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Chronic exposure to 25–80-μT, 200-Hz magnetic field does not influence serum melatonin concentrations in patients with low back pain

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Abstract: There is substantial evidence that magnetic field (MF) exposure influences melatonin secretion in animals. However, data on its influence on human melatonin levels are scarce, and seemingly contradictory. Because of its many beneficial effects, very low-frequency MF exposure is used in physiotherapy of some neurological diseases and overloading syndromes of the locomotor system. In previous studies, we observed a decrease in human serum melatonin nocturnal concentrations after exposure to MF (2.9 mT, 40 Hz), and we suggested that differences among various studies may depend on different characteristics of the applied MF. Therefore, in the present study, we examined whether or not MF of different parameters exerts the same effect. The study was performed in seven men (mean age: 36.7 ± 3.8 years; range: 32–42) suffering from low back pain. Patients were exposed to a pulsating MF (induction: 25–80 μT; frequency: 200 Hz, modulated, automatically programmed; complex saw-like impulse shape; bipolar) generated by a Quatronic MRS 2000 apparatus ("magnetic bed") for 3 wk (5 days/wk, twice a day at 08:00 and 13:00 hr for 8 min each), applied to the whole body in patients laying in a horizontal position. The study was performed in spring. Diurnal serum melatonin profiles were estimated 1 day before exposure to MF (baseline), and 1 day and 1 month after the last exposure. No changes in melatonin concentrations were observed either after 1 day or after 1 month following the exposure in comparison to baseline.

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Introduction

There is widespread public concern that electromagnetic fields (EMF) might be hazardous, even linked to cancer [Kavet, 1996; Brainard et al., 1999]. Although there is still scientific controversy concerning this problem, there seems to be a growing consensus that the human health hazard associated with exposure to EMF is either very small or restricted to small subgroups. The subject has been recently intensively reviewed [Moulder, 1998; Portier and Wolfe, 1998; Reiter, 1998; Repacholi, 1998].

It has been reported in many studies that exposure to EMF influences melatonin secretion in animals [see John et al., 1996]. However, data on its influence on human melatonin levels are rare, and seemingly contradictory [Wilson et al., 1990; Selmaoui et al., 1996; Graham et al., 1996, 1997; Burch et al., 1998; Karasek et al., 1998; Mann et al., 1998; Wood et al., 1998]. On the other hand, because of many beneficial effects of magnetic field (MF) exposure, such as anti-inflammatory and analgesic actions, improvement of soft tissue regeneration processes, vasodilatory action or oxygen utilization, and tissue respiration, very low-frequency MF are used in physiotherapy of some neurological diseases and overloading syndromes of the locomotor system [Basset, 1993; Fisher, 1996].

In a previous report [Karasek et al., 1998], we demonstrated that chronic exposure to MF (2.9 mT, 40 Hz, square wave, bipolar; generated by a Magnetronic MF 10 apparatus; Electromedical

Plant, Otwock, Poland) used in physiotherapy significantly lowered serum melatonin concentrations, and we suggested that differences among various studies may depend on different characteristics of applied MF. Therefore, in the present study, we examined whether or not MF of different parameters (25–80 μT, 200 Hz, modulated, automatically programmed, complex saw-like impulse shape, bipolar; generated by Quatronic MRS 2000 apparatus; Vitalife, Komorow, Poland), also used in physiotherapy, exerts similar effects.

The rationale for exposure to MF generated by Quatronic MRS 2000 apparatus instead of MF generated by Magnetronic MF 10 apparatus used in the previous study [Karasek et al., 1998] came from results obtained by our group [Woldanska-Okonska et al., 1999]. In the latter study, we have shown, using the Husskisson visual analogue scale and the modified Laitinen scale to assess pain intensity, that analgesic effect was much stronger after exposure to MF generated by a Quatronic MRS 2000 apparatus in comparison with the effect of MF generated by a Magnetronic MF 10 apparatus.

Material and methods

The study was performed in seven men (mean age: 36.7 ± 3.8 years; range: 32–42) suffering from low back pain, who were admitted to the Division of Medical Rehabilitation of the Regional Hospital in Sieradz, Poland. The patients did not suffer from other chronic diseases or recent serious acute illness, they were not shift workers, and they had regular sleep habits. No medications were taken at least 1 month prior to the study. Patients were exposed to a pulsating MF (induction: 25–80 μT; frequency: 200 Hz, modulated, automatically programmed; complex saw-like impulse shape; bipolar; details given in Fig. 1) generated by Quatronic MRS 2000 apparatus ("magnetic bed") for 3 wk (5 days/wk, twice a day at 08:00 and 13:00 hr for 8 min each), applied for the whole body in patients laying in horizontal position. The study was performed in spring.

Diurnal serum melatonin profiles were estimated 1 day before exposure to MF (baseline), and 1 day and 1 month after the last exposure. Each subject served as his own control. On the day before and during blood sampling, the period of darkness in the patients' room lasted from 22:00 to 06:00 hr. Blood samples were collected at 08:00, 12:00, 16:00, 20:00, 24:00, 02:00, 04:00, and 08:00 hr; the night-time samples were taken under dim red light. All blood samples were allowed to clot for 45 min. Serum was removed by centrifugation and stored at −20°C until assayed. Melatonin concentration was measured using an RIA kit (DGR Instr. GmbH, Marburg, Germany; cat. no. IH RH 29301): intra-assay CV: 8%; inter-assay CV: 14.8%. The data were statistically analyzed using ANOVA and paired Student's t-test.

The study was approved by the Regional Committee for Studies with Human subjects. The experimental protocol was explained to each patient and informed consent was obtained.

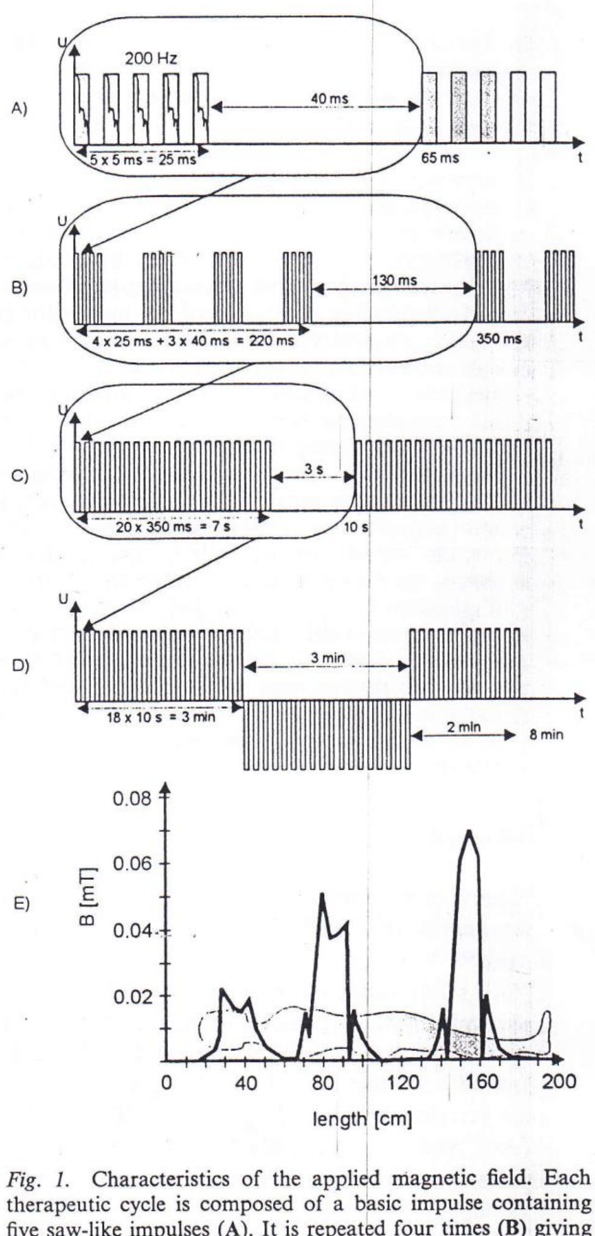

Fig. 1. Characteristics of the applied magnetic field. Each therapeutic cycle is composed of a basic impulse containing five saw-like impulses (**A**). It is repeated four times (**B**) giving sets consisting of 20 elements (**C**) that is repeated 18 times during 3 min. Then, the polarization is changed for another 3 min and changed again for 2 min (**D**). Induction at the certain areas of Quatronic MRS 200 apparatus (**E**) [according to Drzazga et al. 1997, modified].

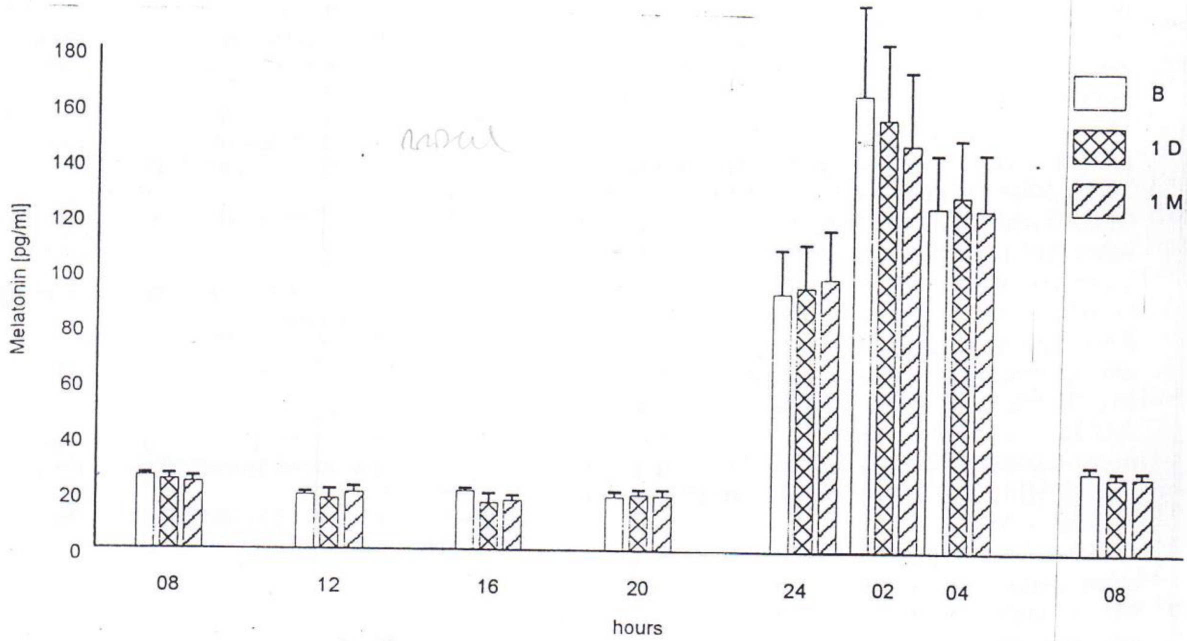

Fig. 2. Melatonin concentrations at baseline (B), 1 day after exposure (1D), and 1 month after exposure (1M). Data are expressed as mean ± S.E.M.

Results

No differences were observed in the mean melatonin serum concentrations at any time point examined (Fig. 2) or in the area under curve (Fig. 3), either at 1 day or 1 month after chronic exposure of patients suffering from low back pain to 25–80-μT, 200-Hz MF.

Discussion

Although large interpersonal variations in melatonin diurnal and nocturnal levels have been observed in the examined patients, the values in the same patients were very similar in the same time points in all three studied time intervals (before exposure, 1 day and 1 month after exposure). This observation is in agreement with the reproducibility of human melatonin rhythm from day to day and from week to week in the same subject when this individual's behavior and environment remain relatively constant [Arendt, 1995].

Studies on the influence of MF on melatonin secretion report inconsistent results, both in animals and humans. Although in many reports, a decrease in pineal or serum melatonin levels has been demonstrated after exposure of animals to MF of different parameters (0.02–100 μT, 50–60 Hz, circular or linear, short-term or long-term exposure) [Welker et al., 1983; Kato et al., 1993, 1994a,b; Löscher et al., 1994; Rogers et al., 1995b; Selmaoui and Touitou, 1995], in other studies no effect of MF of similar parameters has been observed [Lee et al., 1993, 1995; Kato et al., 1994c; Rogers et al., 1995a; Mevissen et al., 1996; Truong and Yellon, 1997; Yellon and Truong, 1998]. Moreover, in some experiments in which a nearly identical paradigm was applied, on some occasions a reduction in melatonin levels was observed, whereas in other there was no effect of the exposure to MF [Yellon, 1994; Rogers et al., 1995a,b; Löscher et al., 1998; Reiter et al., 1998].

Evidence on the effects of MF on melatonin levels in humans is even weaker than that in animals. Graham et al. [1996, 1997] did not find any effect of exposure to 1- or 20-μT, 60-Hz MF on

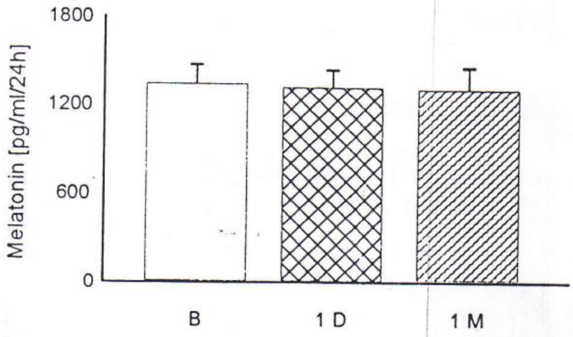

Fig. 3. Area under curve of melatonin concentrations at baseline (B), 1 day after exposure (1D), and 1 month after exposure (1M). Data are expressed as mean ± S.E.M.

nocturnal blood melatonin levels in human volunteers. No changes were found in either serum melatonin or in urine 6-hydroxymelatonin sulfate (6-OHMS) levels in men after acute exposure to 10-mT, 60-Hz MF [Selmaoui et al., 1996] or in plasma melatonin levels after exposure to 900 MHz, pulsed with 217 Hz, average power density 0.02mW/cm^2 EMF [Mann et al., 1998]. On the other hand, decreases in nocturnal serum melatonin concentrations were observed in men exposed to 2.9-mT, 40-Hz MF [Karasek et al., 1998]. Reduced nocturnal 6-OHMS excretion was found among electric utility workers exposed to 60-Hz MF [Burch et al. 1998]. Lowered day-time urinary 6-OHMS levels were found in Swiss railway engineers exposed to 20-mT, 16.7-Hz MF, but nocturnal 6-OHMS levels were not altered [Pfluger and Minder, 1996].

It has been suggested that considerable differences among various studies on the influence of MF on melatonin secretion may depend on different experimental paradigms, including certain characteristics of applied MF (e.g., field strength, frequency, duration, applied vector, etc.), acute or chronic exposure, differences in exposure time and duration, and factors that could interfere with the results of MF studies (e.g., vibration, noise, and synchronization or desynchronization with geomagnetic field) [John et al., 1996; Karasek et al., 1998].

The results of the present study seem to support the hypothesis that the pineal response to MF may depend on field strength, frequency, impulse shape, and application system. In the experimental conditions used in this study, there were differences only in the above mentioned parameters in comparison with an earlier study in which exposure to MF caused a decrease in nocturnal melatonin concentrations [Karasek et al., 1998]. Remaining parameters, such as time of the year, housing, photoperiod, and duration of the exposure, were similar in patients examined in both studies.

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