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The Influence of Low Frequency Pulsating Magnetic Fields of Different Parameters on the Secretion of FSH, LH, Prolactin, Testosterone and Estradiol in Men

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Abstract

The research into the effects of low frequency magnetic fields on living organisms has focused so far on the fields produced by power lines, industry and mobile telecommunication. Although they may influence procreation and teratogenesis, the pulsating magnetic fields that are used in physical therapy have not been sufficiently studied with regard to their impact on the endocrine system

Aim: The aim of the study was to test the influence of magnetic fields applied in long-term magnetotherapy and magnetostimulation (as in physiotherapy) on the secretion of pituitary (FSH, LH, prolactin) and sex (testosterone, estradiol) hormones in men.

Methods: In the research, the patients were divided into three groups: the magnetotherapy group of 16 men and the magnetostimulation group of 20 men (in two groups). Magnetotherapy in the form of magnetic field induction, 2.9 mT, 40 Hz frequency, a bipolar square wave generated by Magnetronic MF-10, was applied for 20 minutes to the lumbar area in patients suffering from chronic low back pain. Magnetostimulation (Viofor JPS system, M2P2 program with a mat as the applicator) was applied for 12 minutes a day in 10 patients treated for the same complaint. The third group of 10 patients was also treated with magnetostimulation (Viofor JPS system, M3P3 program with a mat as the applicator) for 12 minutes a day. All the groups went through 15 sessions that took place at about 10.00 am, one application a day with breaks for weekends. The chemiluminescence micromethod was used to estimate the concentration of hormones (FSH, LH, prolactin, testosterone in ng/dl and estradiol in pg/dl). The data were statistically analyzed with the use of the ANOVA method.

Results: Magnetotherapy did not affect hormone secretion in patients treated for low back pain. Magnetostimulation affects the concentrations of prolactin, estradiol and testosterone.

After the application of M2P2 program, a significant reduction in the concentration of prolactin, as compared to the basal values, was observed a month after the applications. A significant decrease in the concentration of estradiol was observed immediately after the end of the applications and a month later. Furthermore, the application of M3P3 program produced a significant increase in the concentration of estradiol after 15 sessions, and then a decrease in the concentration was noted a month after the applications. A drop in the concentration of testosterone was observed immediately after the end of the treatment and a month later.

Conclusions: The results indicate a possible effect of the magnetic fields used in magnetostimulation on the secretion of prolactin, estradiol and testosterone as they reduce the secretion of these hormones. Both the magnetostimulation programs have a similar effect on the concentration of estradiol. The influence of the magnetic fields used in physiotherapy on the secretion of these hormones requires further research on a larger number of participants, including women.

Keywords: Low frequency Magnetic fields; Magnetotherapy; Magnetostimulation; FSH; LH; Prolactin; Testosterone; Estradiol

Introduction

Gonadotropins, which are secreted by the anterior lobe of the pituitary gland, include the Luteinizing Hormone-LH and the Follicle Stimulating Hormone-FSH. In men, LH stimulates the Leydig cells which produce testosterone. FSH stimulates the growth of stem cells in spermatozoids and the Sertoli cells which are responsible for the production of ABP (Androgen Binding Protein). FSH directly stimulates ABP production. The protein induces high concentrations of testosterone within testes, thus playing an important role in spermatogenesis. FSH is responsible for the quantitative aspect of spermatogenesis. It also influences the synthesis of aromatase, which stimulates the production of estrogen [1-3]. Prolactin, which is a hormone secreted by the anterior lobe of the pituitary gland, has an impact on the growth and secretion of mammary glands and it intensifies the secretion of adrenal androgens. An excess of prolactin blocks ovulation in women and causes impotence and infertility in men [1,2].

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In adolescence, testosterone stimulates the growth of the epiphyseal cartilage. In adulthood, it shows androgenic action as it sustains the male sexual traits and libido. Testosterone has a metabolic effect by stimulating systems and organs (muscles and the immune system). It affects the qualitative component of spermatogenesis [1,2,4,5]. Estradiol, which is processed from testosterone by the Sertoli cells of seminiferous tubuli, affects the proliferation of spermatogonia in the neonatal period. In adult men, it inhibits the production of testosterone in the Leydig cells [2,4,5].

The potential mechanisms of the effects of magnetic fields on the secretion of hormones include their influence on the cell signal transmission, the structure of cell membranes, the ion transport process, the replication and transcription of nucleic acids and the synthesis of proteins (including enzymes) [6-8]. The low-frequency magnetic fields which are used in physical medicine have not been sufficiently studied with regard to their impact on the endocrine system. The potential influence of these fields on procreation and teratogenesis seems to be of particular importance [8]. Cyclotron resonance, for instance, may cause a higher activity of adenylate cyclase, which eventually may increase the effects of the hormones, such as FSH and LH, that bind with the membrane receptors.

The absence, or limited importance, of the side effects that are usually observed during or after exposure to magnetic fields [6-8] does not exclude the occurrence of prolonged, potentially serious, consequences. The endocrine system, which is responsible for sexual functions in humans, seems to be particularly susceptible to the effects produced by magnetic fields. There have been numerous reports suggesting harmful influence of the environmental magnetic fields on the human reproductive system. The long-term effects of low-frequency magnetic fields used in physical therapy on the secretion of sex hormones have never been properly studied. Thus, there is a need to exclude the possibility of such adverse effects, or to study the possible beneficial influence of these fields. The study involved men as the concentrations of their hormones do not reveal periodical fluctuations. The aim of the paper, therefore, is to analyze the effects of the magnetic fields that are used in long-term magnetotherapy and magnetostimulation (as in physiotherapy) on the secretion of FSH, LH, prolactin, testosterone and estradiol in men.

Materials and Methods

The study involved three groups of patients: the magnetotherapy group of 16 men and the magnetostimulation group of 20 men who were then subdivided into two groups. The patients were hospitalized at the Rehabilitation Ward of the Regional Hospital in Sieradz, Poland.

Magnetotherapy was applied for 20 minutes to the lumbar area in patients with chronic low back pain. The field parameters were as follows: 2.9 mT induction, 40 Hz frequency and a bipolar square wave. The average age of patients was 48 (28-58). Magnetronic MF-10, which was used in the study, generated unipolar and bipolar magnetic fields with a rectangular, sinusoidal or triangular shape of impulse in a continuous wave. The available frequencies ranged from 2 to 50 Hz. Various field inductions could be obtained depending on the applicator (550 mm, 315 mm and 200 mm coils) with the maximum of up to 20 mT (the 200 mm coil).

Magnetostimulation was provided with the use of the Viofor JPS device with a mat which generated a basic saw-shaped impulse (expotential). The P2 program, which used the mechanism of cyclotron resonance with the induction of 0-300 μT and which was set to the M2 mode of application with an increasing induction, was applied for 12 minutes in 10 patients who had been treated for the same complaint. The same device was used in the next group of 10 patients. It generated a basic saw-shaped impulse (expotential) in the P3 program which used the mechanism of cyclotron resonance with the induction of 0-300 μT. This time, the device was set to the M3 mode of application with an increasing-decreasing induction. The magnetostimulation session also lasted for 12 minutes. The average age of patients was 44 (34-52) in group 2 and 45 (33-54) in group 3. All the groups were treated with a course of 15 sessions (at about 10:00 a.m.) with breaks for weekends.

The signal structures of Viofor JPS Classic, Viofor JPS Clinic and Viofor JPS Delux are defined in three programs: P1, P2 and P3. The frequencies of basic impulses range between 180-195 Hz. The frequencies for packets of impulses range between 12.5-29 Hz, for groups between 2.8-7.6 Hz, and for series between 0.08-0.3 Hz. Individual impulses take a complex saw-like shape (expotential). In its rising section, there is a part of linearly increasing induction of variable tilt which is intersected by a constant induction (impulses types I and II). Large applicators (mats) of non-homogenous field induction were used in the study [9].

The patients did not suffer from any acute or chronic diseases or take any medicines, including pain relief drugs. All the groups, however, went through a course of kinesitherapy which involved the same set of exercises and the use of lumbar traction for all the patients. The concentrations of FSH, LH, prolactin, testosterone (ng/dl) and estradiol (pg/ml) in the serum were estimated with the use of the chemiluminescence micromethod before the treatment, a day after 15 sessions and a month after the end of the treatment. The ANOVA method was used to statistically analyze the data.

Results

FSH concentrations in ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of the treatment (Figure 1). LH concentrations in ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment (Figure 2). Prolactin concentrations in ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment (Figure 3). Testosterone concentrations in ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment (Figure 4). Comparison of testosterone concentrations

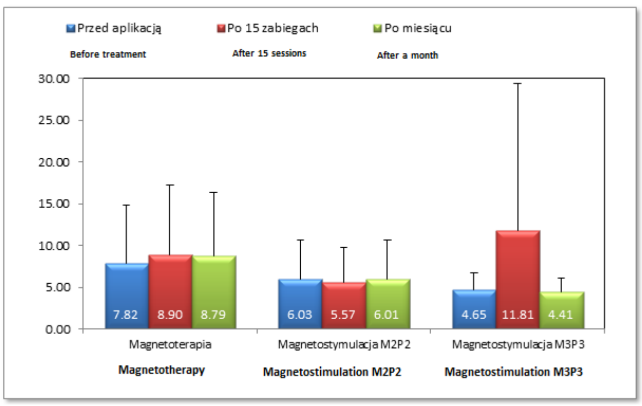

Figure 1: FSH concentrations in ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of the treatment.

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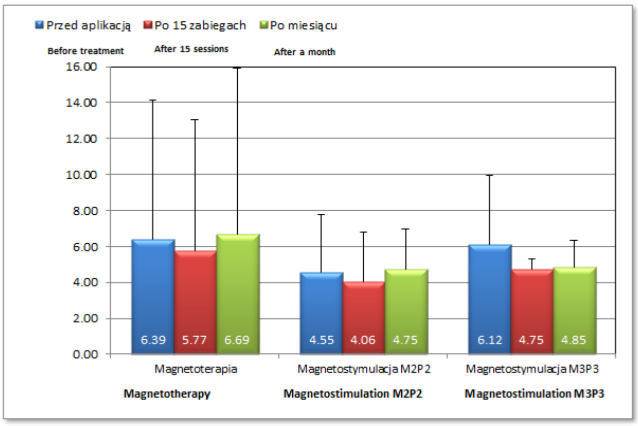

Figure 2: LH concentrations in ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment.

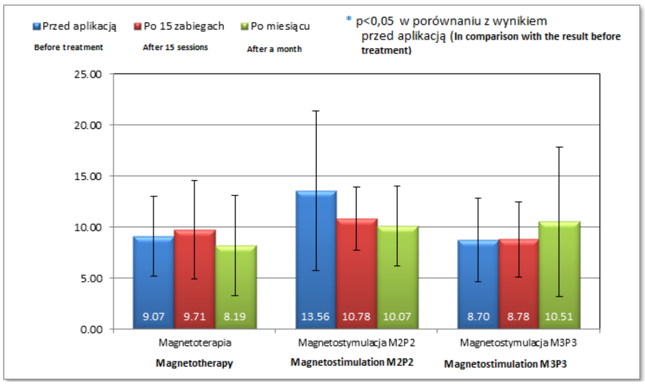

Figure 3: Prolactin concentrationsin ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment.

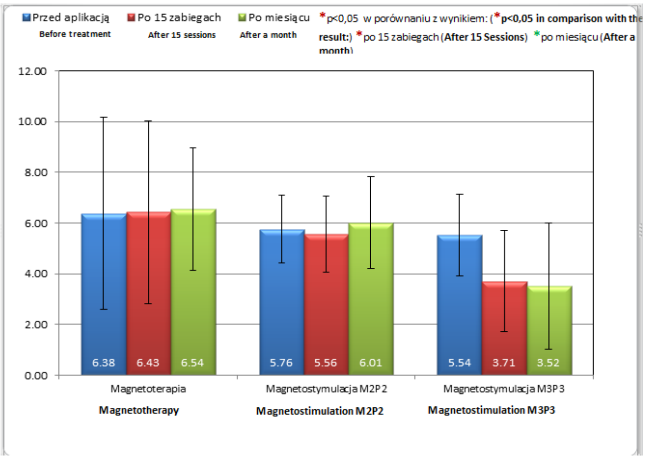

Figure 4: Testosterone concentrations in ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment.

in ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment (Figure 5). Estradiol concentrations in pg/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment (Figure 6). Comparison of estradiol concentrations in pg/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment (Figure 7).

Although no significant effects of magnetotherapy on the levels of the hormones were observed in the patients, magnetostimulation did affect the concentrations of prolactin, estradiol and testosterone. Thus, after the M2P2 program, a significant decrease in the concentration of prolactin, when compared to the initial values, was observed a month after the end of the treatment. A significant decrease in the concentration of estradiol was noted after the end of the sessions and a month after the end of the treatment. Furthermore, after the M3P3 program, there was a significant increase in the concentration of estradiol a day after the end of treatment followed by a decrease in the level of the hormone a month after the completion of physiotherapy. The decrease was accompanied by a significant drop in the concentration of testosterone.

Discussion

It is the effect of low-frequency magnetic fields on the secretion of melatonin [10-15] in humans and animals that has been described

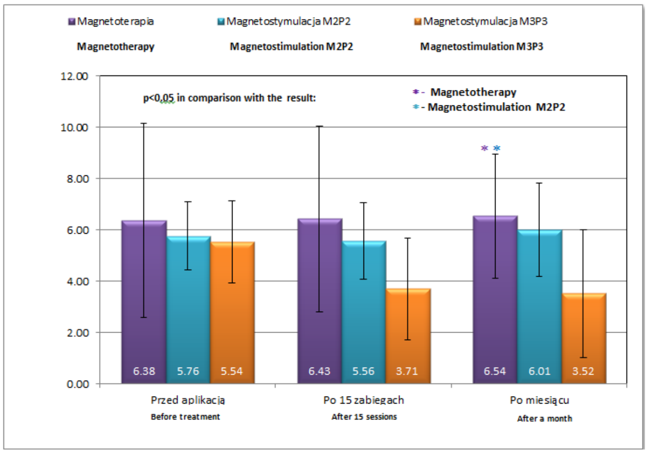

Figure 5: Comparison of testosterone concentrations in ng/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment.

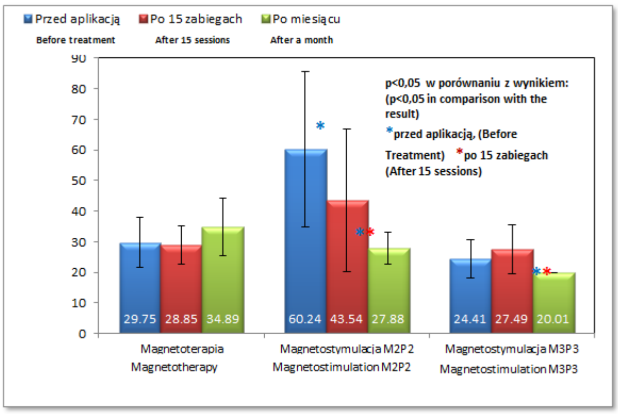

Figure 6: Estradiol concentrations in pg/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment.

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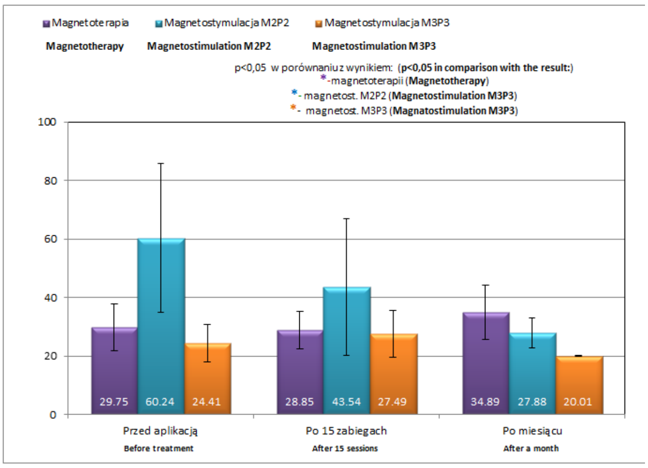

Figure 7: Comparison of estradiol concentrations in pg/dl as the mean value and standard deviation before the treatment, after 15 sessions and a month after the end of treatment.

most comprehensively in the literature. The hormone appears to play an important role in the secretion of the pituitary gland hormones, the growth hormone - GH and prolactin [16]. It can also affect, directly or indirectly (through the antigonadotropic effect), the production and secretion of the pituitary hormones, testosterone and estradiol [16,17]. Thus, one of the potential effects on the secretion of these hormones may involve a regulatory action through the fluctuations in the concentrations of melatonin in the serum and the organs. The expected antigonatropic effect of melatonin was not reflected in the results. Since it is possible that the concentration of melatonin decreased as a result of magnetotherapy [11,18], a rise of FSH and LH concentrations should have been observed as an effect of this treatment. In the study, no significant changes to the concentrations of LH and FSH were observed, which appeared to be debatable in the light of the available literature. What is worth noticing, however, is the upward trend in the concentration of FSH after the completion of the M3P3 magnetostimulation treatment.

In their experiments on rats, Al-Akhars et al. [19] observed a significant increase in the concentration of LH whereas the concentration of FSH remained unchanged. McGivern et al. [20] did not observe changes to the levels of LH and FSH in their research while Ozguner et al. [21] noted an insignificant fall in the concentrations of FSH and LH. On the other hand, studies by Mostafa [12] on rats revealed a significant rise in the concentration of FSH within a week of the experiment and a fall in LH after four weeks.

It is impossible, however, to directly transpose the relevance of the results of the studies on animals onto humans. As Transcranial Magnetic Stimulation (TMS) is more and more widely used in psychiatric treatment, studies into the effects of magnetic fields on humans become more frequent [22]. In a study by Evers et al. [23], TMS of healthy volunteers did not cause changes to the concentration of FSH. Neither were any changes to LH or FSH levels observed in young men after a one night exposure to magnetic fields in the study by Selmaoui et al. [24].

In their comprehensive studies on environmental magnetic fields in Seattle, Davis and Mirick [18] observed a rise in the concentration of LH and FSH metabolites in women, which may be linked to an increased incidence of breast cancer in urban populations. Magnetotherapy in men resulted in a significant rise in the concentration of LH a month after the treatment. The concentration of FSH did not change [25]. In contrast, the concentration of LH in men remained at the same level in a study by Mann et al. [26]. In the study, the parameters of the field were similar to the ones in magnetostimulation (900 MHz, pulsating field, 217 Hz frequency).

The results obtained in the experimental research on animals have not confirmed the uniform theory of the influence of magnetic fields on the secretion of prolactin. Some researchers did not observe changes to the concentration of prolactin, to wit Burchard et al. [27], Hedges-Hedges-Dawson et al. [28], Hedges et al. [29] and Kurokawa et al. [30]. Wilson et al. [15] however, noted a rise in the level of prolactin after exposure to 60 Hz magnetic field. On the other hand, Zyss et al. [31,32] did not observe any significant changes to the secretion of prolactin after TMS applied as a one-time stimulus. Similar results were obtained by Akerstedt et al. [33] and Evers et al. [23]. Hseih-Chiao et al. [34] confirmed a depressive effect of magnetotherapy on the concentration of prolactin in schizophrenic patients as an efficient means to counteracts post-drug hyperprolactinemia. In healthy persons, the concentration of prolactin after TMS did not change. Similar results were obtained in the studies by Yu et al. [22].

With some exceptions, the concentration of melatonin in animals [15,27,35-37] and humans [11,14,18,33,38] changes significantly under the influence of magnetic fields, which may be important for the interpretation of the results from the research into the levels of prolactin. Prolactin is secreted under the influence of melatonin in the circadian rhythm, and its profile is similar to melatonin [16,17]. Nevertheless, a fall in the concentration of prolactin as a result of M2P2 magnetostimulation one month after the end of treatment would not probably be possible under the same mechanism as in the case of melatonin because the concentration of melatonin does not change as a result of magnetostimulation in humans [11].

There have been several reports on the adverse effects of magnetic fields on the secretion of estrogens in mice (Cecconi et al.) [39], (Shi et al.) [40] and on the menstrual cycle in women (Smith et al.) [41], (Graham et al.) [42]. Therefore, magnetic fields may reduce the chances of procreation in the case of couples who want to have children (Hjollund et al.) [43]. In animals, mortality of chicken embryos which were exposed to the magnetic field of a computer screen during incubation increased significantly (68%) [37]. On the other hand, a long-term exposure of cows to environmental magnetic fields increased milk yield (higher quantity and higher fat content) [44]. Adverse effects on the weight and size of embryos were observed in pregnant mice after exposure to magnetic fields of parameters similar to those used in magnetostimulation [45].

A study by Stanosz et al. [46], where M3P3 magnetostimulation was used in the treatment of osteoporosis, described positive effects on estrogen secretion in women. Their bone markers improved as well. It is important to note that the concentrations of estradiol were marked only after the treatment. In the study, magnetotherapy did not affect the concentrations of testosterone or estradiol. Other authors [2,15,29,33,47] did not confirm changes to the concentration of testosterone after the treatment with magnetic fields either. It is important to stress that the characteristics of magnetic fields used in their studies were similar to the parameters of industrial magnetic fields, and that their studies were conducted on animals.

In this study, magnetostimulation had a negative impact on the concentration of testosterone in the patients who were treated with the M3P3 program and on the concentration of estradiol in the M2P2 and M3P3 programs in all the patients. Similar data were collected for estrogens in another study but the level of testosterone did not change after the M2P2 magnetostimulation [25]. The results may have been influenced by individual reactions of the patients to being exposed to magnetic fields [14], which could be explained by a non-linear action of these fields on various threshold values of energy or by individual susceptibility of the patients to different physical phenomena, such as solar radiation or galvanization. Furthermore, as was observed in this study, the effect of magnetic fields on the human endocrine system could continue for a month after the treatment (biological hysteresis). It would be advisable, therefore, to conduct a follow-up study which would take place much later than in the experiment, as described in the article by Woldańska-Okońska et al. [9].

Conclusions

1. The results indicate a possible influence of magnetic fields used in magnetostimulation on the secretion of prolactin, estradiol and testosterone as they reduce their secretion.
2. Both the M2P2 and M3P3 programs of magnetostimulation seem to have a similar impact on the secretion of estradiol.
3. The effect of magnetic fields on the human endocrine system can continue for a month after the treatment, which requires a follow-up study that would take place much later than in the experiment.

The influence of magnetic fields used in physiotherapy requires further research on a larger number of participants, including women.

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