BIOPHYSICAL MATHEMATICAL MODELS: A NEW WINDOW ON THE EFFECTS OF EXTREMELY LOW-FREQUENCY MAGNETIC FIELDS ON HUMAN BRAIN ACTIVITY

Understanding the biological mechanisms by which extremely low-frequency (ELFs, < 300 Hz) magnetic fields (MFs) interact with human brain activity is an active field of research. The implications are twofold: first, such knowledge is required by international agencies providing guidelines for general public and workers exposure to ELF MFs (such as ICNIRP, the International Commission on Non-Ionizing Radiation Protection). Second, such physiological mechanisms could be exploited to improve current transcranial magnetic stimulation (TMS) therapies being developed for a growing number of neurological disorders. Numerous challenges exist in identifying these interaction mechanisms such as the presence of artifacts induced by the MF exposure itself in monitored biological signals or the variety of spatial (from micrometers to centimeters) and temporal (from milliseconds to minutes) scales involved. In order to overcome these issues the use of biophysical models, based on systems of mathematical equations describing electric or metabolic activity of brain tissue, has become increasingly important. Indeed, these models make it possible to simulate how brain tissue interacts with ELF MFs. In this paper, we will present biophysical modeling results regarding the effects of power-line (60 Hz in North America) MFs on human brain activity. Based on reported effects of lasting ELF MF exposure on human neurophysiology we discuss a potential physiological mechanism responsible for these effects, namely modulation of synaptic plasticity. By reviewing biophysical models of synaptic plasticity we provide evidence that 60 Hz MF exposure could result in brain synaptic plasticity modulation with detectable behavioral outcomes. We discuss how these results could be transferred towards therapy, targeting neurological disorders characterized by abnormal changes in brain synaptic plasticity. The use of specific ELF MFs designed to induce predictable changes in synaptic plasticity (e.g., long-term potentiation/depression in targeted brain areas) constitutes a promising therapeutic avenue and biophysical modeling is an ideal guide toward this objective.