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Original Research Article

Impact of magnetostimulation on nerve and muscle electrical excitability in patients with increased muscle tone

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ABSTRACT

Introduction: Increased muscle tension and the shortening of the trapezius muscle are the two most characteristic symptoms of the static–dynamic balance disorder in the muscular system. An abnormal muscle tone is a local reaction, which is located in the immediate vicinity of the disorder, or it may be a generalized reaction of the body associated with the additional psychic burden on the patient. Magnetostimulation, along with magnetotherapy, due to their physical and biophysical mechanisms of interaction are the basic kinds of weak magnetic fields used in the treatment of individuals with increased muscle tone – increased stabilization of the membrane polarization in nerve and muscle cells reduces increased muscle tension and pain.
Aim: The aim of this study was to assess the effect of magnetostimulation on changes in the excitability of nerves and muscles after a single and repeated exposure to a magnetic field.
Materials and methods: The study group comprised 34 patients divided into two subgroups: group I – 22 patients who were treated with magnetostimulation, and group II (control) – 12 subjects exposed to the so-called sham field. All patients underwent nerve and muscle excitability examinations (rheobase and chronaxie calculation), and the severity of spasticity was evaluated in each case according to the Ashworth scale.
Results and discussion: In patients with increased muscle tone with magnetostimulation treatment reduction of nerve–muscle excitability in the rheobase and chronaxie study has been shown. Changes in rheobase and chronaxie took on different values.
Conclusions: Magnetostimulation contributes significantly to reducing the excitability of nerves and muscles in patients with increased muscle tone. Magnetostimulation exhibits the greatest therapeutic efficacy after the first application of the magnetic field. A magnetic field providing magnetic stimulation can be used as an adjuvant therapy in patients with increased muscle tone.

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1. Introduction

Many diseases of the locomotor system and a large number of neurological disorders are associated with impaired muscle functions. Pathologically strained and contracted muscles are often located away from the actual location of the disease, and this in particular concerns those muscles whose tone is subject to stressful situations, causing an increased psychological burden (e.g., trapezius muscle).[16] Increased muscle tension and the shortening of the trapezius muscle are the two most characteristic symptoms of the static–dynamic balance disorder in the muscular system, the static-dynamic balance disorder is also often associated with cervical pain syndromes, causing shoulder elevation and approximating it towards the head. This type of load, i.e., prolonged work in static conditions, results again in increased muscle tension or contraction.[3,15] An abnormal muscle tone is, therefore, either a local reaction, which is located in the immediate vicinity of the disorder, or it may be a generalized reaction of the body associated with the additional psychic burden experienced by the patient.[8]

Magnetotherapy and magnetostimulation is a basic breakdown in the classification of weak magnetic fields and this division is used, i.a., because of the magnetic field strength. Although there is no strictly specified boundary between magnetotherapy and magnetostimulation, it is assumed that such a border point has a value of 100 μT. In magnetostimulation the field strength generally does not exceed the range from 30 μT to 70 μT. The signal of basic frequency used in magnetostimulation is up to 3000 Hz. Waveforms (of higher frequency) are modulated, and their envelopes have frequencies not exceeding a few Hz.[5,9,11,12,13,17]

The shape of the basic impulses resembles that of the saw tooth shape. Basic impulses are grouped in packages, groups of packages and series. There is a possibility to change the amplitude of the impulse – by increments ranging from 0.5 to 13.0 (the figures represent values of relative amplitudes).[5,6,10] Physical and biophysical mechanisms of magnetic fields' effect cause biological changes in the body as a result of:[5,14]

– electrodynamic interaction between the magnetic field and ionic currents in the body,
– magnetomechanic effect of the field on the particles with uncompensated magnetic spins,
– ionic cyclotron resonance of cations and anions in the electrolytic structures of the system.

2. Aim

The aim of this study is to assess the impact of magnetostimulation on changes in nerves and muscles excitability after a single and repeated exposure to a magnetic field.

3. Materials and methods

The study comprised 34 patients (21 females and 13 males), aged 35–76 years, with spastic muscle tone treated in the Department of Rehabilitation and Physical Medicine of the University Hospital WAM – Central Veterans Hospital of Łódź. The subjects were diagnosed with spastic paresis of various etiologies (e.g., stroke, multiple sclerosis). Patients who were recommended for magnetostimulation treatment conducted by a different applicator than a large applicator and those who took muscle relaxing medications during their therapy were not qualified for this study. The selection of patients participating in the research was conducted randomly (randomized selection).

All patients were divided into two groups: group I – 22 patients who underwent magnetostimulation treatment, group II (control) – 12 subjects who were exposed to a sham field. The parameters concerning magnetic stimulation treatment were as follows: application method – M1, the program – P2, intensity – 8, duration – 10 min, where: M1 – an application with a constant intensity (the selected field intensity is constant throughout the duration of application of the magnetic field), P2 – magnetostimulation using an ion cyclotron resonance.

The subjects underwent magnetostimulation sessions everyday (6 times a week). The sessions were performed by Viofor JPS System (Viofor Biomed, Poland) with a large applicator (mats). During the application of magnetic fields patients were lying on their backs in the position that ensured relaxation of the muscles of the limbs and trunk (Fig. 1). A large applicator (mat) was selected due to the proper exposure of the entire trapezius muscle to a magnetic field. During the application, a sound signal indicated that the magnetic field was being emitted; sessions were conducted in rooms with a constant (22–23°C) temperature. Control group patients were exposed to a sham field – the magnetic field emission was switched-off, and operating time was 12 min. Treatment employing the sham field was performed using a single-blind test. Patients from both tested groups, depending on individual indications and contraindications, additionally had kinesitherapy.

All patients underwent:

– examination of neuromuscular excitability (rheobase and chronaxie test),
– assessment of the severity of spasticity degree according to the Ashworth scale.

Fig. 1 – Patient during magnetostimulation.

Chronaximetry (i.e., a rheobase and chronaxie calculation) is a classical electrodiagnostic method that was used in this study to assess neuromuscular excitability. The examination was performed by a unipolar technique which was chosen because of the anatomical structure and the size of the evaluated muscles. The active electrode was placed at a direct motor point of the ascending part of the trapezius muscle, and the passive electrode was located at the descending part of this muscle. The nerve and muscle excitability test was performed before treatment and after 1, 10 and 15 sessions involving exposure to a magnetic or sham field. The muscle selected for this study was chosen because of its being superficial which helps in conducting electrodiagnostic studies and assures its proper exposure to a magnetic field.[4,6]

In addition to the nerve and muscle excitability test, the severity of spasticity was also rated according to the Ashworth scale.

Statistical and graphical analyses were performed by employing Statistica 5.1PL and MsOffice 2003 software. To examine the average difference between tested groups Student's *t*-test for independent samples was used, and to verify the difference between average consecutive measurements Student's *t*-test for dependent variables was used. Additionally, the correlation between the measured values was examined by calculating the Pearson correlation coefficients.

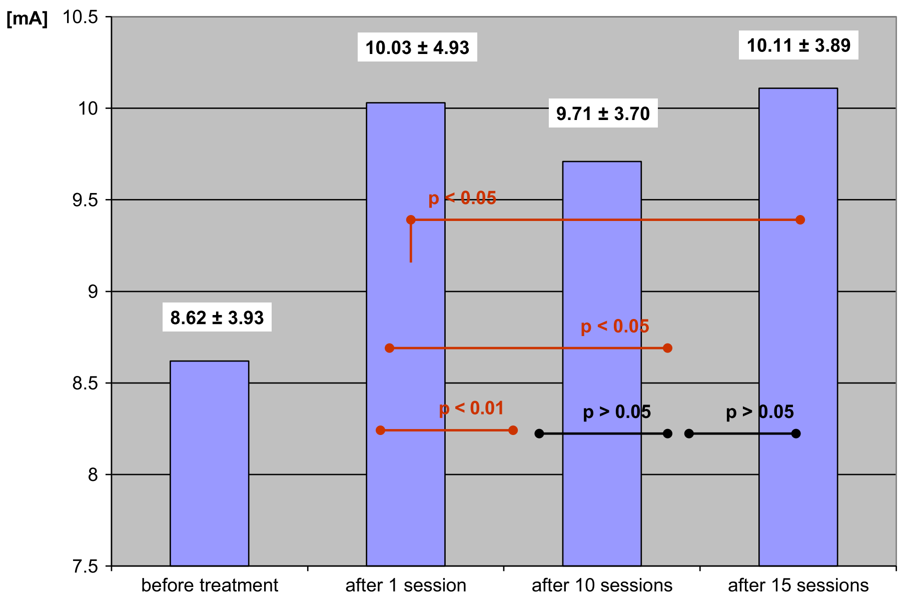

Fig. 2 – Mean values of rheobase in patients with increased muscle tone before and after magnetostimulation.

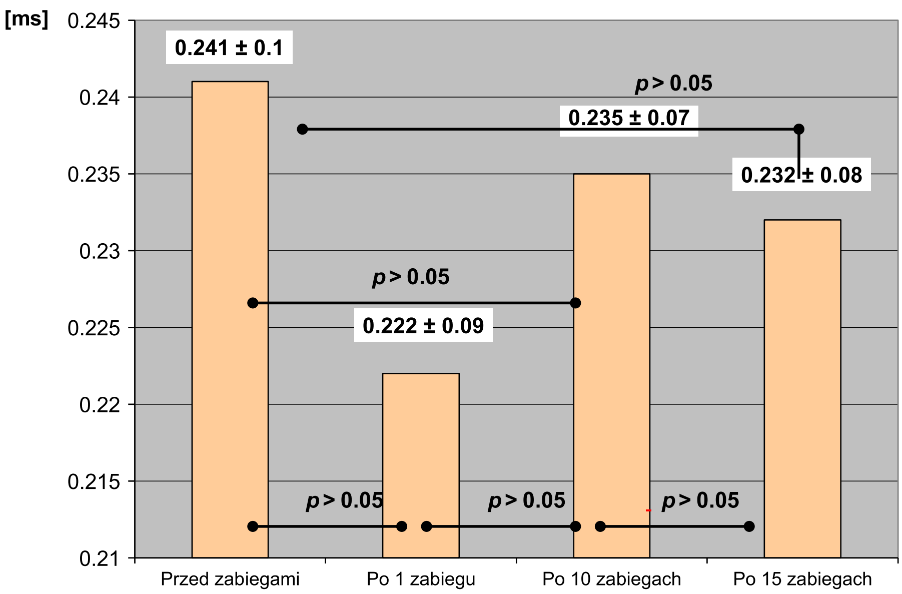

Fig. 3 – The average value of chronaxie in patients with increased muscle tone before and after magnetostimulation.

4. Results and discussion

In patients with increased muscle tone a reduction of nerve and muscle excitability in the rheobase and chronaxie study was shown as a result of magnetostimulation. Statistically significant variations of excitability in magnetostimulation treatment were observed only in the rheobase study (Fig. 2). As for chronaxie, changes in this parameter value were also found, but were not statistically significant (Fig. 3).

In the rheobase testing statistical significance in parameters differences (compared to the pre-study values) was observed after 1 session ($p<0.01$) as well as after 10 ($p<0.05$) and 15 ($p<0.01$) magnetic field applications. The analysis of correlation between rheobase and chronaxie indicated a statistically significant ($p<0.05$) negative correlation at each stage of electrodiagnostic testing, i.e., changes in rheobase and chronaxie took on different values (Table 1). A similar trend can be observed in a few reports, where after the rheobase calculation (which is a preliminary study) the values obtained in the chronaxie study either indicated negative correlation characteristics, or showed no statistically significant changes.[7]

Table 1 – The level of statistical significance (*p*) for coefficient correlation of differences in values of rheobase and chronaxie.

Correlation of rheobase and chronaxie between sessions	Way of treatment	
	Magnetostimulation	Sham field
Pre-study and 1st	**<0.05**	>0.05
1st and 10th	>0.05	>0.05
10th and 15th	**<0.05**	>0.05

Comments: negative correlation in bold.

The tendency for the different values in rheobase and chronaxie calculations can be explained by a two-stage specificity of the chronaximetry procedure. This procedure, like any other classical electrodiagnostic method, is designed first of all to assess the degree of degeneration of the peripheral nerves damages.[4] Rheobase examination is the first step of the study, when the nerve and/or muscle excitability is initially evaluated (as regards the direct motor point). Then, on the basis of this initial calculation, chronaxie is evaluated at the second stage of the examination. This two-step testing course elicits the dependence of chronaxie on rheobase. In the peripheral nerve degeneration examination dependence between rheobase and chronaxie does not affect the final evaluation, i.e., the chronaxie value. However, in patients without damage to the peripheral nerves, changes in the excitability of muscles were often evident at the rheobase calculation stage, which compensated for possible changes in the values of chronaxie and, consequently, the latter showed no change or showed a tendency to adopt inverted values. In magnetostimulation therapy that trend was marked more clearly because, on the one hand, there was a negative correlation between these two parameters, and on the other hand, changes in chronaxie were not statistically significant. A similar trend was observed also by other authors.[5] A decrease in neuromuscular excitability after the first session of magnetic stimulation ($p<0.01$) (with greatest changes in the values of rheobase and chronaxie) also draws attention. Similar values of these parameters were obtained only after the completion of therapy (15 sessions). Similar changes (significant changes in the parameters evaluated at the first phase of exposure to a magnetic field) were also observed by other authors. Their works, despite a different theme (the influence of magnetic field on changes in blood cholesterol), demonstrate similar responses of living organisms treated by weak magnetic fields.[1] This may indicate the specific effect of magnetic fields (depending on their physical characteristics)

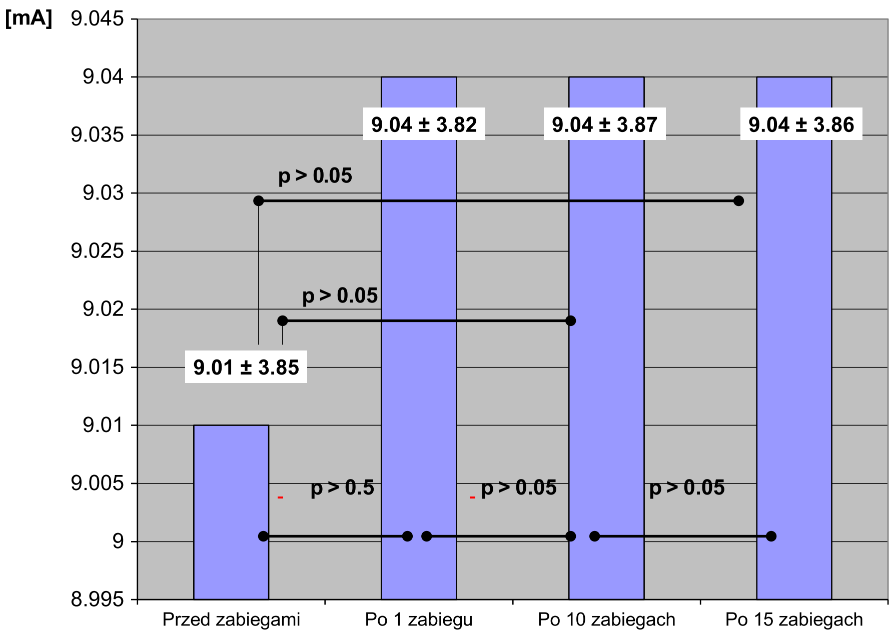

Fig. 4 – Mean values of rheobase in patients with increased muscle tone before and after sham field therapy.

on living organisms. As a result, two types of reaction have been differentiated.[13] The first type is characterized by an improvement in the first 2–3 days of exposure to the magnetic field, followed by a constant regression of symptoms during therapy. The second type of reaction involves improvement in the first days of exposure to the magnetic field, followed by a deterioration and, eventually, returning to the level at the beginning of therapy.[1,13] In patients with increased muscle tone who underwent magnetic stimulation the second type of reaction dominated.

It is worth noting that the variability of parameters after the first session of magnetic stimulation could also have been affected by the short time (about 15 min) between consecutive chronaximetric examinations. A double shock stimulation of the muscle within a small interval of time could have led to its fatigue and, consequently, a momentary decrease of excitability could appear. As another study demonstrates,[2] muscle fatigue can have a significant impact on changes in the values of rheobase and chronaxie.

Patients with increased muscle tone undergoing sham field therapy showed no statistically significant changes in neuromuscular excitability. However, minor changes in excitability (mainly rheobase) indicated a slight decrease in the excitability of the evaluated muscles, and the probable cause for the reduction of excitability after the first session could have been the already described muscle fatigue after a double shock stimulation during electrodiagnostic testing. A difference concerning values obtained before and after 1 exposure to a sham field was not statistically significant. This suggests that also in the case of the group undergoing magnetostimulation

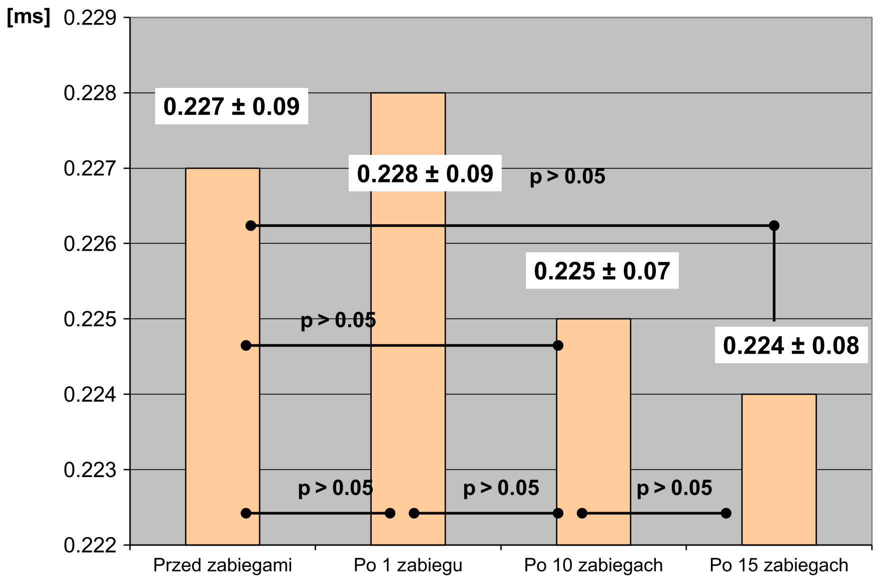

Fig. 5 – The average value of chronaxie in patients with increased muscle tone before and after sham field therapy.

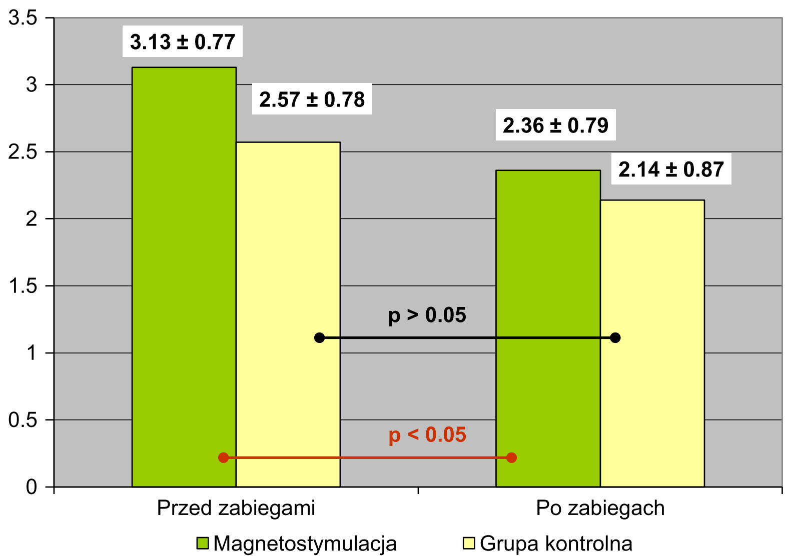

Fig. 6 – Comparison of mean values of spasticity according to the Ashworth scale in patients with increased muscle tone before and after magnetostimulation and sham field therapy.

therapy the effect of muscle fatigue after the first two studies affected the variability only in a limited way (Figs. 4 and 5).

The study of correlation between rheobase and chronaxie showed statistically significant ($p<0.05$) negative correlation in each stage of electrodiagnostic testing, which means that changes in rheobase and chronaxie took on different values (Fig. 6).

5. Conclusions

1. Magnetostimulation significantly affects the reduction of excitability of nerves and muscles in patients with increased muscle tone.
2. Magnetostimulation has the greatest therapeutic efficacy after the first application of magnetic fields.
3. A magnetic field providing magnetostimulation can be used as an adjuvant therapy in patients with increased muscle tone.

Conflict of interest

None declared.

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