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Review Article

Magnetoledtherapy in comprehensive pediatric rehabilitation

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ABSTRACT

Introduction: LED light therapy with magnetostimulation (magnetoledtherapy) has a vast range of applications in the treatment of neurological, rheumatic and orthopedic illnesses. In some cases it serves as an alternative procedure to pharmacological treatment, in particular to nonsteroidal anti-inflammatory drugs.
Aim: The aim of this study was to discuss the use of magnetoledtherapy in the rehabilitation of children.
Materials and methods: This article is a review of selected literature and other available source materials.
Discussion: Due to biological hysteresis, therapeutic outcomes of magnetoledtherapy appear later than in the case of other physical therapy methods; they last longer, even up to several months after the exposure, thus leading to more beneficial treatment effects. Therapeutic methods available for very young people are limited due to various contra-indications. When exposure conditions are carefully considered and accounted for, magnetoledtherapy can be applied even in infants, serving as a beneficial complement to kinesiotherapy. Children willingly participate in such treatment because magneto-ledtherapy produces few side effects and has a positive effect on a patient's well-being following the application. Selected indications for the use of this method in children include neuralgias, juvenile rheumatoid arthritis, collagenoses, aseptic necrosis, osteo-porosis, tendinitis, tendovaginitis, bursitis, injuries without a disruption in tissue con-tinuity including sprains, bruises and fractures, improvement in the quality and time of healing, burns, effects of exposure to sunlight and laser light, neonatal physiological jaundice, dermatoses including dermatitises, acne, herpes, vitiligo, psoriasis, central nervous system lesions, dental periapical lesions, cerebral palsy, peripheral nerve lesions, especially perinatal brachial plexus palsy, polyneuropathies, amyotrophic lateral sclerosis, spinal muscular atrophy, muscular dystrophies, congenital bone deformations, neuroses, sleep disorders, stress, Attention Deficit Hyperactivity Disorder (ADHD), speech impair-ment therapy and therapy for children with Down's syndrome. Therefore, this therapy is widely applicable. In the treatment of children, it is indispensible to strictly follow application parameters and observe specifications concerning the size of the area that is exposed to treatment.

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Conclusions: Magnetoledtherapy is a valuable complement to the comprehensive rehabilitation of children and should be recommended for a wider application.

1. Introduction

In 1976, Kyochi Nakagawa described the magnetic field deficiency syndrome for the first time. Its major symptoms are stiffness of shoulders and back and an abnormal configuration of the cervical lordosis. Other symptoms include low back pain and chest pain, heaviness of the head and non-specific headaches, dizziness and insomnia for uncertain reasons, habitual constipation and general fatigue. This syndrome was treatable with the therapy that Nakagawa originally called magnetotherapy. Nakagawa saw the theoretical basis for the syndrome in the weakening of the intensity of the Earth's magnetic field by 0.05% per year, which led to the decrease of 50% in magnetic field strength within the last 500 years.[16]

On 12 April 2011, at the press conference commemorating the 30th anniversary of the first space shuttle launch, NASA's chief technologist Dan Lockney announced a list of new technologies which would be developed by the Agency within the next decade. He remarked that a similar program had been launched during space shuttle operations. Since 1981 several new inventions, both for the mass consumer and in the field of new technologies, have been put forward and implemented. These included Light Emitting Diodes (LEDs), which were constructed during experiments with light sources onboard space shuttles, Video Image Stabilization and Registration (VISAR) technology enabling stable, sharp and contrasting images independent of camera position, and life shear cutters.[17] The first of these inventions, LEDs, revolutionized the treatment of poorly healing wounds and ulcerations as well as the field of cosmetology.[3]

Light is a fundamental element of any biological ecosystem which sustains all living organisms. Most biochemical and biophysical processes involve light. Sunlight, i.e., natural electromagnetic radiation, brings beneficial effects and is indispensible to humans. Tissues exhibit different ways of employing sun radiation. A lack of sunrays diminishes the concentration of many hormones and the activity of enzymes in humans. Aheliosis, one of the first diseases of the industrial civilization, was caused by the shortage of sunlight in factories and thus affected industrial workers.[20]

The use of the two types of energy mentioned above in one therapeutically active element exploits the synergy of LED light and magnetostimulation, their complementary positive actions and, occasionally, their reciprocal neutralization of undesirable effects. Magnetoledtherapy involves a simultaneous application of magnetostimulation and LED light therapy. The application of both types of electromagnetic radiation aims at an increased efficacy of treatment.[26]

The rehabilitation process of children should be based on the neurophysiological foundations and should be closely correlated with the maturity of the central nervous system. Perception of external stimuli develops the cognitive capabilities of the child and enhances the activity of brain maturity processes. The phenomenon known as the plasticity of the brain facilitates proper motor patterns remembered by the child and inhibits pathological patterns. Supplying new stimuli in the form of the synergic actions of monochromatic light and alternating magnetic fields should accelerate the proper brain plasticity processes and the reproduction of motor patterns along with a decrease in the muscle tone.

2. Aim

The aim of this study is to present the uses of magnetoledtherapy in the rehabilitation of children.

3. Discussion

3.1. *Magnetostimulation*

Therapy that employs the energy of electromagnetic radiation belongs to the domain of physical medicine, a dynamically developing discipline which uses physical factors in restoring a patient's health. Among other branches, physical medicine includes magnetotherapy, magnetostimulation and magnetoledtherapy.[2]

Therapeutic employment of the magnetic field draws on the experiences of many generations, beginning with the ancient cultures of Egypt, Greece and Asia. For the last several decades, due to the development in technology, scientific foundations have been established for the use of magnetic fields in medicine, diagnostics, therapy and prophylaxis.

Magnetostimulation exploits magnetic fields below 100 μT. The idea of stimulation originates from a well-known fact in medicine that properly applied external stimuli enhance immunological and regenerative processes. Electromagnetic fields (the Earth's magnetic field, cosmic radiation, artificial magnetic fields) are not only an external factor that influences an open system of the human organism, but are also its integral part.[2]

Magnetostimulation involves exposure to a low frequency magnetic field in order to achieve the organism's functional equilibrium – homeostasis. Magnetostimulation uses magnetomechanical and electrodynamic forces as well as the forces of ion cyclotron resonance of cations and anions in the body fluids. Body fluids such as blood, lymph and intracellular fluids are the so-called conductors of the second kind, which relates to the ionic nature of electrical conductivity.[34]

Due to a complex and manifold influence of magnetostimulation on the organism, therapeutic effects are better than the ones obtained with the previously applied physiotherapeutic methods. These effects include:[2]

- acceleration of recovery,
- efficacious analgesic action,
- prolonged analgesic effect,
- effective relaxing action,
- better antispastic effect,
- accelerated post-traumatic regenerative action in soft and hard tissues.

Magnetostimulation beneficially modifies bioelectrical activity of the brain in individuals with Down's syndrome through external neurostimulation which enhances the intellectual efficiency of such patients.[21] From the perspective of the treatment method, magnetostimulation can be applied, in some cases, as an alternative procedure to pharmacological treatment both as a first-aid and prolonged method. This refers to both the nonsteroidal anti-inflammatory drugs as well as sedative and hypnotic drugs. [26]

It is worth emphasizing that in the case of magnetostimulation the benefits of the biological hysteresis result in prolonging the biological action, e.g., analgesic action, after ceasing exposure to the magnetic field. This action can be sustained for several months after the end of active therapy. The magnetic field produces changes in the organism which are similar to the ones that appear during physical activity. This enhances the processes of post-exercise recovery. The regeneration of both vital and mental forces is correlated with movement. The magnetic field appears to have a similar effect.

With respect to the nervous system, exposure to magnetic fields enhances nerve conduction and modulation of neuronal activity.[34]

3.2. *Ledotherapy*

Phototherapy is a branch of physiotherapy in which visible and invisible light radiation, infrared and ultraviolet radiation is used for therapeutic or prophylactic purposes. The sun is a natural source of radiation (heliotherapy), whereas various generators produce artificial radiation.[20] Unlike natural sunlight, whose availability and intensity are strongly related to the time of the day and season of the year, modern phototherapy can be applied at any time and place. Phototherapy, in general, is applied in both prophylaxis and treatment. It naturally stimulates regenerative processes at the cellular level.[27]

Ledotherapy is an innovative phototherapeutic method that is applied, among others, in Viofor JPS systems. The first device of this kind was made by Whelan and colleagues exploiting technology that is used in space shuttles. This method employs the energy of incoherent light generated by highly energetic LEDs in the visible spectrum and in near-infrared region. Invisible infrared radiation (IR) is emitted by heated objects. In treatment, radiation of the wavelength of 770–15 000 nm is most commonly used. This type of radiation

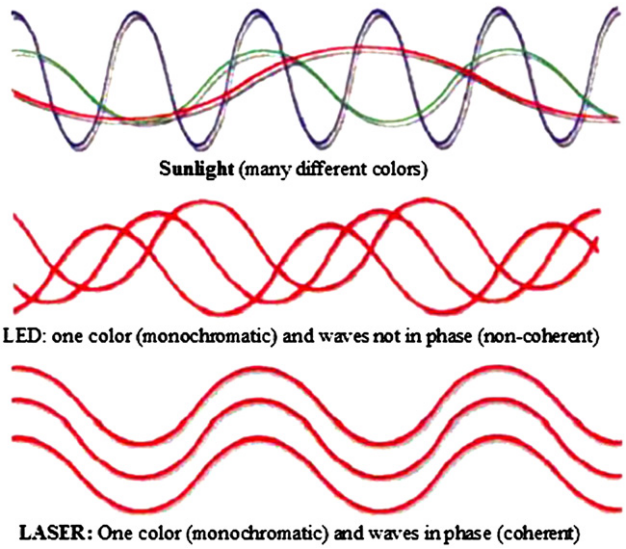

Fig. 1 – Differences between sunlight, LED light and laser light.[23]

is subdivided into short-wave IR (A), mid-wave IR (B) and long-wave IR (C). The shorter the waves, the deeper they penetrate into the skin (Fig. 1).[26]

Biological action results from the influence of wave heat on the tissue. This causes, among others, the expansion of skin capillaries, the reduction of tone in skeletal muscles, a rise in the pain threshold, enhanced metabolism, and stimulation of heat receptors in the skin and healing processes. The reaction of the organism to IR may be local or global, depending on the amount of absorbed energy. Visible red radiation (R) of the wavelength of 760–400 nm produces a heat effect.

Monochromatic light applicators can emit radiation of a wavelength similar to laser radiation but without the coherence and polarization effects. However, the density and energy of the light beam is high enough to produce photostimulation. Ledotherapy, within the range of therapeutic doses, replaces laser therapy with a scanner, without the necessity of compliance with the safety and hygiene regulations required for the use of lasers.[1,30]

Ledotherapy exploits "pseudolaser" radiation in the red region (R), infrared (IR) or mixed (RIR) which differs from laser radiation by a larger number of component spectral lines that are next to the baselines. In laser therapy, the range of the length of waves of component spectral lines in relation to the length of waves of the baselines lies within 10 nm. In ledotherapy, the range of the length of waves of component lines can be several times higher in relation to the range of the length of waves of spectral lines in laser therapy. Visible radiation of a wavelength between 700–600 nm is characterized by reduced tissue penetration and is applied in the treatment of surface or shallow lesions. It mainly exerts action locally on limited areas. It is indicated that the IR of 904–830 nm wavelength should be used in the treatment of lesions which are located deeper.[25]

Specific biological reactions are produced by the photothermal and photoionizing effects of light radiation: an increase in ATP synthesis, an increase in the amounts of DNA and RNA, intensified production of proteins, and

enhanced permeability of nuclear membranes for calcium ions.[27,29] Radiation emitted by LEDs has the unique quality of reducing the proliferation of nanobacteria, thus blocking the development of atherosclerosis and consequently reducing the myocardial infarction death rate.[28]

3.3. *Magnetoledtherapy*

Magnetoledtherapy is a combined application of magnetostimulation and the light emitted by highly energetic LEDs. Main biological effects of magnetoledtherapy include[8,11,26,25,27] acceleration of recovery, vasodilatation, angiogenesis, cellular membrane stabilization, anti-inflammatory action, relaxation, antispastic action, analgesic action, rejuvenation and improvement of skin, enhanced quality and time of healing, reduction of sunlight and laser light effects.

The analgesic effect of magnetoledtherapy is based on the unique mechanism of β-endorphin endogenous opiates secretion that is responsible for an increase in the pain threshold. The analgesic effect appears not only during magnetoledtherapy, but also following the end of exposure. This points to the biological hysteresis of magnetoledtherapy. Other effects of magnetoledtherapy include[31] increased activity and number of fibroblasts, increased collagen synthesis,[15] enhanced microcirculation, stimulation of osteoblasts, bone tissue regeneration, enhanced bone growth in fractures,[19] enhanced peripheral circulation, normalization of lipid metabolism and a decreased level of triglycerides, enhanced assimilation of vitamins, macro- and microelements.

Incoherent monochromatic light does not pose such threats as eye lesions or skin burns (as in the case of laser light). However, the following contraindications to the application of magnetoledtherapy should be taken into consideration:[2,26,34]

- pregnancy,
- cancer,
- active TB,
- bleeding in the gastrointestinal tract,
- severe bacterial, viral and mycotic infections,
- presence of electronic implants,
- post-transplant conditions,
- intake of photoallergic drugs,
- using photoallergic cosmetics,
- in the case of children: lack of cooperation of the patient or legal guardian, aversion towards the treatment, fear and stress may be the reasons to render the treatment pointless; treatment should be stopped and, in some cases, it should be ceased completely,
- the child's age: usually magnetoledtherapy is applied to children over 3 months, neonatal and early infant periods are adaptive phases and one should exert extra caution in ordering physiotherapeutic treatment.

In the hitherto reports, serious side or adverse effects of magnetoledtherapy have not been indicated. The following effects may, however, appear:[34] tingling sensation, stiffening, sensation of warmth, irritation, disorders of concentration, a transient increase in pain and in children: sleep disorders, hyperactivity, but also sleepiness and tranquilization.

The above effects are of a sporadic, short-term and transient nature. The use of magnetoledtherapy is safe. Indications for the application of magnetoledtherapy include:[2]

- degenerative diseases of osteoarticular system, extremities and vertebral column, radiculopathies, pain syndromes, e.g., shoulder pain syndrome and neck syndrome, neuralgies,[2,14]
- rheumatoid arthritis (juvenile rheumatoid arthritis), ankylosing spondylitis, collagenoses, and scleroderma,[19]
- aseptic necrosis, i.e., Osgood–Schlatter disease, Legg–Calvé–Perthes syndrome, osteoporosis,[2]
- tendinitis, tendovaginitis, bursitis,[19]
- profound and superficial injuries without disruption in tissue continuity including sprains, bruises and fractures,[15]
- vessel diseases like venous and arterial insufficiency as well as microcirculatory disturbances, diabetic and atherosclerotic angiopathy,[12,13]
- improvement in the quality and time of healing of wounds, ulcerations, bedsores,[4,9,10,22,32,33]
- burns caused by sunlight and laser light, neonatal physiological jaundice,[30]
- dermatoses including dermatitises, acne, herpes, vitiligo, psoriasis,[7]
- central nervous system lesions including post-stroke rehabilitation,[24]
- old and new as well as white and red striae (stretch marks),[11]
- skin rejuvenation and improvement,[15]
- treatment of cellulites,[11]
- pigmentary and vascular changes,
- hair loss and support in its regeneration,
- dental periapical lesions,[26]
- cerebral palsy – contracture treatment, reduction of spasticity, improvement of joint mobility, improvement of qualitative and quantitative expressions of motion evaluation,[19]
- peripheral nerve lesions, especially perinatal brachial plexus palsy, facial nerve paralysis, post-traumatic peroneal nerve paralysis,[35]
- polyneuropathies, spinal muscular atrophy, muscular dystrophies, amyotrophic lateral sclerosis,[35]
- congenital bone deformations, i.e., pes equinovarus,
- neuroses, sleep disorders, stress, ADHD,[18]
- support in speech impairment therapy (in cooperation with a psychologist, a speech therapist and a neurologist), especially in children with Down's syndrome.[21]

This combined therapy is very well-perceived by children and their guardians. It produces objective effects with respect to the activation of children's articulatory and oral apparatus. Children treated with this therapy speak more often and use a wider range of vocabulary.

Photoradiation mainly exerts local action in a limited area of application. Despite a large surface of applicators, about 150 cm^2, one should be cautious about their local effects as their surface is still small relative to the body area. The

situation is different with respect to small children because the proportion of the applicator surface to the body area of a child is radically different from that of adults. In such a case, indications for the use of monochromatic light emitted by applicators should be precisely specified and monitored by a specialist physician.

The components of application parameters are as follows:

- set programs (P),
- mode of application (M),
- intensity of application,
- type of applicator, e.g., mat,
- duration of a single application,
- number of applications within a course of treatment,
- number of courses (usually 15 applications per course) per year,
- frequency.

Programs:[2,34]

- P1 – magnetoledtherapy without ion cyclotron resonance,
- P2 – JPS system with ion cyclotron resonance, mainly used in prophylaxis,
- P3 – JPS system with ion cyclotron resonance, mainly used in therapy.

Mode of application:

- M1 – application with constant intensity of the field is recommended for patients in general good condition and young individuals,
- M2 – application with increasing intensity; the intensity of the field increases every 10 or 12 s from 0.5 μT to the set value; recommended for persons whose general condition is poorer,
- M3 – application with increasing and decreasing intensities; the intensity increases for 2 min from 0.5 μT to the set value, remains at the set level for the next 8 min and decreases within the final 2 min to 0.5 μT.

The parameters are set by selecting the program (P), mode (M) and intensity.

The intensity of 0.5–12.0 μT corresponds to the proportional values of the magnetic field emitted by the applicators. It is recommended to begin the therapy with an intensity of 1.0 μT and gradually move to the higher levels. For individuals particularly sensitive to the field and children, it is recommended to start the applications at 0.5 μT.

Suggested field intensity for adults[26] is 0.5–7.0 μT – depending on the patient's age and individual sensitivity.

Suggested field intensity for children:[2]

- age 0–2 – values 0.5–1 μT,
- age 2–5 – values 1–2 μT,
- age 5–11 – values 1–4 μT,
- age 11–15 – values 1–6 μT.

The following aspects should be taken into consideration while setting the parameters of the application for individual patients: age, general condition, history of the primary disease, comorbidities, administered medicines, time of day of the application, duration of the application, and other types of physical therapy.

The use of magnetoledtherapy is a valuable element of comprehensive pediatric rehabilitation. This type of physical therapy is well tolerated by children. Patients willingly participate in the application. They are particularly interested in LEDs. The use of magneto-light applicators enables a separate application of photoradiation – ledotherapy, or a combined application of light and magnetic field.

Analgesic, vasodilatative and spasmolytic effects have a special value in the treatment of spasticity and contractures. They accelerate the healing of fractured bones, a frequent occurrence in children. Magnetoledtherapy is also used in the treatment of rheumatic conditions in children. Frequent recurrences of generalized multi-joint juvenile rheumatoid arthritis are difficult to treat.

Treatment of speech impairment with the use of magnetoledtherapy is a relatively innovative approach. Such treatment relies on the enhanced metabolic and trophic processes in the peripheral tissue including mimic muscles, masseters and the tongue, and on the reduced muscle tone of articulatory and oral apparatus, which is common in children with cerebral palsy. The combination of magnetoledtherapy, psychotherapy and speech therapy produces better effects as compared to treatment with only one of these methods.

4. Conclusions

1. Because the mechanisms of monochromatic light of a specific wavelength and magnetostimulation are similar or complementary, a simultaneous application of magnetostimulation and ledotherapy results in combining the stimuli and, therefore, is by all means justified.
2. The synergic effect of ledotherapy and magnetostimulation is particularly beneficial in analgesic, vasodilatative and spasmolytic treatment. It stabilizes cellular membranes of neurons and enhances plasticity processes in the brain, which is particularly important in children with central and peripheral nervous systems lesions.
3. Biological hysteresis (sustained analgesic effect after the end of exposure) is the unique characteristic of magnetoledtherapy. It enhances treatment outcomes and makes them last longer.
4. In some diseases, magnetoledtherapy can be used as an alternative procedure to pharmacological treatment.
5. Neither magnetostimulation nor magnetoledtherapy produces adverse effects, which is another important benefit. Safety of magnetoledtherapy is particularly important in pediatric rehabilitation.
6. Magnetoledtherapy as part of comprehensive rehabilitation has a vast range of applications in the treatment of neurological, rheumatic, orthopedic and dermatological diseases. It is one of the basic physiotherapeutic methods in the treatment of children.

Conflict of interest

None declared.

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