiomodulation. This technique uses a laser (Light Amplification by Stimulated Emission of Radiation), which amplifies the emitted light through directional electromagnetic radiation, accumulating energy in the form of photons that penetrate the tissue.[17]

The first studies on the laser were elucidated by Albert Einstein in 1917, in his work "Zur Quantun Theorie der Strablung". The first laser light shot was carried out in 1960 by the Hungarian Theodore Maiman and has since been used as a treatment. The laser classification is divided into high intensity (ionizing radiation), which can cause changes in the tissue such as cuts, and low intensity (non-ionizing radiation), which promotes tissue repair and inhibition of pain, infection and inflammation.[17]

Studies on photobiomodulation are widely adopted by nurses, regulated by the Federal Nursing Council (COFEN) of Brazil, according to COFEN opinion No. 13/2018. Professionals must have adequate training, including knowledge in physics, tissue interactions, dosages, biophotonics, physiology and rehabilitation, integrated into the Systematization of Nursing Care.[17.19]

Photobiomodulation exerts a biostimulatory effect, accelerating the tissue regeneration process and acting on subsequent physiological, physical and biochemical events. Its molecular action is absorbed by chromophores — extracellular membranes, enzymes and extracellular substances — that absorb light. The main chromophore, cytochrome, present in cellular respiration, absorbs light through photobiomodulation, inhibiting the action of nitric oxide, reducing oxidative stress and producing reactive oxygen species (ROS), Ca2+ ions, which favors an anti-inflammatory, analgesic and healing physiological response, through the production of adenosine triphosphate (ATP).[19]

In tendon injury, there is a decrease in ATP and a delay in the regenerative process; thus, photobiomodulation, by acting on cell membranes, generates ATP production and accelerates regeneration, favoring the synthesis of growth factors and the increase in the production of fibroblasts and collagen. Fibroblasts synthesize fibronectin, proteoglycans, and type III, and later type I, collagen fibers, which are essential for tendon repair and tensile strength.[20]

In addition, the modulation and synthesis of cytokines, such as interleukins 1β, 6 and 10 called anti-inflammatory, control the inflammatory process and prevent the disorganization of the body's defenses that favors collagen synthesis, the formation of granulation tissue and epithelialization. This action can also be enhanced by photodynamic therapy, which produces an antimicrobial effect when associated with photosensitizing agents, generating reactive oxygen species capable of inactivating viruses, bacteria and fungi.[17]

Several photobiomodulation modalities have been studied in the treatment of tendonitis, with the aim of accelerating the regenerative process, reducing the inflammatory process and reducing pain. Its radiation can be visible (red) or invisible (infrared), differing from ordinary light by presenting monochromaticity (a single wavelength), coherence (phase waves) and collimation (parallel waves), with wave emissions ranging from 600 nm to 1,000 nm.[3]

The World Association for Laser Therapy has standardized some dosages, so that, for each type of tissue treated, doses and wavelengths appropriate to its properties are indicated, allowing the light to penetrate the surface of the skin and the energy generated to be reached in a way that is not harmful to the tissue. The response to biostimulation depends directly on the wavelength, energy density [Joules per cm² (J/cm²)], power and application time. The penetration of the radiation is influenced by the wavelength, and it is necessary to adjust it to avoid unwanted responses.[7]

OBJECTIVE

To investigate and synthesize evidence available in the literature on the efficacy of photobiomodulation in the management of nociceptive pathways and in the inflammatory and pain processes associated with tendinitis.

METHODOLOGY

It is a systematic review study, carried out through articles searched in the Virtual Health Library, PubMed, and Scielo databases. In the study, national and international articles in

Portuguese, English and Spanish were used, and 20 scientific articles with inclusion criteria were surveyed between the year 2011-2024

The descriptors were: Nociceptive Pain, Nociceptors, Low Intensity Light Therapy, Laser Biostimulation.

DISCUSSION AND RESULTS

This systematic review analyzed 20 scientific articles published between 2011 and 2024, focusing on the pain and inflammation associated with tendonitis. The main question addressed was about the modulating effect of photobiomodulation on the inhibition of inflammation and the pain process in cases of tendinitis. Studies that dealt with other pathologies that also benefited from photobiomodulation were excluded.

Tendonitis is characterized by tendon injuries, with inflammation and tissue degeneration. These conditions are often associated with mechanical overload and repetitive motions. This inflammatory and pain process activates the nociceptors in the affected area, transmitting pain signals to the Central Nervous System.[1]

Nociceptive pain, which is associated with actual tissue damage or potential non-neural pain, involves the activation of these nociceptors. In view of this, health professionals are continuously looking for more effective methods to accelerate tissue repair, aiming to improve physiological outcomes and optimize costs and treatment time, in addition to minimizing unwanted side effects. A dental study identified that photobiomodulation, used as an adjunct in post-surgical treatments, reduced complications and relieved pain, significantly improving the quality of life of patients.[11.18]

Evidence suggests that photobiomodulation effectively modulates inflammatory cytokines, with experimental and clinical studies pointing to a reduction in pain and promotion of tissue repair. About 45% of the included studies recorded a significant decrease in pain and one of the studies highlighted an increase in functionality. The need for more research on the combination of photobiomodulation with exercise and on the optimal dosages to treat tendon inflammation is emphasized.[6]

Regarding the management of pain and inflammatory signs in injured tendons, pharmacological therapy, although effective, is often limited by its side effects. On the other hand, photobiomodulation presents itself as a promising adjuvant alternative. A rat study using the paw lift test after tendon trauma demonstrated that light with a wavelength of 670 nm, at

doses of 2 J to 8 J, significantly reduced pain and edema compared to the placebo group and the pre-treatment group.[14]

Photobiomodulation presents itself as an anti-inflammatory alternative with efficacy comparable to non-steroidal anti-inflammatory drugs (NSAIDs), reducing or minimizing the concentration of prostaglandin (PGE2), cyclooxygenase (COX-2) and histamine, and interrupting the arachidonic acid cascade in injured tissues, which consequently decreases inflammation. It is a safe and effective treatment for inflammatory and pain processes, stimulating the release of histamine, serotonin and bradykinin, which promotes the production of Adenosine Triphosphate (ATP), stimulates the formation of new blood vessels and tissue repair, providing analgesia and anti-inflammatory action. In addition, it normalizes the action potential in the stimuli generated for the Na/K pump, keeping the membrane at rest for longer and reducing sensitivity to pain by increasing the production of endorphins.[15]

The analgesic benefits of photobiomodulation derive from the mechanism of endogenous opioid release, increased velocity in nerve conduction, alteration in action potential and hypernociception, raising the pain threshold and regulating inflammatory pain mediators. At the wavelength of 670 nm, a decrease in hypernociception is observed, but when applied to distal regions, such as the sole of the foot, the wavelength of 830 nm obtains better results. Although non-steroidal anti-inflammatory drugs are used as analgesics, they have several side effects, and photobiomodulation can be an adjuvant alternative for a better therapeutic adjustment. In a mouse study, photobiomodulation demonstrated significant anti-inflammatory effects at wavelengths of 830 nm at 2.94 J and 660 nm at 5.88J. The parameter of 2.94J showed greater efficacy in reducing hyperalgesia.[8]

In patients with chronic inflammation, there is a disorganization in tissue repair that interferes with normal physiological processes, especially in the proliferative phase. Photobiomodulation contributes in these cases through its photochemical, photophysical, and photobiological effects, promoting the recruitment of cytokines, growth factors, collagen synthesis, and fibroblasts, which act on cell organization and improve tissue oxygenation, angiogenesis, and tissue repair, providing pain relief and improving vascular and nervous system response.[15]

In the treatment of injured tendons in rats, the analysis of dosages, wavelength, power, energy, energy density, power density and irradiation time indicated that photobiomodulation generates positive effects on the modulation of the inflammatory response, both in the acute and chronic phases, after tendinopathy induction. However, it is suggested that further studies

involving the standardization of methodological parameters, application times, and experimental models for tendinopathy induction would be essential for a better understanding of the action of this therapy on the inflammatory response.[3]

In a study conducted at the Laboratory of Biochemistry and Nanosciences of the Franciscan University Center (Unifra) in Santa Maria, RS, it was observed that the immediate application of photobiomodulation after induction of acute inflammation in the calcaneal tendons of rats with cigarette smoke, with a dose of 3J for 100 seconds, significantly improved the inflammatory process. This improvement is associated with increased local blood flow and decreased activity of the enzyme myeloperoxidase, induced by nicotine.[4]

When stimulated by algogenic substances that lead to hyperalgesia in acute processes, the wavelength of 830 nm, with 2.94 J, proved to be effective in reducing edema. Wavelengths of 660 nm (5.88 J/2.94 J) and 830 nm (2.94 J) demonstrated inhibition of the acute inflammatory and edematous process. Photobiomodulation is often used as a therapeutic resource, especially in treatments for acute inflammation, with visible light being more common and invisible light used in some cases of pain and edema, acting as an adjuvant in inflammatory diseases.[14]

Another study involving rats after eccentric exercises showed that photobiomodulation, at a dose of 3J and a wavelength of 904nm, initiated 24 hours after the induction of inflammation in the Achilles tendon, increases the amount of collagen fibers, with a subsequent reduction of type III collagen. wavelength and time of application, suggesting the need for further investigations to standardize treatment parameters.[5]

It was noted that the wavelengths most used for modulation of the inflammatory response in the articles are 660 nm, with a power of 30 mW, fluence of 4 J/cm² and an application time of 80 seconds. Red (620-750nm) and infrared (750-950nm) light spectrums are preferred due to their deep tissue penetration.[13]

CONCLUSION

This systematic review allows us to conclude that photobiomodulation plays a significant role in reducing inflammatory and pain effects, and in stimulating the tissue regenerative process. These benefits are evidenced in cases of tendonitis, where the physical, chemical or mechanical action serves as an initial stimulus. Photobiomodulation acts as an adjuvant in this process, regulating both pro-inflammatory and anti-inflammatory cytokines, and blocks nociceptor signaling, interrupting the transmission of painful information in the dorsal horn. This is accomplished by normalizing the action potential and ATP production, as well as preventing

the conduction of the stimulus through the release of substances such as histamine, bradykinin, and serotonin, resulting in effective analgesia.

However, it is important to highlight the need for further studies to thoroughly explore the optimal application parameters, such as time, dosages, and wavelengths, in order to optimize the efficacy of photobiomodulation treatment. Future research should focus on standardizing these aspects to ensure a more accurate and efficient therapeutic approach.

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