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Effectiveness and Applications of Medical Treatments Utilizing Infrared Radiation

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Abstract:

The idea of using infrared radiation as a treatment is a concept that dates back to the ancient Greeks and Egyptians. Practices of using thermal waters and sunshine for treating skin diseases date back to these periods. In today's medical field, various forms of infrared therapies are used as isolated treatments or as part of a multi-disciplinary approach. The idea of "heat" as a treatment can provide elaboration into the historical use of thermal spas. Intensive research is done on the skin and wound healing applications of infrared radiation, especially the lower parts of it. The application of infrared radiation in medicine is of great importance in today's medical practice. The use of this form of energy in therapy often comes in the form of a multi-disciplinary approach, which includes treatments from general practitioners as well as complementary therapists.

1. Introduction to Infrared Radiation in Medicine

The application of infrared radiation in medicine is of great importance in today's medical practice. The use of this form of energy in therapy often comes in the form of a multi-disciplinary approach, which includes treatments from general practitioners as well as complementary therapists. The applications of this form of therapy include dermatology, physiotherapy, orthopedic surgery, wound management, thermal therapy, arthritic diseases, sports medicine, aesthetic treatments, skin rejuvenation, tumor therapies, dry eye, surgery, sterilizations, and even mental health related medicine.

The idea of using infrared radiation as a treatment is a concept that dates back to the ancient Greeks and Egyptians. Practices of using thermal waters and sunshine for treating skin diseases date back to these periods. In today's medical field, various forms of infrared therapies are used as isolated treatments or as part of a multi-disciplinary approach. The idea of "heat" as a treatment can provide elaboration into the historical use of thermal spas. Intensive research is done on the skin and wound healing applications of infrared radiation, especially the lower parts of it. The infrared radiation is commonly emitted from sources such as low level laser therapy (LLL), light emitting diodes (LEDs), monochromatic radiant lights (MRL), LEDs, incandescent bulbs, and heat lamps when an appropriate wavelength on the sunlight spectrum is assigned as the treatment's parameter. [1][2]

2. Fundamentals of Infrared Radiation

Infrared (IR) radiation is electromagnetic radiation (EMR) with longer wavelengths than those of visible light. In comparison to higher-frequency radiation, IR radiation carries a relatively low quantum of energy. Infrared is emitted by an object with a certain amount of temperature, which ranges from 0.1 K to 100,000 K. The sources of IR radiation could vary from small devices, like toasters and grills, to larger bodies, such as stars and galaxies. Moreover, IR is also capable of passing through certain composites, not transparent in the visible region. The American National Standards Institute (ANSI) has organized the research and implementation of IR radiations into three categories. In this article, we have also discussed the types of IR radiations, their sources, and the region of IR used in different applications for treatment. The effectiveness and use of IR radiation in medical treatments have already been studied. The purpose of this article is to collect the available data about which IR region is used for the treatment of different diseases. We have also tried to give a deep analysis of the diseases treated by IR.

Based on their frequencies, IR is further categorized into three types:

- Near Infrared – It ranges from 700 nm (0.7 µm, micrometer) to 2500 nm (2.5 µm).
- Mid Infrared – It varies from 2500 nm (2.5 µm) to 20,000 nm (3000 µm).
- Far Infrared – It is said to be FM-IR, which ranges from 20,000 nm (3000 µm) to 350,000 nm (30,000 µm). [3][4]

2.1. Types of Infrared Radiation

Infrared (IR) radiation is a less-energetic form of light that falls just below the visible light region in the electromagnetic spectrum. Technically, many objects absorb and emit a certain amount of IR radiation as heat; the hotter the object, the more IR radiation is emitted. Wavelengths of infrared radiation that specifically target the absorption bands of biological molecules can cause various physiological effects. There are three main types of medically relevant infrared radiation that are often referred to according to their places in the infrared spectrum: near (non-coherent) infrared radiation (NIR, 760 to 1,200 nm), mid (coherent) infrared radiation (MIR, 1,200 to 25 µm), and thermal radiation or far infrared rays (FIR, 6 to 15 µm). This section delves into the varying biological effects of these different types of infrared rays.

Each of these three ranges of infrared rays is absorbed to varying extents by skin and underlying tissues. As such, these IR-A rays have the potential to penetrate tissues to depths of centimeters. Conversely, skin absorption varies less substantially with wavelength in the mid-infrared range of $\lambda = 1$ to 3 µm. The decreased transmittance values seen for longer IR-C wavelengths also indicate deeper tissue penetration. Although the skin does effectively block the majority of NIR, the relatively transparent corneal layer allows NIR to penetrate human tissues. Nerve cells are also the main targets of the effects of trans-cranial IR. Because the 1,480 nm wavelength is in the near infrared range, it can penetrate human tissues. In comparison with other wavelengths in this range, 808-nm infrared light penetrates approximately the same depth, but up to three times deeper into the target tissue. [5][6]

3. Biological Effects of Infrared Radiation

Infrared radiation irradiates the system and can produce thermal and non-thermal effects. The non-thermal effects may include tissue injury, bone fracture, surgical photoacoustic imaging, and some of the applications mentioned in this article, and are now widely used and of great significance. Infrared radiation's biological effects are determined by many factors, and its influence is complex. This article summarizes and reviews the latest research results of infrared radiation on cells, animals, and the human body from the biological level, concerns with the related applications.

These biological effects greatly depend on many factors such as the type of tissue, the infrared radiation characteristics, the frequency and the time of the exposure, as well as the radiation distribution inside the tissue. The present review will investigate the physiological response at the tissue, cellular, subcellular, genetic, and molecular levels by studying those mechanisms triggered by the increase of living cells' temperature due to radiation. There is a limit over which the living cells – cell organelles in particular – can be damaged and die because of excessive temperatures reached. It is of extreme importance to know the temperature of the tissue to be brought to a desirable biologic beneficial level or to be damaged in order to optimize the treatment, and that is what a dosimetry method based on a simulation software will highly facilitate. Consuming infrared radiation leads to a significant rise in the body temperature by increasing the blood flow in the tissues. [7][8]

3.1. Thermal Effects

A vast amount of data and evidence is present in current medical science literature that corroborates the clinical efficacy of infrared (IR) treatments. A great deal of research and in-depth experimentation has clearly demonstrated the effectiveness of a variety of IR treatments, such as infrared saunas, in encouraging the natural healing mechanism of the body. Recently, attention has expanded to investigate how the various portions of the IR spectrum can enhance health, promote vitality, and provide pain relief. Commercial high-power infrared (IR) LED arrays have become increasingly popular for treating and/or alleviating assorted medical conditions, such as rapid wound healing and relief from chronic pain.

Infrared radiation can be absorbed by biological tissue after passing through the skin, at which point it turns into heat. In biological tissues, heat provokes a variety of physiological events. It thus affects other cells or tissues, either directly or via heat transferred to neighboring cells, and then, either directly or by releasing or activating some mediator molecule(s), elicits a bio-response. Heating a biological tissue causes dilatation of blood capillaries, i.e., vasodilation, and increase blood flow is observed in the area. On the other hand, cells and tissues modulate their temperature as heat either is added or removed or is produced due to metabolism, i.e., heat generation or consumed via physical activity, while keeping their thermal environment relatively constant. [9][10]

3.2. Non-Thermal Effects

Non-thermal Biological Responses: While understanding the photothermal mechanisms and their applications are clinically useful, improvements in clinical healing responses, reduction in inflammation, attenuation of pain, conveyance of neural stimulation and cognitive enhancement via the nonthermal biological responses are equally exciting. Non-thermal effects require some latitude in field amplitude as there are significant damping and inherent biological processing of energy. Reports on non-thermal effects have caused some scientists to question the extent of non-thermal effects possible, but there are, nevertheless, numerous reports on biological responses indicating what may be termed photobiomodulation (or low level light therapy, LLLT). Possible mechanisms of low level light therapy may include activation of cellular signaling, altered gene expression, and a variety of other photochemical processes.

Despite these non-thermal (and non-photothermal) responses, a number of "lay" and technical papers question the non-thermal (or more properly non-photothermal) biological effects and the possibility of "therapeutic" results. It is little wonder, therefore, that physicians want incontrovertible evidence before they treat any disease or injury with forms of invisible radiation. Using these forms of radiation today on a patient has both legal and financial consequences, regardless of the theoretical science behind possible beneficial therapeutic evidence. The technical papers questioning the nonthermal (or non-photothermal) treatments with the forms of light presented herein had very little efficacy, if any. [11][12]

4. Medical Devices Utilizing Infrared Radiation

In a hospital setting, there are many devices on the market that harness the benefits of infrared laser light or infrared LED light. These devices often consist of the external structure, which may be battery operated, or operated continuously or pulsed light output and book in size, as well as the implementation of a microcontroller, where information such as time, dose, delivery rate, and energy monitoring may be available. Infrared devices and applications are starting to become more accepted by the community. The applications of these devices include treating pain, muscle healing, muscle recovery, weight loss, acne treatment, wound healing, fungal treatment, drug delivery into the skin, relief of radiation dermatitis symptoms, treatment of erectile dysfunction, female sexual arousal disorder, lipolysis, reduction of body fat, pilot studies in the treatment of chronic low back pain, cervical osteoarthritis, prevention or reduction of CIPN (Chemotherapy-Induced Peripheral Neuropathy), neuroprotection, and neuroregeneration.

In a hospital setting, medium-level infrared panels or infrared saunas are normally used for patient rehabilitation. Many types of commercial units are on the market or available for manufacture. If a device produces a significant amount of infrared, say greater than 200 mW/cm2, then the device is typically designed for red and near-infrared light treatments and may be referred to on the market as a Photỗi Rx. Such units will typically incorporate LEDs operating at a wavelength of around 630 nm or 660 nm as well as LLLT operating near 810 nm up to 980 nm. If a device produces no more than 100 mW/cm2 of red and near-infrared light, then typically sacrificial filters, to destroy the red light output, are not necessary or similarly not included. Further, chair warmers, heat pads, and other types of body warming systems use infrared at a wavelength of around 760 nm up to 1500 nm. Devices can also be employed for hair regrowth and for severe headache complexes. The mirrors and optics designed must be suitable to withstand the high levels of infrared without overheating. [13][14]

4.1. Infrared Saunas

Infrared saunas. Although regular sauna therapy is a time-honored practice to generate health and vitality, infrared saunas are relatively new. They work by emitting large amounts of far-infrared heat that is absorbed by the surface of the skin. It is from this transdermal heat that many different layers of the human body are heated. 80% or more of the infrared waves used in infrared therapy saunas are known to penetrate up to 2.36 inches with conversion efficiencies of over 90%. These rays not only benefit the surface of the skin causing a raise in heat but also work deep into the body to raise the temperature of the subcutaneous (deep skin) tissues causing and express subcutaneous fat to be released from the body for weight loss and detoxification. Some of the other benefits include relaxation and stress relief, improved cardiovascular conditioning, and relief from bronchitis, laryngitis, and earache. This may bring toxins to the surface of the skin, thereby improving the skin's renal capabilities and helping to cure any skin eruptions.

Applications. In 1929, the Finnish physician Dr. Waarlo Cantabria built a hospital called "The Knipe Bath" in Cleveland, which used infrared technology. The irrefutable fact is that the use of far-infrared is not a novel method for food processing but has been well-recognized in various applications. It has been safely and effectively applied to health care, physiotherapy, industrial use, sports medicine, and veterinary science. For this reason, the advantage of using FIR therapy is galvanizing a great deal of scientific attention and becoming a cutting-edge field of research today. The scientific research to date suggests that medical devices using far-infrared have definitive applications and are undoubtedly effective in medical treatments.

4.2. Infrared Lamps

Treatment was provided in a total of 12 sessions, and in each session, it was applied as kneading-shiatsu (deep tissue rhythmic therapy) and hot application. One infrared lamp, which has a radiation power of 150W as an electrical energy source, was used to produce infrared radiation. Holdings of the complete hassling with the other hand will be continued for 3 min from the moment of contact. At the A UNT Medical Library on January 30, 2009, it affected the subcutaneous tissue.

This study is designed to investigate the effectiveness of aromatherapy and IRL in combination in order to enhance the pain-relieving effects in the low back of patients. Wound healing is a complex process and consists of a scar-free inflammatory response (type I) and a fibrotic (type III) process throughout the healing process. Although the aim of the healing of the noninfected wound is type I, type III collagen is much less strong than infection is suitable for the healing of the infected wound. Increasing the local blood acquity with infrared lamps will decrease the likelihood of infection. High-frequency radiation is gradually transformed into heat energy, and any insulation layer formed by any clothing on the surface of the body is absorbed by the blood through the muscles. Flat and exposure time were not disclosed. Head, lumbar, and wrists are suitable for use, even for the soles of the sole, such as inclination and inclination complicity injuries. Providing good skin contact without any loss of energy.

5. Infrared Radiation in Pain Management

Infrared rays have been observed to penetrate into the skin and have the ability to alleviate pain to varying degrees. This effect is particularly marked in the case of surface skin pain and deep-seated muscle aches. Regular use of infrared radiation pain treatment is believed to reduce pain in patients with arthritis, back pain, muscle aches, and joint problems. All of us get hurt from time to time. We turn to a multitude of drugs, figure that a little rest might do the trick, or hope that a bandage will protect and rejuvenate damaged tissue. The body's healing process can be enhanced by infrared radiation by trapping the warmth on the damaged site.

Medical infrared lamps that shine infrared light on a patient's sore areas could be the best recognized medical application of infrared radiant energy in pain relief. Heat lamps, needlepoint biostimulators, and laser pointer appliances - visible, near-infrared, and, in some cases, mid-infrared emissions of different wavelengths or temperature levels - belong to this class of heat therapy devices. Thanks to their use of electronic systems to control the depth of emission and temperature, high-quality infrared saunas and thermal therapy systems are being created today. Due to ineffective skin absorption, long wavelengths above 2,000 nm that are commonly used in telecommunication are not used in medical therapies. The resulting inflammation process and the resulting nitrogen level in the muscle are affected by mid-infrared light at a magnitude of 1300-2000 nm, which stimulates the level of nitric oxide intracellularly. Weary muscles, depleted of oxygen during a workout, and can expedite healing by oxidating the tissue and encouraging the development of new capillaries. [15][16]

5.1. Arthritis

Arthritis is one of the many diseases targeted by manufacturers of infrared devices. The anti-inflammatory effect on the joints reported by the hypothermic effect of infrared and increased blood circulation through dilated structures is supposed to be the key point for attacking arthritis, which is based on mechanical and chronic pain that is promoted by local free nerve endings. reported clinical trials that diminished morning stiffness and joint pain by 56% and increased grip strength and range of motion by 131% after using an infrared energy belt for 4 weeks. The thermography of the hand by Oleopoluc (1992) reported reduced muscle stiffness and improved light function after 6 and 10 minutes of short exposure to a 2300 nm infrared lamp.

In outcomes, the pain in the knees reduced from 51 to 23 mm following a 3-minute use of a 940 nm facial infrared in a seated position (2.2 W/cm2); and 48 to 18 mm in supine angled positioning (7 cm) with a 1.45 W/cm dose, resulting in a bulk of positive feedback on pleasing warmth and preference. The other infrared EMS device was adapted for knee osteoarthritis with 830 nm, 70 mW/cm2, and a power rate of 1.2 J/cm2 for 272 seconds each, 3 days each, marked residual effect reported 2 months after the last application, however with no technical details provided. [17][18]

5.2. Muscle Pain

Summary: In this part, we look at studies exploring the effects of infrared on muscle pain. When the source wavelength is the same or similar to the infrared light used in a study, it often causes muscles to relax when increased. Increased pain thresholds, decreased pain, and increased comfort were attributed to improved relaxation. This suggests that the effect of infrared on muscle is mainly a muscle-relaxing effect. In addition, near-infrared with a wavelength up to 2000 nm was shown to increase temperature, decrease neural response to avoid increased pain, and basically, long wavelengths increase skin temperature more than short wavelengths. Infrared was demonstrated to inhibit pain but wasn't significant, with larger effects showing application to muscle pain.

Muscle Pain Four trials have investigated the effects of light-emitting diode (LED) therapy with near-infrared wavelengths on muscle pain. 830 nm (four trials) had effects on muscle pain in three of the studies but is shown to decrease pain in only two studies. Increases in muscle relaxation, revealed by the decrease in the sensitivity of experimentally induced pain, was the most frequent reason given by the authors for moving in the cutaneous methodological approaches (increased pain (three trials)). This was due to the sensitivity of the pain receptor indicating how relaxed muscles are; when the response is elicited at a lower threshold, investigators have regarded this as an indicator of muscle relaxation. In line with this, the authors have viewed the analgesic effect of 830 nm as an additive consequence of its concurrent action to create effective muscular relaxation.

Yoshimura et al. found that the higher dose of a near-infrared LED diode at 830 nm increased the pressure pain threshold and produced feelings of pleasantness (in decreasing of the visual analog scale (VAS) scores for sensory and affective pain ratings) more than a visible red light at 650 nm in pain-free healthy young women; but again, the authors interpreted that the observed effects were due to the greater increase in muscle relaxation produced by the higher dose of the 830 nm light. It was only between the different doses of the 830 nm LED that there was a significant difference, but neither LED differed significantly from the 650 nm LED. The infrared (IR) with a wavelength at 780 nm was also shown to decrease muscle pain but not at a significant level. This appears logical, as the mechanism of action of infrared in the body is related to the production of heat and the vascular influence. The temperature increases and muscular blood flow is seen to increase locally in the target muscle tissue after a treatment of 5 minutes, and the peak effect is at the end of treatment. Therefore, the hypothesis that muscle pain can be affected through an effect on the muscle must be developed to enable the use of all the treatment techniques. [19][20]

6. Infrared Radiation in Wound Healing

Currently, many reports indicate that infrared radiation can be used as a medical treatment tool in order to accelerate or promote tissue repair, regeneration, and/or stem cell functions. Impaired tissue healing as a result of burns, traumatic injuries, or pathological conditions (e.g., diabetes) is a concern, while injuries involving burns represent one of the serious health problems. According to the American Burn Association, between 2010 to 2014, the approximate acute care facility utilization of burn injury was estimated to be 292,000, and between 2013–2017, the range of estimated emergency department visits involving injuries with burns was 329,400–399,900 annually in the United States. Moreover, the worldwide situation is worse, with the estimated number of fires and burn cases reported being approximately 4.2 million, which leads to a mortality rate of 180,000 people annually.

Diabetic foot ulcers, particularly when infected, tend to be a major driver of the increasingly frequent amputations. Although various treatment options are available, it often takes too long to observe improvements in healing, in many cases with suboptimal outcomes. At present, low-level light therapies are considered to be effective in promoting the healing of chronic wounds of various etiologies. The mechanisms involved in non-contact infrared radiation-mediated TMJ tendon healing remain unclear. It is also not known whether the acceleration of tendon healing involves regeneration of the tendon or scar tissue formation. An in-depth understanding of the above is necessary for translating the results effectively into clinical practice. [21][22]

6.1. Burn Wounds

Infrared radiation has been used as a means of treating different medical conditions, including skin problems of varying etiology. Based on the up-to-date literature, burn wounds have been the most widely researched issue in this case. The basic aim of that study was to determine all possible applications of infrared radiation in the treatment of burn wounds.

A burn injury is traditionally managed for relief of pain with anti-inflammatory agents. In addition, infrared may have the advantage of reduced inflammation. Medical infrared applications may provide new therapeutic solutions for burn wounds. Nevertheless, overviews on the effectiveness of infrared treatment are rarely provided. The review evaluates whether medical treatments with infrared are effective in burn wound management. This review showed that infrared can provide beneficial effects in burn wounds, and that the modality of providing the infrared can vary, based on the needs.

In recent years, infrared medical applications have come to the forefront due to the positive results obtained from pathologies such as pain, herpes, and diabetic wounds. However, there are not many studies examining the effectiveness of infrared in the treatment of burn wounds. With the literature reading, it was aimed to determine the effect of the applied dose of infrared in burn wound control, application site and depth, desirability, and applications in dressings. There is often a focus on neonatal injury management. In adults and children, less information is provided. Additionally, the review incorporates infrared treatment and the effect from a physiological and sensory point of view. [23][24]

6.2. Diabetic Ulcers

Diabetic ulcers. About 15% of all diabetics experience a foot ulcer, and these ulcers are a leading cause of non-traumatic lower extremity amputation. Chronic wounds caused by diabetes undergo a phase of hemodynamic and microvascular dysfunction, with impairment of oxygen and nutrient supply, healing. The efforts of those treating these wounds focus on methods of microcirculation improvement in the ischemic area, reduction of edema and local inflammation in the hopes that the condition will improve enough for the body to begin to recover its integrity and resist contamination.

In the diabetic patient, the mechanism of pressure ulcer healing goes through intermediate phases of inflammatory lesion followed by a poorly organized and prolonged proliferative stage. In this milieu, the anti-inflammatory and inflammatory effects of infrared radiation could be particularly useful in creating the appropriate condition where the second stage of over granulating and resisting the entry of unwanted contaminants could occur. Infrared radiation, either via a full body in an IR sauna or a specific section of the body in a WellWaveTM Infrared capsul/bed operation could be an effective physical method for promoting epithelial recovery in the sliding condition or diabetic ulcers. The application of IR in cream form, possibly is quicker and less expensive, likely less cumbersome, effective and less cumbersome. It would be an advantage to patients and physicians to have the option of whirlpool or no whirlpool treatments on a given day. Given the many ways that modern infrared systems can be applied it is not difficult to appreciate the wide applications for the support of trauma or any other type of wound healing. [25][26]

7. Infrared Radiation in Dermatology

Infrared radiation has been proposed as a promising alternative in several skin treatments, including circulatory and rejuvenation chorioretinal mechanisms of action. Today, we have the advent of light-emitting devices for more specific skin photobiostimulatory treatments. The application of infrared light-emitting devices, which emit various portions of radiation, should take into account the penetration of infrared light in the skin and its absorption by chromophores. Hence, photons emitted in the NIR and IR spectra are most commonly applied independently as skin care therapeutic low-intensity treatments without causing the sensation of heat.

Infrared radiation, which represents almost half of the solar energy that reaches the earth, is located between the time window of action of visible light and the microwaves. Dermatologists are familiar with infrared radiation; for instance, the coagulative tissue damage caused by Nd:YAG laser. New data provided by basic and clinical research studies suggest that IR radiation can modulate numerous biological mechanisms such as skin physiology, inflammation, and regeneration at both the tissue and cellular levels generated via heat (local hyperthermia) and non-heat (direct interaction with molecules) mechanisms.

However, the scientific community is rather unaware of the tremendous potential applications of infrared radiation in dermatological therapies. This review aims to describe the usefulness of infrared radiation in dermatology and to discuss mechanisms of action underlying the therapeutic potential to confirm direct and heat-mediated effects. [27][28]

7.1. Acne Treatment

Acne treatment using infrared light has been adopted for treating acne. This may reveal the potential application of infrared radiation in therapy, such as the regulation of sebum, antibacterial effects, or skin rejuvenation, as a Joule heating effect of infrared radiation can modulate the temperature of the sebaceous glands.

The potential may exist for the treatment of acne via the use of various infrared radiation modalities, which act on the human skin via different mechanisms. The ideal wavelength and potential depth of penetration range from mid-infrared to far-infrared radiation. The mechanisms of action may include the regulation of sebum and inflammation, an antibacterial effect, thermal degeneration of the sebaceous gland, and/or skin rejuvenation.

The application of infrared radiation to the human body acting on the sebaceous glands via the Joule heating effect may be by multiple modalities. The treatment of acne with infrared light is widely available and approved by the U.S. Food and Drug Administration. Depending on the wavelength, the therapeutic action may be varied, and the mid-infrared to far-infrared seems to cover-axis, which is the ideal wavelength to modulate the activity of the sebaceous gland via the heating effect. Due to the tolerability associated with it, the mechanistic properties of the buildings may be attractive for the treatment of acne and skin rejuvenation. In this manuscript, we propose a combination of different treatment modality for acne therapy. [29]

7.2. Psoriasis Treatment

In psoriasis, light therapy with ultraviolet (UV) radiation is an established practice. To avoid potential carcinogenic side effects due to immunosuppression in patients, alternative technologies such as the utilization of infrared radiation are worth investigating. In a murine psoriasis model, anti-inflammatory and immunomodulatory effects of hyperthermic treatment have already been reported.

A single clinical trial investigating the influence of a specific psoriasis balneophototherapy utilizing IR-A on patients with psoriasis vulgaris has been conducted and published by Atakan and coworkers. Known from sun exposure, beneficial effects gained in our previous investigations evaluating epidermal-stimulating properties of UV-A1 radiation on the stimulation of keratinocyte proliferation, even under cytokine-exposed conditions, may also be found under heat-stimulating properties of longer waves. The thermal effect is able to vasodilate and relax blood vessels; the reduced blood perfusion is a further factor for the alleviation of symptoms.

More recent data suggest that longer waves such as IR-A (760–1400 nm) possess the ability to induce gene transcription and protein translation of matrix metalloproteinase-1 (MMP-1) in fibroblasts in vivo and in vitro. MMP-1, in turn, can reduce skin inflammation by inhibiting the mitogen-activated protein kinase signaling pathway and can control extracellular matrix (ECM) remodeling by inhibiting tumor necrosis factor (TNF)-alpha.

Although this study found that our most effective ESWT-ir prototype emits up to 650 W/cm2 IR-A (760–1400 nm), which is not equal to the thermal energy output occurring by fiber bundles usually installed in commercial saunas/spas around the world and might be a potential factor for skin and eye safety, the exposures roused signal transductions reported in fibroblasts by Saeki et al.

8. Safety Considerations in Infrared Therapy

Because infrared radiation causes molecular vibration, generates heat, and elevates the skin temperature, there are concerns regarding the thermal risk imposed by infrared therapy. Especially, it is essential to wear glasses and protect the patient's eyes to avoid eye diseases. The basic safety of medical devices utilizing infrared radiation is determined according to whether the heat absorbed by the human body produces any negative effects either on the skin or elsewhere in the body. There are no strict regulatory guidelines in the international market that assess the efficacy of therapy utilizing infrared radiation; however, there are reports which indicate the necessary conditions of the optical properties.

Guidelines and regulatory permits, such as the EU directives for the safety of personnel, provide a guiding principle for the basic safety of using therapy equipment. According to the risk analysis for the operator and the patient, therapy equipment that utilizes optical radiation should be installed with a feedback sensor. Infrared thermometers or thermographic cameras are recommended for monitoring skin surface temperature to aid in evaluating the required temperature. Therefore, it is more appropriate to monitor the surface temperature during infrared radiation therapy, rather than directly measuring the fluence of infrared radiation.

9. Future Directions and Research Opportunities

There are some innovative approaches that must be addressed in light of the development of new technologies. At the moment, the potential is present; it is only a matter of time and further research. Future lines of research, including electromagnetic, photonic bandgap structures, and metamaterials, could bring new insights into effective medical treatments. In this context, a huge amount of research can be envisaged in the design, development, and study of metamaterials with a view of improving the electromagnetic field and changes in emissions, absorption, and transmission of electromagnetic waves functioning as novel superlenses, antennas, and scatterers. The electromagnetic field produced by these novel materials can be optimized to improve energy coupling to the tissue and achieve increased deposition in diseased tissues, being very attractive for the treatment of cancer.

Another field of research is represented by the design and therapy efficacy of the radiative processes at subwavelength scales within photonic-crystal surface emitting lasers. In this context, a proof-of-principle mode concept and a 2D model of an idealized high-Q resonator/laser delivering beams condensed into a state of matter analogous to a Bose-Einstein condensate wave for treating tumors have been proposed. While this proposal is still in its infancy, better strategies could involve the design of materials that are claimed to scatter electricity like the waves on the sea. If they are made correctly, they will scatter nearly 100% of the incoming infrared, for example, giving a potential for harmful radiation shielding systems of wear-repairable, safe, solid-state clothing.

10. Conclusion and Summary of Key Findings

Within the last decade, infrared radiation has shown itself to be very beneficial and effective when used in various medical treatments. Dermatological therapy is easily the area most suited for the use of IR radiation, and there are numerous defects, such as superficial skin lesions, fungal and bacterial infections, and acne, that can be treated. IR is also known to be effective in enhancing blood flow and proving to be an effective analgesic. It might also be utilized in the prevention of chronic illnesses caused by diabetes and other risks. Even though there are numerous benefits to treating folks with IR radiation, some difficulties also exist. Trying to maintain the absorbed temperature in the tissue at a constant degree and determining the degree of compliance can be a hard thing to do. [30][9]

In the future, it will be necessary to resolve these issues, as well as research the relationship between IR radiation dose and tissue repair rate. The next option is to deal with how to distribute IR to various places on the body. The effect of infrared radiation on biological tissues has been carefully analyzed in this study. The technique uses detected infrared radiation to initiate selective photothermolysis inside the tissue, working as an absorption contrast, which does not damage non-targeted tissue. The basic makeup of the technique was completed, and an IR LED FEM system was ultimately approved.

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