ELSEVIER

Bioelectrochemistry and Bioenergetics 36 (1995) 9–13

BIOELECTROCHEMISTRY AND BIOENERGETICS

Evidence for genotoxic effects of resonant ELF magnetic fields

S. Tofani [a,*], A. Ferrara [b], L. Anglesio [a], G. Gilli [b]

[a] *Public Health Laboratory, Physics Dept., Ivrea, Italy*
[b] *Hygiene and Community Medicine Dept., University of Turin, Turin, Italy*

Received 10 November 1993; in revised form 22 April 1994

Abstract

The possibility that extremely low frequency (ELF) magnetic fields affect the genomic integrity of the cell is the objective of this study. Human peripheral lymphocytes (HPLs) were exposed to different exposure conditions combining ac and static magnetic fields. We used the micronuclei (MN) cytogenetic technique, because MN formation is considered as a marker of chromosomal damage produced by genotoxic agents.

The first set of experiments were performed at 50 Hz, 150 μT rms and 32 Hz, 75 μT and 150 μT rms magnetic fields with the static geomagnetic field components nulled. No effects were detected using the MN test on HPL as an indicator for cellular genomic damage when the static magnetic field was nulled. Moreover, such exposure to an ac magnetic field does not appear to interfere with the action of a powerful genotoxic agent mytomicin-C (MMC), i.e. there was no synergistic effect.

The second set of experiments were conducted exposing cells to 32 Hz, 150 μT and 75 μT rms, parallel to a 42 μT dc magnetic field. The 75 μT rms, 32 Hz exposure condition was chosen to maximize the resonance effect on Ca^{2+} according to parametric resonance theory. We found a statistically significant increase of MN for both exposure conditions. This experiment provides evidence for the genotoxic effects of resonant ELF magnetic fields in human lymphocytes.

Keywords: Human lymphocytes; Mytomycin-C; Micronuclei; Genotoxic effects; ELF; Magnetic fields

1. Introduction

A number of epidemiological studies suggest a rise in the incidence of some tumoral pathologies (leukemia and central nervous system neoplasm) in healthy subjects exposed to extremely low frequency (ELF) magnetic fields or living close to power lines [1,2]. Experimental studies performed under controlled ELF exposure conditions are needed to evaluate biological effects correlated with the mechanism of oncogenesis. Effects on the cellular function, the synthesis of melatonin and calcium efflux have been found [3]. However, available biological data on the oncogenic potential of ELF electromagnetic fields are unable to provide a cause–effect relationship between exposure conditions and induction of tumoral pathology. In this context, the question of possible genotoxic effects is particularly relevant.

We have used the micronuclei (MN) cytogenetic technique first proposed by Fenech and Morley [4]. This technique evaluates the frequency of occurrence of MN (small round bodies deriving from chromosome fragments or from whole chromosomes whose centromeres have lost their affinity for the mitotic spindle) in human peripheral lymphocyte (HPL) cells, where cytokinesis has previously been blocked by cytochalasin-B. The MN are in evidence as secondary nuclei in one of the cells generated from a progenitrix cell.

We choose this mutagenesis test not only for its sensitivity, but also because MN formation can be correlated with some effects induced by ELF fields. In particular, chromosomal breaks and changes in direction, formation and functionality of the mitotic spindle have been reported [5,6]. The above-mentioned changes may prevent correct chromosomal segregation [7,8]. A consequence of this last effect could be the production of aneuploid cells, an effect that seems correlated with genetic pathologies and unhealthy conditions like leukemia [9–11].

An important issue receiving attention concerns which exposure parameters may be crucial to the induction of biological effects [12]. We exposed HPL cells to 50 Hz and 32 Hz sinusoidal magnetic fields B_{ac}

* Corresponding author.

0302-4598/95/$09.50 © 1995 Elsevier Science S.A. All rights reserved
SSDI 0302-4598(94)01722-D