High-induction electromagnetic field – biophysical basis and review of scientific reports

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Abstract

Background: In the 21st century, the first devices generating a high-induction electromagnetic field of up to 3T were used, which, in comparison to the previous century, meant a more than 70-fold increase in the device's power. The novelty of the therapeutic method discussed in the article means that more needs to be scientifically proven about the effectiveness of therapy.

Aims: This paper aims to present the principle of operation of the device and the possibility of its use in physiotherapy. The article considers the fundamentals of high-induction electromagnetic field applications, device construction, and its functions.

Summary: Attention is paid to contraindications and recommendations set by the manufacturer, and the issue of therapeutic effects determined by the creators of the device was raised. The authors also reviewed current scientific reports and research results on a high-induction electromagnetic field and its use in various disease entities, using available research reports of international and national scope for this purpose.

Key words

deep electromagnetic stimulation, high-induction electromagnetic field, physical therapy.

Introduction

In ancient times, attempts were made to use the properties of the magnet for medicinal purposes. With the advancement of years, and thus technology, the action and popularity of magnetic fields have increased. Their occurrence on the globe is natural, but they are not perceptible by the human senses. The unit of measurement of the strength of an electromagnetic field is the tesla (T), whose value in apparatuses used from the 19th century to the present day reached a maximum of 0.04 T. Great changes occurred in the 21st century when the first equipment generating high-induction electromagnetic fields (or deep electromagnetic field, DEMF) of up to 3 T came into use, which means more than 70 times the power of the device. The new devices are characterized by convenience of use thanks to the use of movable heads that can work more precisely at the site of the condition. They have built-in programs tailored to specific conditions and offer the possibility of completely new stimulation of human tissues: highly inductive, deep-penetrating, pulsed electromagnetic stimulators are increasingly used in physical therapy [1–5].

The effect of these devices can be observed in many of the conditions described later in this article. However, despite the passage of several years since the introduction of the device into widespread use, we do not find many reliable studies confirming the device's effect. The article presents the theoretical basis and practical applicability of the DEMF. Biological effects at the level of individual organs and systems of the human body are considered. The indications and health contraindications for the procedure are approximated, and the issue of methodology and practical recommendations for patients is addressed. The elementary differences between low and high-induction electromagnetic fields are listed. The authors also carefully reviewed the current scientific literature to indicate the latest research results using DEMF-generating apparatuses in relation to various disease entities.

Fundamentals of high-induction electromagnetic fields

The generation of a DEMF is made possible by using an electromagnet in the device, which generates a static magnetic field associated with the movement of electrons around the atomic nuclei of certain elements like iron. The static magnetic field does not affect the carriers of electricity, which are electrons and ions; as long as they are at rest, it causes them to be put on circular tracks, which is associated with the formation of local eddy currents in the medium.

The exact mechanism of action of DEMF on the body's tissues is not known, but we can look for several explanations in the scientific literature. The first focuses on the analgesic effect, which argues for the release of hyaluronic acid in the synovial fluid in the amorphous intercellular mass directly and indirectly through the activation of the sympathetic apparatus [2]. Another more complex treatment is the improvement of the function of a single cell. Each cell is surrounded by a cell membrane, which serves as its protection and, based on the principle of differential charge, transports oxygen and nutrients inside the cell and takes away unnecessary products. The membrane charge of healthy cells is higher than that of diseased, aged, bacterial, viral, or cancer cells. For example, the latter has a membrane charge of about 15 mV lower than healthy cells. When a cell's membrane charge is low, it has too little energy to perform its normal functions. Stimulation with electromagnetic fields is known to increase the energy of the cell and optimize its functions, and more broadly improve the function of the entire tissue. Electromagnetic fields can pass through cells, tissues, organs, and bones without any deformation or loss [1,2,6–8].

Construction and functions of the DEMF-generating device

An example of a device generating DEMF is the Salus Talent device (REMED, South Korea) or de-

vices operating on a similar principle from BTL (EMSULPT, EMSELLA). This article will discuss the operation of the Salus Talent device to give an idea of the possible beneficial effects of DEMF on tissues. This device produces an induction of up to 2.5 T at a frequency of up to 50 Hz, which allows tissue penetration to a depth of 10 cm. Such power causes subjective sensation of mechanical vibrations or oscillations and noticeable muscle contractions in patients. The procedure is carried out non-invasively and painlessly. The precision of the action is ensured by a movable circular head with a diameter of 16 cm.

The therapy uses built-in four automatic programs that are tailored to the conditions in question, according to the manufacturer:

- Mode A1 uses low-frequency stimulation, which it modulates at different lengths in the range from 3 to 15 Hz. It should be used for joint disorders (knee or hip osteoarthritis).
- Mode A2 also uses a low frequency but increases the action limits to 23 Hz. It is used in structural disorders with significant soft tissue response (excluding muscles) in the joint area.
- Mode A3 also modulates frequency and amplitude, and ranges from 3 to 30 Hz. Available for activities nearby as in A1, but also in physical space where a situation of increased physical activity may occur. This allows action in areas similar to A1, but also in the muscular area, where it can also serve in situations of increased muscle tension.
- Mode A4 has the highest frequency value of 40 Hz, and a device operating in this mode should target problems with increased muscle tension, reflex disorders, and fascial mobility disorders. The power of the device should be adjusted for the patient and set below the pain threshold of the person receiving the treatment.

Salus Talent device, by its size, exceeds typical physical therapy devices (dimensions 40 x 54 x 165 cm). The weight of the device is 50 kg. The device is operated using a panel with buttons and a 3.15" LCD display, which allows you to set device parameters and select previously described modes. In addition to 4 automatic modes, the manufacturers allow you to program four manual modes. A dial regulates the power of the device, and all other options are available via buttons. SALUS-TALENT has a large red safety button that the patient or therapist can press if necessary, and the device itself is turned on with a key to prevent third-party access to the device [1] (**Figs. 1-4**).

According to the manufacturer, the presented DEMF stimulation device has a primarily analgesic effect. The most common conditions are spinal disorders (acute/chronic sacro-lumbar pain, sciatica, spondylosis), nervous system disorders caused by peripheral nerve damage, as well as musculoskeletal disorders (arthritis, rheumatoid arthritis, cervical pain, or frozen shoulder pain), or genitourinary problems associated with prostate pain (prostatitis). The device is used in sports rehabilitation, as well as in the treatment of weakened muscles and atrophies. It is also possible to purchase this device together with a seat adapted for urogynecological patients, so it can also be used in the therapy of urinary incontinence, acute/chronic urogynecological pain, sexual dysfunctions, chronic prostatitis, and other urogynecological conditions, i.e., overactive bladder, chronic pelvic pain.

The manufacturer also notes other therapeutic effects of the device. Dispersive, anti-edema, as well as myorelaxant and tropotrophic effects, have been observed, and with 1-2 treatments per week, even improved range of motion in the affected joint [1]. However, there needs to be more reliable scientific reports confirming such effects.

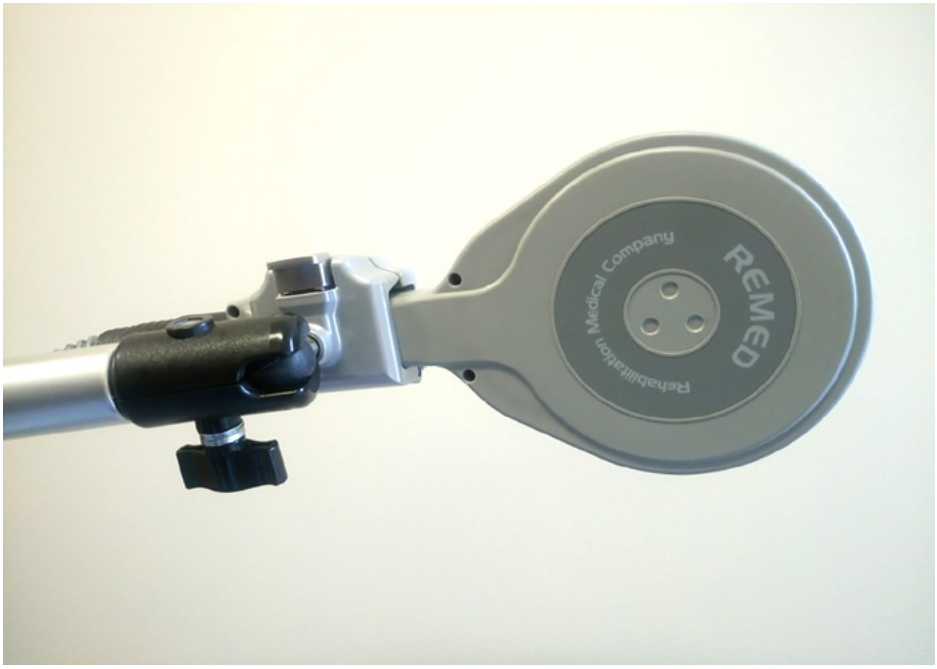

Figure 1. Application head of the Salus Talent device.

Figure 2. An example of the treatment position using the Salus Talent device.

Figure 3. The control panel of the Salus Talent device.

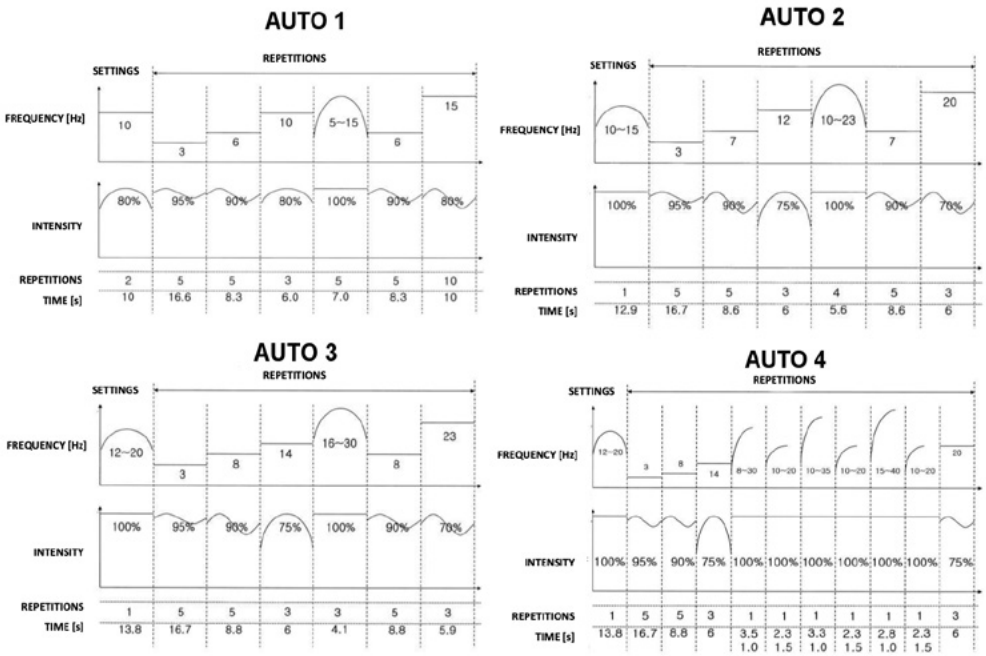

Figure 4. The course of treatment in automatic modes on Salus Talent – therapeutic effects of the treatment.

Contraindications and recommendations of the manufacturer

When using the Salus Talent device, the first thing to pay attention to is the contraindications.

The most important contraindications are:

- high fever
- pregnancy
- advanced age
- heart disease, especially an implanted pacemaker
- metal implants, especially endoprostheses
- spinal cord and bladder pacemakers
- epilepsy
- active cancer or tumors in the treatment area.

General recommendations for use include the following methodological conditions:

- placing the device at an appropriate distance from generators, devices using high-frequency waves, and loose wires
- a separate electrical circuit and a stable power source are recommended
- not to use the device at the same time with other medical equipment
- not to use near cell phones, radios, portable wireless receivers, and radio-controlled toys [3].

Literature review

The review of scientific reports was performed based on international medical database engines (PubMed, Scopus, MEDLINE, PEDro) using the following keywords: deep electromagnetic stimulation, Salus Talent, electromagnetic field, and high-induction electromagnetic stimulation. The search resulted in the selection of seven papers of a research nature, including five papers by Polish authors and two papers (sponsored by the manufacturer, which will not be discussed in the following review) by foreign authors. However, it should be noted that there are not many reliable articles confirming the effectiveness of the device. The following summary includes papers with a total of 234 patients with musculoskeletal diseases and five patients with hemophilic arthropathy.

A study conducted by Tomska et al. [9] in 2017 included patients with spinal pain who were diagnosed with degenerative lesions or discogenic changes in the cervical and lumbar regions of the spine. The study participants (73 people) were divided into two groups. The first group (37 people: 27 women and 10 men) were treated with DEMF stimulation, while the second group was treated with another therapeutic method. In the group subjected to DEMF stimulation, ten treatments were carried out, which were performed daily, with a 2-day break after the five treatments performed. The following device parameters were used: frequency: up to 50 Hz, magnetic induction: up to 2.5 T, treatment duration: 10 min. The results of the study were a significant decrease in pain (in subjective assessment) immediately after the series of treatments ($p<0.001$), two weeks ($p<0.001$), and one month after the series of treatments ($p<0.001$). The largest decrease was noted one month after treatment compared to the pre-treatment assessment, with a DEMS score of 4.14 on the Numeric Rating Scale (NRS) scale (pre-treatment: 6.00±1.94, one month after treatment: 1.86±1.70) [7].

Another two clinical studies conducted by Przedborska et al. [8, 10] in 2012 and 2015 included patients with low back pain syndromes in the lumbosacral region. Both of these studies included a total of 129 participants (90 women and 39 men), and the goal was to evaluate the effectiveness of treatment with DEMF stimulation (a series of 10 treatments performed daily) using the Visual Analogue Scale (VAS), the Laitinen scale and the pain impact scale on behavior.

The study used a Salus Talent device with an automatically programmed mode A3 (as recommended by the manufacturer). In both studies, there was a statistically significant reduction in the severity of pain as assessed by the VAS and Laitinen scales. In the study that used the Pain

Behaviour Scale (PaBS), there was a positive effect of the therapy on improving motor skills in activities of daily living. The study also assessed the subjective effectiveness of the therapy by patients (69.5% of respondents rated the effectiveness of the therapy as good and very good, while 4% considered the therapy ineffective) and examined the return of pain, where 84 patients (80%) had their pain return after 12 months, and the average time without pain in these patients was 5±3.5 months. DEMF therapy has been found to produce a much more durable analgesic effect in patients whose spinal pain syndromes resulted from overload (the probability of surviving up to 12 months without a return of pain is about 50%). Similarly, DEMF therapy produces the most sustained analgesic effect in patients whose pain syndromes last no longer than 1 year (the probability of surviving up to 12 months without a return of pain is about 32%) [8, 10].

Another study was also conducted by Przedborska et al. [11] and considered 32 patients (24 women and 8 men) with knee osteoarthritis. The patients were subjected to a series of 10 treatments performed daily (mode A3.) According to the manufacturer's recommendations), the study aimed to evaluate the effectiveness of treatment of pain syndromes caused by knee osteoarthritis using DEMF stimulation. The study assessed the range of motion in the knee joint, examined subjective pain sensation as measured by the VAS and Laitinen scales, and subjectively evaluated patient outcomes using the Tapper scale. The study showed that the average knee flexion of patients before therapy was 104.84° ± 20.81°, while after therapy, it was 109.53°± 17.48°, but half of the patients before and after the treatments had a flexion of no more than 110°. The subjective pain assessment showed a significant reduction in pain intensity, and a correlation was noted between age, body mass index (BMI), pain duration, and reduction in pain sensation as measured by the VAS and Laitinen scale. Subjective assessment by patients according to the Tapper scale showed 24 very good and good scores, indicating 75% patient satisfaction with therapy [10].

Zawilski et al. [12], in their 2017 study, studied five patients (three patients with severe hemophilia A, and two patients with severe hemophilia B). The following rehabilitation methods were then applied: training on an anti-gravity treadmill, therapy with the Salus Talent device, manual therapy, post-isometric muscle relaxation, balance, coordination, and proprioception exercises, and strengthening exercises. A significant reduction in joint swelling was observed (the average difference in the swelling test before and after was 48%). The authors conclude that therapy with the DEMF stimulation apparatus can be an effective adjunct in anti-edema management [12].

Summary

DEMF stimulation is becoming an increasingly used biophysical therapy modality. Researchers are constantly working to assess the increasing practical applicability of DEMF accurately. Its effectiveness and spectrum of applications is a particular subject in clinical research. In light of the presented review of the available literature and the confirmed therapeutic advantages of DEMF, it is advisable to keep a close eye on further progress in terms of scientific research on the theoretical and practical foundations.

References

1. REMED: Salus-Talent User Guide, REMED, 2017.
2. Jacob CI, Paskova K. Safety and efficacy of a novel high-intensity focused electromagnetic technology device for noninvasive abdominal body shaping. J Cosmet Dermatol. 2018;17 (5): 783–787.
3. Kinney BM, Lozanova P. High intensity focused electromagnetic therapy evaluated by magnetic resonance imaging: Safety and efficacy study of a dual tissue effect based non-invasive abdominal body shaping. Lasers Surg Med. 2019; 51 (1): 40–46.
4. Leonik S, Smoczok M, Sazanów-Lubelski J, Bergler-Czop B. High-intensity focused electromagnetic field – application in aesthetic medicine. Dermatol Rev. 2022; 109 (3): 229–235.
5. DiBernardo B, Chilukuri S, McCoy JD, Katz B, Goldberg DJ. High-Intensity Focused Electromagnetic Field With Synchronized Radiofrequency Achieves Superior Gluteal Muscle Contouring Than High-Intensity Focused Electromagnetic Field Procedure Alone. Aesthet Surg J Open Forum. 2023; 5: ojac087.
6. Fortina M, Vittoria A, Giannotti S, Biandolino P, Cevenini G, Carta S. Short time effects of a low-frequency, high intensity magnetic field in the treatment of chronic neck and low back pain. AIMS Public Health. 2022; 9 (2): 307–315.
7. Kranjc M, Dermol-Černe J, Potočnik T, Novickij V, Miklavčič D. High-Intensity Pulsed Electromagnetic Field-Mediated Gene Electrotransfection In Vitro. Int J Mol Sci. 2022; 23 (17): 9543.
8. Przedborska A, Misztal M, Raczkowski JW. Assessment of the Therapeutic Effectiveness of Deep Electromagnetic Stimulation in Patients with Chronic Low Back Pain. Ortop Traumatol Rehabil. 2015; 17 (5): 531–541.
9. Tomska N, Turoń-Skrzypińska A, Szylińska A, Rył A, Lubińska-Gruszka A, Mosiejczuk H, et al. Deep Electromagnetic Stimulation and Radial Shock Wave Therapy in Back Pain, Ortop Treumatol Rehabil. 2018; 20 (6): 189–195.
10. Przedborska A, Leszczyńska, M. Pruszczyńska, Misztal M, Raczkowski JW. Ocena skuteczności terapeutycznej głębokiej fali elektromagnetycznej u pacjentów z przewlekłymi bólami kręgosłupa lędźwiowo-krzyżowego – doniesienie wstępne [Evaluation of the therapeutic efficacy of deep electromagnetic wave in patients with chronic lumbosacral spine pain - preliminary report], Kwart Ortop. 2012; 4: 600.
11. Przedborska M, Misztal JW. Raczkowski: Ocena skuteczności terapeutycznej głębokiej stymulacji elektromagnetycznej u pacjentów z zespołami bólowymi dolnego odcinka kręgosłupa [Evaluation of the therapeutic effectiveness of deep electromagnetic stimulation in patients with lower back pain syndromes], Trends Pediatr. 2015; 17 (5): 531–541.
12. Zawilski J, Dudek M, Lisiński P. The effects of new methods of physiotherapy in patients with haemophilic arthropathy, Acta Haematol Pol. 2017; 48 (1): 28–34.