Human exposure to a 60 Hz, 50,000 µT magnetic field and biological indicators of stress

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Summary
Previous studies conducted on human volunteers investigating blood parameters with exposure to power-line frequency magnetic fields (MF) have not exceeded 1,000 µT. This experimental pilot work tested 5 volunteers sitting in a system exposing their entire head to a 60 Hz, 50,000 µT MF for 10 minutes. EEG activity was recorded and blood samples of cortisol and Thyroid Stimulating Hormone (TSH) were collected before, during and after the exposure. There were no noticeable differences in the blood parameters and EEG alpha activity due to MF exposure. There were no reported adverse effects from participating in the study. This work reports the highest power-frequency magnetic flux density applied to humans to study blood parameter changes.

Introduction
In a recent study, we have explored in a systematic manner the threshold for magnetophosphene perception at 50 and 60 Hz by performing magnetic field (MF) exposures rising from 5,000 to 50,000 µT in healthy volunteers. This threshold appears to be between 15,000 and 20,000 µT for a whole head exposure [1]. The final results of this study will be presented at BioEM 2016. It is important to underline that despite the particularly high MF flux densities used in this study, the volunteers did not report any other noticeable perception of feeling than magnetophosphenes. The intense exposure capabilities developed for this study provided an opportunity to complete biophysical and neurophysiological evaluation with biochemical assessment focusing on stress hormones.

Previous studies reported that acute and prolonged MF exposure up to 100 µT did not show significant variation of stress hormones compared to controls in animals and in humans [2-4].

The hormones affected, to various degrees, by a stressor are mainly cortisol, ACTH, catecholamines, and prolactin. Furthermore, they are secreted as a consequence of a stress with a kinetics response compatible with the 10-minute exposure capabilities developed and allowing for volunteers' exposure. No other study of this kind, allowing for such high exposure levels in the power-frequency range, has previously been conducted in humans.

The aim of this pilot study was to explore the feasibility of testing for blood parameter changes in humans exposed to 50,000 µT for 10 minutes using a minimally invasive blood sampling methods. The selected dry blood sampling method only allowed to access cortisol and TSH concentrations.

Methods

This feasibility study was carried on 5 healthy human adults (2 F, 3 M) in the context of a restricted ethical authorization. Exposure was delivered with the "Medical Grade" exposure system (certified by the "Canadian Standards Association") previously used for the study on magnetophosphene threshold perception [1] (Figure 1). Blood samples were taken from the volunteer's fingertip using a HemaSpot® blood collection device. Volunteers were recruited from laboratory personnel.

Participants completed two test sessions, a Sham and a Real exposure session. In the Sham session, there was no MF applied to the volunteer, while in the Real exposure session the MF was delivered. The 2 sessions were completed on different days, and were always starting at 8:30 am. During the Real exposure test session, the participant's entire head was exposed for 10 minutes to a 50,000 µT magnetic field at 60 Hz. Blood samples were taken with HemaSpot at 4 time points: 3 minutes before

the start of the exposure, then 2 and 7 minutes after the start of the exposure (i.e. during the exposure), and finally 7 minutes after the end of the exposure (Figure 1). In addition, the EEG activity was recorded at the same time point (during the minute preceding the blood collection), and alpha waves (8-12 Hz) from the occipital lobe were analyzed.

Results

Blood cortisol and TSH were measured in this feasibility study, and occipital alpha activity was analyzed. Due to the small sample size, no statistical comparisons were applied to the data, and descriptive statistics only are reported. The blood samples collected from each participant in the Real and Sham exposure condition do not show any difference outside the standard error of the mean for both cortisol (Figure 2) and TSH levels in each condition.

Normalized EEG power spectra were calculated for each condition in each participant. The alpha activity present tends to increase over time for both Real and Sham exposure. The normalized alpha power for O1(Figure 3), O2 and OZ shows similar pattern of increase over time. It is interesting to notice that the alpha power increase tends to stall in the last exposure condition (i.e. 7 minutes after the end of the exposure period) for the Real, while this trend towards an increased alpha power with time continues after the end of the exposure for the Sham condition.

Discussion/conclusion

This study confirms the feasibility of testing selected blood parameters in human using a minimally invasive technique, within a 50,000 µT exposure environment.

The reported standard morning values of cortisol levels in healthy adults are 5 – 23 µg/dL [5]. Participants were in this range as all samples acquired during the study were between 8 – 15 µg/dL. The reported standard values for TSH levels in health human adults is between 0.4 – 4.2 µU/mL [6]. All samples from participants in this study were in the range of 0.6 – 3.8 µU/mL. There is no noticeable effect of the 60 Hz, 50,000 µT MF exposure on the cortisol and TSH shown in this pilot work, however a larger sample-size study targeting a wider range of blood stress markers (now becoming available through HemaSpot) would need to be conducted to confirm these observations.

Although this protocol was not designed to study magnetophosphene perception, it should be mentioned that participants always reported magnetophosphenes for the first few minutes of MF exposure. An interesting observation is that over the 10-minute period of exposure, the reported magnetophosphene perception tends to gradually diminish until it became barely noticeable at the end of the 10 minutes. This may point towards a possible adaptation of the retinal photoreceptors to the stimulus that needs to be further investigated.

It is important to notice that there were no adverse effects reported by participants. This work presents the highest reported power-frequency magnetic flux density exposure continuously delivered to humans for 10 minutes with blood parameters analyses.

References

1. Legros A, Modolo J, Goulet D, Plante M, Souques M, Deschamps F, Ostiguy G, Lambrozo J, Thomas AW. Magnetophosphenes perception threshold and EEG response in humans exposed to 20, 50, 60 and 100 Hz MF up to 50,000 µT. Annual Joint Meeting of the Bioelectromagnetics Society and the European Bioelectromagnetics association - BioEM2015, Asilomar, US, June 14th - 19th 2015.

2. Kurokawa Y, Nitta H, Imai H, Kabuto M (2003) Acute exposure to 50 Hz magnetic fields with harmonics and transient components: lack of effects on nighttime hormonal secretion in men. Bioelectromagnetics 24 (1):12-20.

3. Lewczuk B, Redlarski G, Zak A, Ziółkowska N, Przybylska-Gornowicz B, Krawczuk M (2014) Influence of electric, magnetic, and electromagnetic fields on the circadian system: current stage of knowledge. Biomed Res Int. 2014:169459. doi: 10.1155/2014/169459.

4. Touitou Y, Selmaoui B (2012) The effects of extremely low-frequency magnetic fields on melatonin and cortisol, two marker rhythms of the circadian system. Dialogues Clin Neurosci. 14 (4):381-99.
5. Fischbach, F.T. and M.B. Dunning, *Manual of Laboratory and Diagnostic Tests*. Philadelphia: Lippincott Williams and Wilkins ed. 2009.
6. Fisch, B.J., *Fisch and Spehlmann's EEG Primer*. Third Revised and Enlarged ed. 1999, Amsterdam: Elsevier.

Keyword: magnetic field, extremely low frequency, acute exposure, cortisol, THS, EEG

Figure 1: The coil system is mounted on the motorized vertically adjustable lift platform. Experimenter takes blood sample from a participant's finger using HemaSpot SE

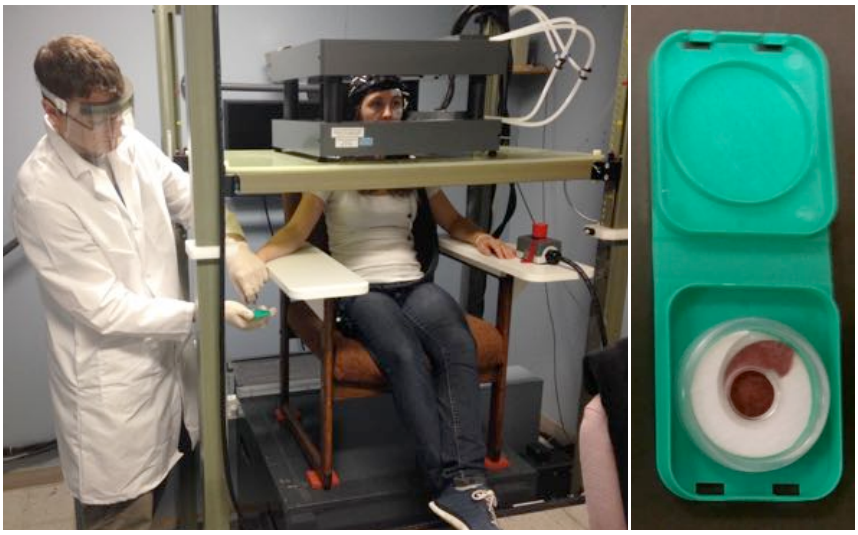

Figure 2: Mean cortisol levels of the 5 participants at 60 Hz, 50,000 μT in Real (red bars) and Sham (blue bars) exposure conditions. The error bars represent the standard error of the mean

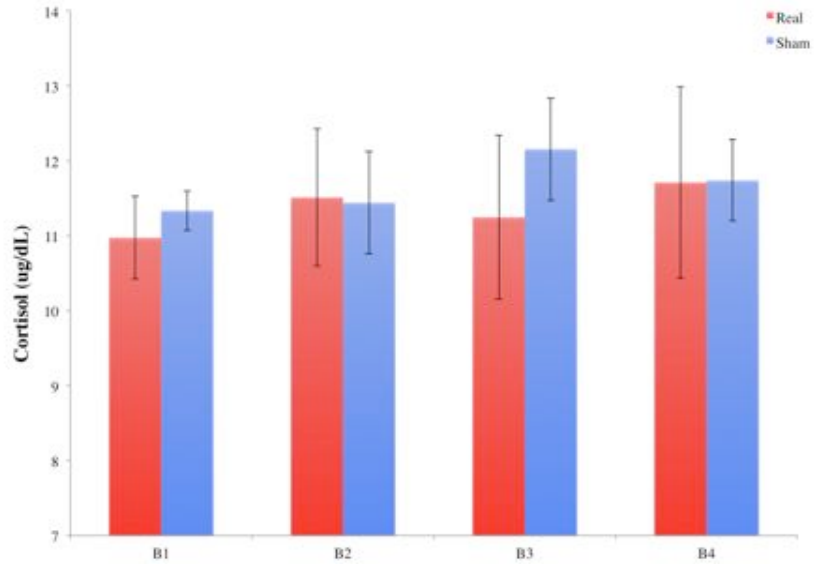

Figure 3: Normalized EEG alpha activity in O1 electrode averaged over the 5 participants at 60 Hz, 50,000 μT in Real (red bars) and Sham (blue bars) exposure conditions. Error bars represent the standard error of the mean