# Analgesic effect of simultaneous exposure to infrared laser radiation and μT magnetic field in rats

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## ABSTRACT

The aim of the experiment was to estimate the effect of repeated simultaneous exposures to infrared laser radiation and μT variable magnetic field used in magnetostimulation on pain perception in rats, as well as the involvement of endogenous opioid system in the mechanism of this effect. In experimental group clean-shaven scull of male Wistar rats placed individually in a specially designed plastic chamber were simultaneously exposed to infrared laser radiation (wavelength – 855 nm, mean power – 4,1 mW, energy density – 30 J/cm$^2$) and variable magnetic field of saw-like shape of impulse, at a frequency of basic impulse 180-195 Hz and mean induction value of 120 μT generated by magneto-laser applicator of device for magnetostimulation Viofor JPS (Med & Life, Poland) 12 minutes daily for 2 periods of 5 consecutive days, with 2 days-lasting break between them, while control animals were sham-exposed. The pain perception was determined by means of "hot plate" test on the basis of calculated analgesic index. As a result of repeated exposures a significant increase in analgesic index persisting also till 14$^{th}$ day after the end of a cycle of exposures was observed. This analgesic effect was inhibited by prior i.p. injection of opioid antagonist – Naloxone.

**Keywords:** infrared laser radiation, variable magnetic field, simultaneous exposure, analgesic effect, analgesic index, rats

## 1. INTRODUCTION

Many literature data confirm that various forms of electromagnetic fields, especially extremely-low-frequency (ELF) magnetic fields evoke a strong and long-lasting analgesic effect in experimental animals. Some results of experimental studies indicate that ELF-MF may influence the activity of endogenous opioid system of animals and their responses to exogenous opiates and this effect is related to a change of daily profile of endogenous opioid secretion and reduction of the effect of agonists of mu and kappa opiate receptors, as well as inhibition of delta receptor activity[1,2]. In our previous study[3] we found that an analgesic effect of ELF magnetic fields is related to central opioid system stimulation, as it was blocked by prior i.p. injection of Naloxone hydrochloride (an opioid receptor antagonist).

Also experimental studies performed on animal models indicate significant analgesic effect of low-level laser radiation[4,5,6]. It was proved that analgesic effect of laser radiation is dose-related[7] and that both endogenous opioid system and some other mediators not related to endogenous opioids are involved in the mechanism of this effect[8,9,10,11].

In recent years in some clinical trials an unique therapeutic efficacy of magnetostimulation – a new method of physiotherapy using weak variable magnetic fields of μT range generated basing on ion cyclotron resonance phenomenon in the treatment of pain syndromes of different origin was observed[12,13,14,15].

As the above mentioned reports confirmed that both various forms of variable magnetic field and light radiation evoke analgesic effect in experimental animals, the aim of the study was to estimate the influence of repeated, topical simultaneous exposure of animal's head to infrared laser radiation and μT variable magnetic field used in magnetostimulation on pain perception in rats, as well as the involvement of endogenous opioid system in the mechanism of this effect.

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## 2. METHODOLOGY

### 2.1. Experimental animals

Experimental material consisted of 32 male Wistar albino rats weighting 180-200 g, which were housed in the University's Animals Department (four animals per cage) at a temperature of 22 ± 1°C under a 12 h light-dark cycle (light on at 07:00 h) with free access to tap water and pellet food (Murigran, Motycz, Poland).

### 2.2. Variable magnetic field and laser radiation parameters

Infrared laser radiation (wavelength – 855 nm, mean power – 4,1 mW, energy density – 30 J/cm$^2$) and weak variable magnetic field of saw-like shape of impulse, at a frequency of basic impulse 180-195 Hz and mean induction value of 120 µT generated by magneto-laser applicator (a specially designed probe containing laser diode and a solenoid for topical application) of device for magnetostimulation Viofor JPS (Med & Life, Poland) were used.

### 2.3. Procedure of exposure to laser radiation and variable magnetic field

The parameters of the magnetic field and light radiation were monitored by a computer system. During exposure animals were placed individually in a specially designed plastic chamber enabling fixing of clean-shaven scull in a stable position directly below magneto-laser applicator (Fig. 1). An efficient ventilating system was used to maintain a stable temperature inside the chamber during exposure. No significant changes in animal's body temperature during exposure were observed.

All animals were randomly divided into 4 groups (8 animals each). In first group whole body simultaneous exposure to infrared laser radiation and weak variable magnetic field lasting 12 minutes daily for 2 periods of 5 consecutive days with 2 days-lasting break between them, was made. In second, control group sham-exposure without generating magnetic field and infrared radiation inside of applicator was made.

Fig. 1. Experimental system for simultaneous exposure of rat's head to and laser radiation and variable magnetic field generated by magneto-laser applicator of Viofor JPS device (Med & Life, Poland)

In order to estimate the involvement of endogenous opioid system in the mechanism of laser radiation and magnetic field-induced analgesic reaction, in next 2 groups after prior (30 minutes before exposure) i.p. injection of Naloxone hydrochloride (1mg/1kg of body mass) – antagonist of opioids - following 12 minutes lasting exposure to infrared laser radiation and variable magnetic field or sham-exposure respectively was made.

### 2.4. Estimation of pain perception and analgesic effect

The pain perception was determined by latency of foot-licking or jumping from the surface of hot plate (temperature of 56°C). On the basic of measured values of pain reaction latency time the analgesic index expressing the percentage of maximal analgesic effect was calculated according to the equation (1):

$$T_{\%} = (T_x - T_o) : (15 - T_o) \text{ x}100 \qquad (1)$$

where: $T_{\%}$ - analgesic index, $T_0$ – initial latency time, $T_x$ – latency time in particular time interval

The measurements were made at 5$^{th}$, 15$^{th}$, 30$^{th}$, 60$^{th}$, 90$^{th}$ and 120$^{th}$ minute after the end of a single exposure. Next the estimation of pain reaction was made at 24 hours after a single exposure, at 5$^{th}$ and 12$^{th}$ day of exposure cycle and at 7$^{th}$ and 14$^{th}$ day after the end of a cycle of exposures.

### 2.5. Statistical analysis

The results from each group presented as mean value and standard deviation were statistically analyzed by means of STATISTICA 6.0 program using the Kruskal-Wallis rang ANOVA test and the post-hoc U Mann-Whitney's test.

## 3. RESULTS

As a result of a single simultaneous exposure to infrared laser radiation and weak variable magnetic field, a significant increase in analgesic index value persisting till 120 minute after the end of exposure as compared to sham-exposed group was observed (Fig. 2). This magnetic field–induced analgesic effect was not inhibited by prior i.p. injection of opioid antagonist – Naloxone hydrochloride (Fig. 2).

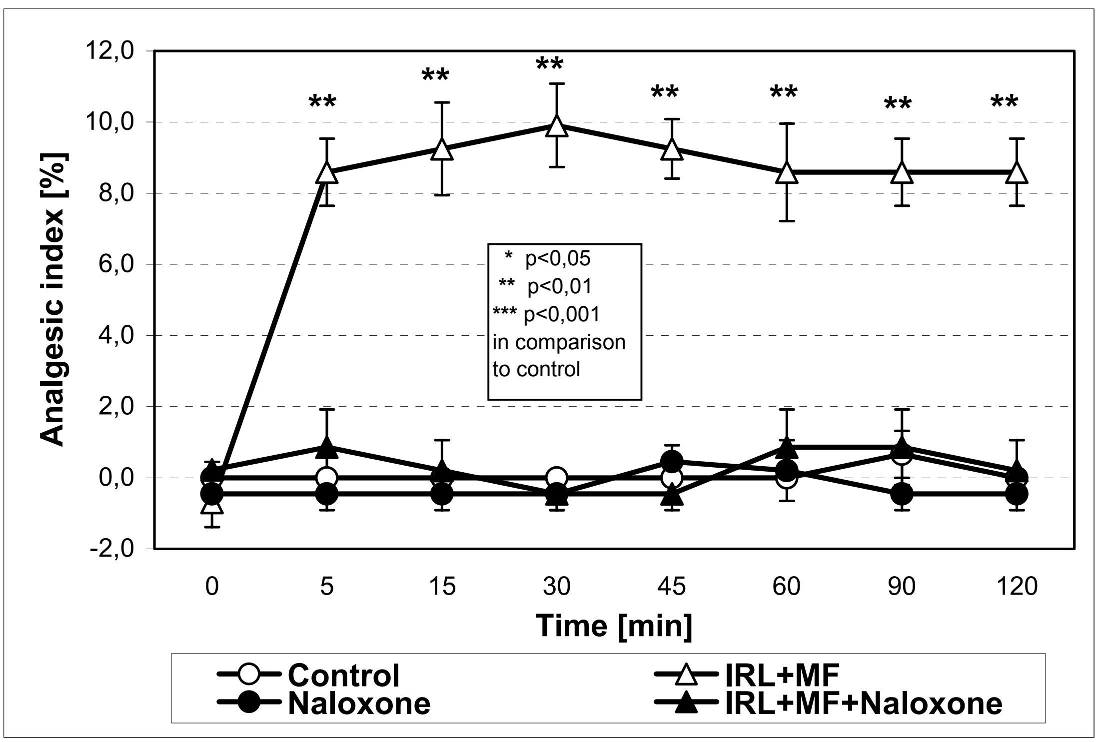


Fig. 2. Analgesic index (mean value ± SEM) in experimental group of rats exposed simultaneously both to infrared laser radiation and weak variable magnetic field (IRL+MF) and in control group of sham-exposed rats, respectively - in particular time intervals after the end of a single exposure (including groups with prior i.p. injection of Naloxone)

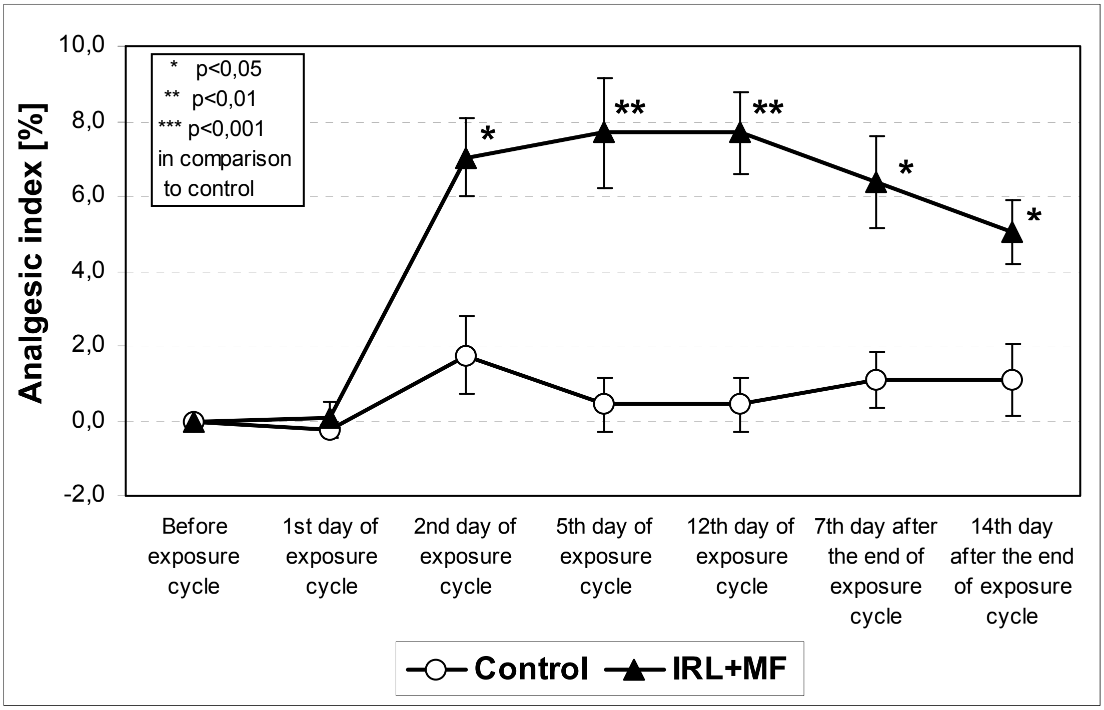


Fig. 3. Analgesic index (mean value ± SEM) in experimental group of rats exposed simultaneously both to infrared laser radiation and weak variable magnetic field (IRL+MF) and in control group of sham-exposed rats, respectively - in succeeding days of exposure cycle as well as after the end of this cycle.

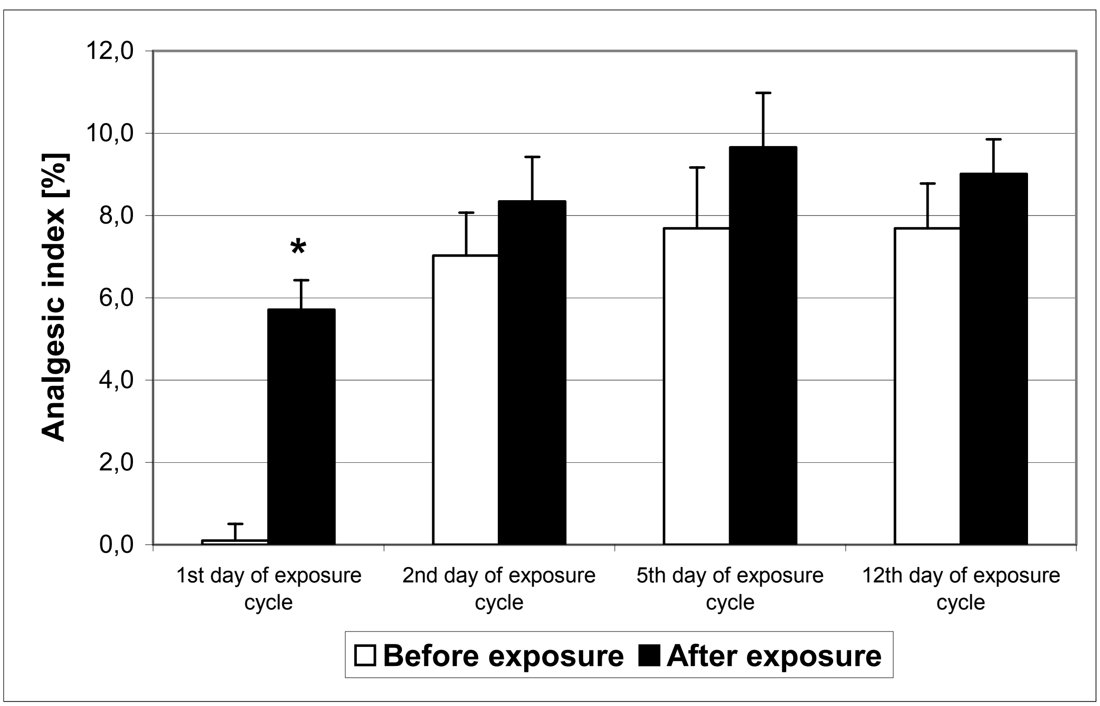


Fig. 4. Analgesic index (mean value ± SEM) in experimental group of rats exposed simultaneously both to infrared laser radiation and weak variable magnetic field immediately before and after the end of exposure in succeeding days of exposure cycle.

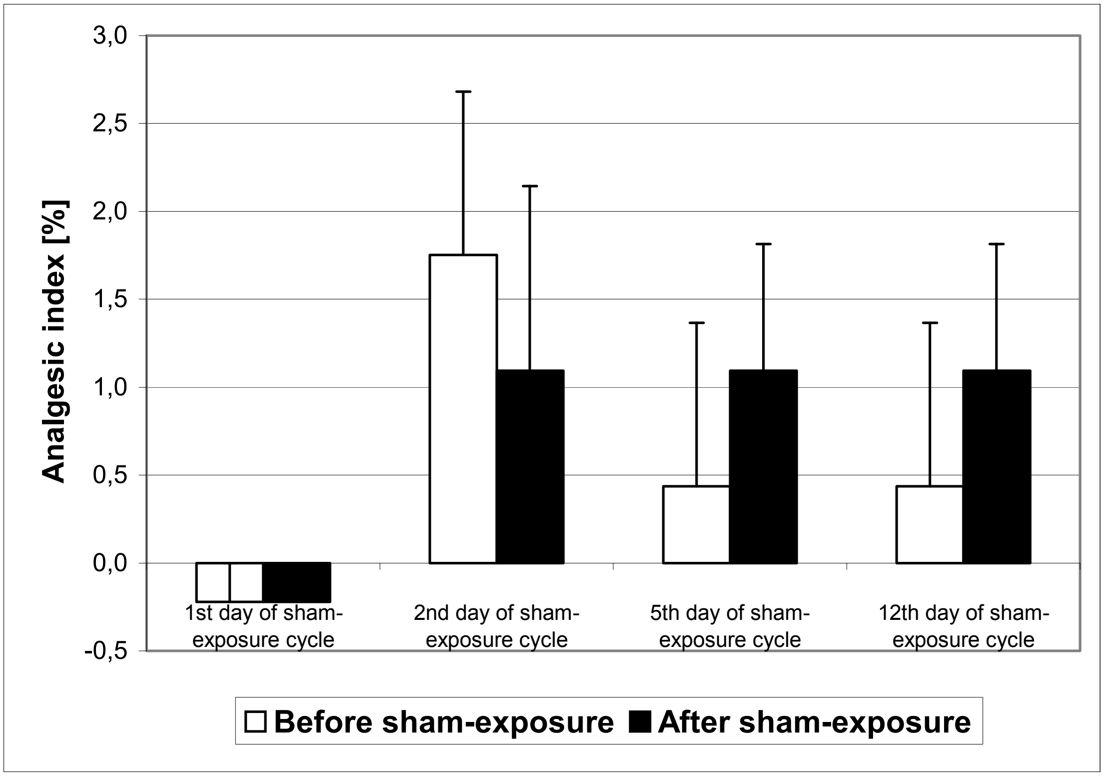


Fig. 5. Analgesic index (mean value ± SEM) in control group of sham-exposed rats immediately before and after the end of sham-exposure in succeeding days of sham-exposure cycle.

In succeeding days of exposure cycle, an increase in analgesic index value was observed in rats exposed simultaneously to infrared laser radiation and variable magnetic field, as compared to control rats, which was significant from $2^{nd}$ day of exposure cycle till $14^{th}$ day after the end of this cycle (Fig. 3).

In group of rats simultaneously exposed to infrared laser radiation and weak magnetic field in succeeding days of exposure cycle, after each exposure, a distinct increase in analgesic index value as compared to the values before particular exposure was noticed, which was significant only on $1^{st}$ day of exposure cycle (Fig. 4). In control group no distinct changes in analgesic index values before and after exposure in succeeding days of sham-exposure cycle was observed (Fig. 5).

## 4. DISCUSSION

The results of our previous experiments[16,17] confirmed that repeated exposure of rats to weak variable magnetic field with low values of induction of μT range used in magnetostimulation based on ion cyclotron resonance phenomenon exerts a strong, long-lasting analgesic effect similarly as in case of extremely low frequency (ELF-MF) magnetic field and low level laser radiation applied separately. Moreover the intensity of this analgesic effect was time-dependent and it was strictly related to duration of a single exposure.

But in opposite to ELF-MF the observed analgesic effect was not blocked by i.p. injection of Naloxone hydrochloride, which means that in case of magnetostimulation endogenous opioid system is not involved in the mechanism of magnetic field-induced analgesia.

As numerous experimental and clinical studies have shown, variable magnetic fields influence the structure and function of the central and peripheral nervous systems of experimental animals and humans. For example, the following biological processes in the nervous system have been reported to be affected by low frequency magnetic fields: increase of activity of neuron oscillators of hypothalamic and intracerebral nuclei, activation of neurotransmitter synthetizing enzymes in nerve ganglia and endings, changes of nerve impulse conduction in axons, changes of structure and transmission of synaptic endings, and changes of structure and activity of cellular receptors of the nervous system[18,19,20] .

In our other study[21] we found that ELF-MF magnetic field-induced analgesia was blocked by L-NAME (nitric oxide synthase inhibitor) and by methylene blue (soluble guanylate cyclase inhibitor) pre-treatment, which indicates the involvement of nitric oxide and other oxygen reactive species in the mechanism of neural transmission resulting in modification of pain perception. This observation confirmed in report[22] of other investigators suggest the possible role of this neurotransmitter also in the mechanism of analgesic effect of weak variable magnetic field as a component of simultaneous exposure found in present study.

As it was mentioned in the introduction experimental studies confirmed that one of mechanisms of laser radiation-induced analgesia is related to action of endogenous opioid system. Taking this into account it seems that in case of simultaneous exposure of animals both to weak variable magnetic field and laser radiation this last physical factor plays probably more important role.

In our previous experiment[23], in which we exposed whole body of rats simultaneously to weak variable magnetic field with higher values of induction and non-coherent infrared radiation with lower values of energy density (generated by LED diodes) in identical time intervals, we also confirmed comparable analgesic effect with the involvement of endogenous opioid system. It suggests that obtained analgesic effect in not univocally related to cohesion of light radiation and the values of physical parameters of both factors used.

Regarding these data it seems that final explanation of the mechanisms of effect of simultaneous exposure of experimental animals to infrared radiation and μT variable magnetic fields on pain perception needs still further research with use of another experimental models.

## 5. CONCLUSIONS

1. Repeated, simultaneous exposure of animals head to infrared laser radiation and weak variable magnetic field evokes strong, persistent analgesic effect in rats
2. In the mechanism of this laser radiation and magnetic field-induced analgesic effect endogenous opioid system is involved.


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