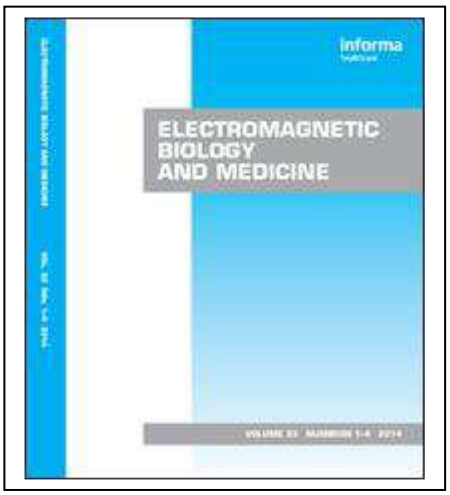

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Extra-low-frequency magnetic fields alter cancer cells through metabolic restriction

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Abstract

Background: Biological effects of extra-low-frequency (ELF) magnetic fields (MFs) have lacked a credible mechanism of interaction between MFs and living material. *Objectives*: To examine the effect of ELF-MFs on cancer cells. *Methods*: Five cancer cell lines were exposed to ELF-MFs within the range of 0.025–5 µT, and the cells were examined for karyotype changes after 6 d. *Results*: All cancer cells lines lost chromosomes from MF exposure, with a mostly flat dose-response. Constant MF exposures for three weeks allow a rising return to the baseline, unperturbed karyotypes. From this point, small MF increases or decreases are again capable of inducing karyotype contractions (KCs). Our data suggest that the KCs are caused by MF interference with mitochondria's adenosine triphosphate synthase (ATPS), compensated by the action of adenosine monophosphate-activated protein kinase (AMPK). The effects of MFs are similar to those of the ATPS inhibitor, oligomycin. They are amplified by metformin, an AMPK stimulator, and attenuated by resistin, an AMPK inhibitor. Over environmental MFs, KCs of various cancer cell lines show exceptionally wide and flat dose-responses, except for those of erythroleukemia cells, which display a progressive rise from 0.025 to 0.4 µT. *Conclusions*: The biological effects of MFs are connected to an alteration in the structure of water that impedes the flux of protons in ATPS channels. These results may be environmentally important, in view of the central roles played in human physiology by ATPS and AMPK, particularly in their links to diabetes, cancer and longevity.