Effect of a low intensity static magnetic field on different biological parameters that characterize the cellular stress

Hakki Gurhan, Rodolfo Bruzón, Yanyu Xiong & Frank Barnes
Electrical, Computer and Energy Engineering
University of Colorado at Boulder
Boulder, Colorado, USA

***Abstract*—Low intensity static magnetic fields (SMF) modify different biological parameters that characterize the cell stress. We have initial measurements of oxidative stress (OS), mitochondrial superoxide, Ca^{2+} and cell and mitochondrial membrane potential. The observed variations in these parameters show decreases in cell growth, mitochondrial superoxide and OS that could explain the decrease of intracellular calcium. The decrease in intracellular calcium could explain the increase in cell membrane potential and the latter the increase in cell growth observed. We believe that modulation of these parameters using a magnetic field and the consequent modification of the rates of cell division could have important clinical implications. Additional results at larger SMF will be presented.**

I. INTRODUCTION

An increasing number of studies suggest that short and long-term exposure to magnetic fields (MF) modifies oxidative stress. The observed biological effects depend on the amplitude and duration of the MF exposure in relation to the status of oxidative stress and antioxidant defense in the organism. The redox reactions, with simple transfer of electrons affect almost all complex biological processes and have profound effects on cell growth, proliferation, survival and the propagation of various pathological processes [1]. The mitochondria play a fundamental role because are the major source of reactive oxygen species (ROS) and are involved in the regulation of cytosolic Ca^{2+} levels, intracellular pH and apoptosis.

II. MATERIAL AND METHODS

A. Static Magnetic Field Stimulation and Temperature Control

The experiments have been carried out in a Mu□metal shielded incubator containing Helmholtz coils so that we can control the static magnetic field and eliminate most of the external sources electromagnetic fields. In the first experiment to the treated group was applied a SMF of 46.4μT and to the control 0.72μT. In the second experiment to the treated group was applied 100μT and to the control 46.4μT. In both experiments the magnetic field was continuously applied for 4 days. The temperature was controlled during the experiments and our studies were carried out under conditions where variations in temperature were less than 0.3°C and independent experiments have shown that these temperature changes did not affect the results.

B. Cell Culture

We have used fibrosarcoma cells (HT1080□ATCC® CCL.121™). Cells have been maintained under controlled conditions of temperature (36.6°C), CO_2 concentration (5%) and relative humidity (90%).

C. Fluorescence and Cell Growth Studies

Fluorescence studies were performed using the Infinite® M200 PRO (Tecan Group LTD.) and the SpectraMax® M5 (Molecular Devices) Multi-Mode Microplate Readers. Cell growth studies were performed using the Countess™ II Automated Cell Counter (Thermo Fisher Scientific Inc.)

D. Statistical Analysis

Differences were considered statistically significant for $p < 0.001$. Statistical analysis for the fluorescence was performed using the Mann-Witney U test and for the cell growth was used the Student's t-test (Origin Pro 2017 Statistical Package, OriginLab Corporation).

III. RESULTS AND DISCUSSION

In Fig. 1 shows OS (A), cell membrane potential (B) and cell growth (C) for experiments 1 and in Fig. 2 shows OS (A), mitochondrial membrane potential (B) and cell growth (C) for experiments 2. For both experiments, the observed differences in the measured parameters were statistically significant ($p < 0.001$). In experiment 1, a decrease in OS and an increase in cell membrane potential and cell growth in the treated cells (46.4μT) with respect to control (0.72μT) are observed. In experiment 2, a decrease in OS and an increase in mitochondrial membrane potential (Ψ_m) and cell growth in the treated cells (100μT) with respect to control (46.4μT) are observed.

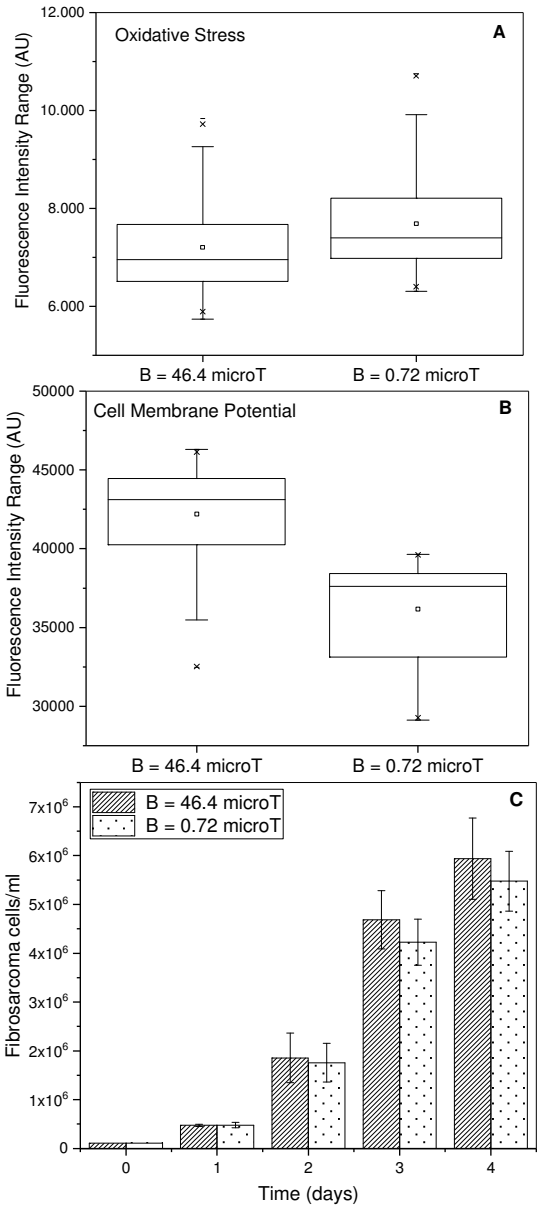

Fig. 1. Oxidative stress (A), cell membrane potential (B) and cell growth (C) for experiment 1.

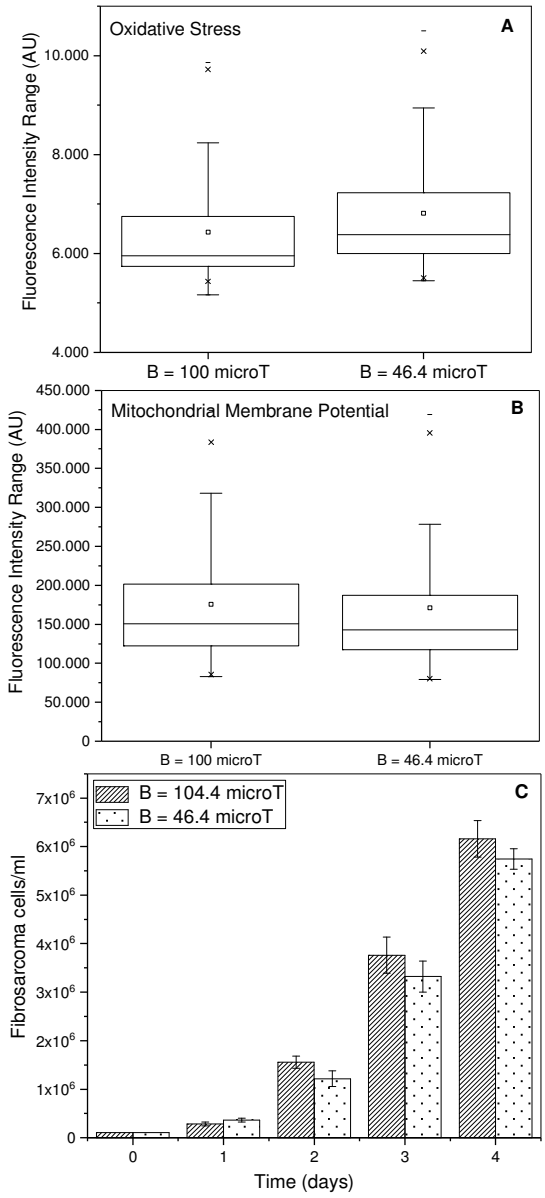

Fig. 2. Oxidative stress (A), mitochondrial membrane potential (B) and cell growth (C) for experiment 2.

In addition, superoxide mitochondrial and intracellular calcium concentration has decreased in the treated cells compared to their controls (results not shown).

Our results and those of other authors indicate that the magnetic field could modulate the production of ROS. Oxidants have been shown to stimulate Ca^{2+} signaling by increasing cytosolic Ca^{2+} concentration.

In our experiments we have observed a decrease in mitochondrial superoxide and OS that could explain the decrease $[Ca^{2+}]_i$. The decrease in $[Ca^{2+}]_i$ could explains the increase in membrane potential and the latter the increase in cell growth. Other authors have obtained similar results; Magnetic Fields suppressed the production of ROS, thus exerting a protective role in cardiomyocyte against hypoxia reoxygenation (H/R) injury [2].

Cancer cells have hyperpolarized mitochondria and their Ψ_m modifies their role in controlling cell division. In our experiments we observed an increase in the Ψ_m which is consistent with the increase in the cellular division, see Fig. 2.

ACKNOWLEDGEMENT

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IV. REFERENCES

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