

The use of electromagnetic radiation in the physiotherapy

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Abstract

The electromagnetic field is a physical field produced by electrically charged objects. Types of radiations in the electromagnetic spectrum include: radio waves, microwave, infrared, visible light, ultraviolet light, X-rays and gamma rays. Understanding the mechanisms of cellular responses to particular types of electromagnetic radiation has enabled the development of the variety of methods of physiotherapy suitable for different types of diseases. The main ones are: electrotherapy, magnetic therapy and phototherapy. Electrotherapy is the use of electrical energy like direct current, impulse currents of low frequency and alternating current of medium frequency and high frequency. Magnetotherapy uses a pulsing magnetic field to induce intracellular movement of ions due to the electromagnetic field, resulting in hyperpolarization of the cell membrane, and thereby the increment of the

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metabolism. Phototherapy is based on the use of visible light, polarized light, infrared or ultraviolet in the treatment of various ailments. The main indications for the physical therapy with the use of EMF are pain syndromes and musculoskeletal disorders.

Introduction

The use of magnetic and electromagnetic fields (EMF) in physical therapy is considered as an effective method of treatment of various diseases of the musculoskeletal system. The development of research on the effects of EMF started at the beginning of XX century, when Yale University anatomy professor Harold Saxton Burr described the role of electricity in disease [1]. Nevertheless, the positive impact of energy medicine were known even in ancient times, when people used energy produced by electric eels or static electricity of rubbed amber to treat different ailments [2, 3]. Today, the development of science allows to specify both positive and negative impacts of the different types of radiation on the human body.

The EMF is a physical field produced by electrically charged objects. It can be interpreted as the combination of electric and magnetic field, where the former is produced by stationary charges, and the latter by moving charges [4]. Types of radiations in the electromagnetic spectrum include: radio waves, microwave, infrared, visible light, ultraviolet light, X-rays and gamma rays and can be divided into ionizing and non-ionizing radiation depending on the amount of energy and the ability to detach an electron from an atom or molecule.

In physiotherapy, these electromagnetic modalities are generally used to expedite recovery of soft tissue injuries or relieve the pain [5]. The main methods of therapy used for that purpose are: electrotherapy, magnetic therapy and phototherapy.

Phototherapy

Phototherapy is based on the use of light in the treatment of various ailments. This method uses both

visible light and invisible light spectrum – infrared and ultraviolet.

Infrared radiation (IR) is an invisible electromagnetic radiation of the wavelength range of 750 nm–100 μ m. The spectrum of the IR lies between the microwaves and the visible part of red radiation and its source are heated bodies [6]. Recently, the infrared radiation has become popular and relatively safe method of treatment which is used in many diseases of the locomotor system. Its therapeutical effect is the result of local hyperemia and the positive heating impact which reduces muscle tension [7, 8]. Furthermore, it is described that IR influences favorably pain perception (due to increase of endorphin secretion), immunological reactions, acceleration of metabolism and also regulation of activity of autonomic nervous system in the aspect of controlling muscle tension. In cellular level the mechanism of infrared radiation is based mainly on the interactions with water molecules [9].

Discussing biological effects, infrared radiations might be grouped into subdivisions: near, mid and far. The division is based on the rule that the longer the wave of radiation is, the lower penetration it has. Especially interesting part of IR is far infrared (FIR) which is alternatively called as biogenetic radiation or biogenetic rays. It is the part of the IR which has the pure heating effect on the human cells due to marked sensitivity of our thermoreceptors. It penetrates up to 4 cm beneath the skin and, what is more, the wavelength of the FIR is too long for human eyes [9]. FIR therapy is the method of treatment in which the whole body is being radiated in special saunas [10]. It results in its systemic effect which is used in therapy of such diseases as chronic heart failure or peripheral arterial diseases [11, 12, 13].

The most common generators of IR, which are used widespread in physiotherapy, are Sollux lamps. They

belong to the light generators in which the source of radiation is light bulb. Non-light generators are Helios and Emita with filament – IR source which is heated to the high temperature. All of them are used to the local treatment for example in injuries, neuralgia and pain syndromes, chronic arthritis, chronic inflammation of joints or soft tissues, bacterial inflammations or frostbites. The method might be also undertaken as a preparation before kinesiotherapy, massage and other forms of physiotherapy [6].

Unfortunately, infrared radiation therapy has contraindications which limit possibilities of its common use. Most important of them are: pregnancy, epilepsy, active tuberculosis, malignancy, acute inflammation, severe coagulation disorders and cachexia [6].

Ultraviolet radiation can be divided due to the wavelength into UVA (400-315 nm), UVB (315-280 nm) and UVC (280-200 nm). UV is widely used in medicine. Starting from the decontamination of the surfaces, hospital rooms and medical equipment, going through the use in the treatment of dermatological disorders, ending up on the use of irradiation in physiotherapy. UV is considered helpful in the treatment of muscle pain, periarticular inflammation and rheumatic disorders. Interestingly, it is also the method used supportively to normalize internal organs functioning during vegetative disorders. [14, 15]. Contraindications to UV therapy are allergic reaction to UV, acute skin diseases, systemic lupus erythematosus, photochemical erythema, skin graft, ionizing radiation skin damage and fever [16].

Polarized light is a kind of electromagnetic waves, which, unlike the sunlight, oscillate only in parallel planes. The numerous research show that the polarized light has high biological activity, as well as the infrared and UV [17] and can stimulate the human immune system [18]. Biostimulative character of the polarized light leads to anti-inflammatory effects, analgesic, harmonization of the metabolic processes, stimulation of regeneration and self-healing of the organism. This has been applied in many fields of medicine, such as traumatology, rheumatology, neurology, dermatology, sports medicine, plastic surgery and cosmetology. In physiotherapy indications for the use of polarized light are: chronic and sub-acute arthritis, pain syndromes in osteoarthritis of the spine, spinal

disc herniation, musculoskeletal disorders, periarthritis, neuralgia, contractures, badly healing wounds and difficulties in bone merging [18]. The strength of the biological effects depends much more on the polarity of the light beam than its intensity [17]. However, some researches undermine the effectiveness of polarized light and claim that the therapeutic effect is mainly caused by the placebo effect.

Laser techniques are another methods commonly used for physical therapy purposes [19]. Low Level Laser Therapy (LLLT) is a light source that generates extremely pure light of a single wavelength. The effects are related to photochemical reactions in the cells but the exact mechanism is still to be determined [20]. The possible action of laser therapy is associated with enhanced production of ATP. The increased ATP amount prompts mitosis and proliferation but also supports reassuming of homeostatic function of the cells [21, 22]. Laser therapy should be considered in the management of musculoskeletal conditions such as muscle strains, minor musculoskeletal pain, epicondylitis, carpal tunnel syndrome, osteoarthritis and rheumatoid arthritis [23]. The U.S. Food and Drug Administration classifies LLLT devices as “lamp, non-heating, for adjunctive use in pain therapy”. The other pointed profits of the laser therapy are improvement of mobility and flexibility.

It is difficult to determine precisely the effects of laser therapy due to incompatibilities in studies concerning the modality of different authors. The effectiveness of this therapy remains controversial despite the recent reviews and meta-analyses which support its validity [24, 25]. In conclusion, laser therapy has not been shown to cause adverse effects, but a benefit has not been still clearly established [23].

Magnetic therapy

Magnetotherapy is a form of physical therapy that uses a pulsing magnetic field to generate electromagnetic energy. The magnetic field in magnetotherapy uses frequency less than 50 Hz (typically 10-20 Hz) and magnetic induction exceeding the induction of the Earth's field, which is of 0.1 mT to 20 mT [26]. The mechanism involves intracellular movement of

ions due to the electromagnetic field, resulting in hyperpolarization of the cell membrane, and thereby the increase of the metabolism. This improves the blood supply to tissues and raises the partial pressure of oxygen. The advantages of magnetotherapy include an equal penetration of the magnetic field through all the tissues, as well as the ability to perform procedure through clothing, bandages or plaster. The low frequency EMF were proved to accelerate coalescence of broken bones and the healing of wounds and trophic ulcers. The beneficial effects of these fields on some motor diseases and peripheral nervous system, peripheral circulatory disorders, inflammation and certain skin diseases were also demonstrated. Important therapeutic reason for use of magnetotherapy is its analgesic effect [27].

Treatment with a magnetic field of high frequency is based on the use of the magnetic field of induction similar to the Earth's field and the frequency of 2000-3000 Hz. The essential aim of the use of high frequency magnetic field in treatment was to reduce the thermal effect. In this method tissues are exposed to pulses of high peak power separated by long intervals, sufficient to achieve heat dispersion. This method is especially characterized by the anti-inflammatory, analgesic and antiedematous effect. It also causes acceleration of the absorption of a hematoma [28].

Electrotherapy

Electrotherapy is the use of electrical energy as a medical treatment. The types of energy used in therapy are direct current, impulse currents of low frequency and alternating current of medium frequency and high frequency [18].

Galvanization, iontophoresis and galvanic bath are the methods based on direct electric current. Direct current influences positively the function of the organism due to improved circulation in tissues exposed to the therapy. It makes tissues oxygenated and nourished, while toxic metabolites are eliminated. That makes the therapy undeniably useful in patients under risk of muscle atrophy. Moreover, direct

current therapies might accelerate wound or chronic ulcers healing by mobilization of cells division. The main indications include neurological disorders such as neuralgia, neuritis, paralysis of the facial nerve, sciatica but also peripheral circulatory disorders, disorders of bone merging, chronic wounds or ulcers, post-traumatic conditions (swelling, hematoma) and also muscle disabilities (overload, painful muscle tension). Iontophoresis is a type of medical treatment during which the drug is administered deeply into the tissue. It is an excellent way to localized application of the drug what improves its analgesic and anti-inflammatory effects. In addition, iontophoresis widens the range of motion, improves the economics of muscle work and reduces the tension of the muscles. Galvanic baths can be divided into ventricular and total baths. The therapeutic effects may be different, depending on the direction of current flow and the quantity of the baths. The electric-water baths are indicated in polyneuropathy, neuralgia, paresis, pain syndromes, ankylosing spondylitis, osteoarthritis and disorders of the cardiovascular system e.g. excessively high or low blood pressure and peripheral circulation disorders [14].

Impulse currents of low frequency finds application in NMES, FES and TENS methods.

Neuromuscular electrical stimulation (NMES) is used for muscle strengthening, maintenance of muscle mass and strength during prolonged periods of immobilization, selective muscle retraining and the control of oedema. NMES is used as a support therapy by professional athletes and by patients after muscle injuries [29].

Functional Electro Stimulation (FES) provides the stimulation of the muscles showing impairment or lack of function and tension control. FES may also rely on the stimulation of the nerves of injured muscles. The method is designed primarily to achieve functionally useful movement. It is proper complement to prosthetics, orthotist and rehabilitation [30].

Transcutaneous electrical nerve stimulation (TENS or TNS) is used to treat pain due to analgesic and neuromodulating properties. TENS is useful in disorders such as rheumatoid arthritis, osteoarthritis, neuropathy and radiculopathy, post-traumatic

and postoperative pain, migraine, dysfunction after stroke and painful menstruations. TENS is also effective in labor pains relief [31].

Impulse currents of medium frequency (1000-100000 Hz) are used in order to stimulate skeletal muscles contraction, dilate blood vessels, affect the autonomous system and improve tissue regeneration. It can also bring positive effects in management of musculoskeletal pain [14].

Among the methods of high frequency current (300 kHz – 300 GHz) darsonvalization, short-wave diathermy, microwave diathermy and high frequency pulsed electromagnetic field therapy can be distinguished. [14].

Darsonvalization is the physical therapy based on alternating current high voltage to the human body through a gas-filled glass electrode. Darsonvalization therapy combines two disparate methods – general and local. The results in local darsonvalization are improvement of central nervous system activity, metabolic processes and blood circulation. Whereas the mechanism of the effect of general darsonvalization is still unknown, but it is considered to result in calmative effect, increased metabolism and reduced arterial blood pressure [32].

Diathermy involves local heating of the tissue using a strong magnetic field or electric field, leading to muscle relaxation and easing of pain. Microwave diathermy uses waves of 69 centimeters of length and frequency of 433.93 MHz, while short-wave diathermy – a wavelength of 22.12 meters and 13.56 MHz of frequency [33].

High frequency pulsed electromagnetic field therapy generates shorts bursts of electrical current in injured tissue without producing heat or interfering with nerve or muscle function. Since the FDA approval, it has been widely used to counteract pain resulting from various conditions. In addition, it has been also used to enhance scar healing and prevent osteoporosis [34].

Summary

Physiotherapy with the electromagnetic field has become over the last century common method of

treatment used in rehabilitation centers and health resort treatment. Understanding the mechanisms of cellular responses to particular types of electromagnetic radiation has enabled the development of the variety of methods suitable for different types of diseases. On the other hand some of them are still not clearly established to benefit and are mainly considered as a placebo effect. The most common indications for the physical therapy with the use of EMF are pain syndromes and musculoskeletal disorders.

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