Do low frequency electromagnetic fields interfere with cellular physiology?

Electromagnetic radiation, fields, or waves have been around since the birth of the universe, with daylight as the most familiar one. We are continuously exposed to different EMFs, mostly without even noticing them. Depending on their frequency, they may be either ionising or non-ionising (Fig. 1). Low frequency electromagnetic fields (LF EMF) are non-ionising and are generally considered harmless as they are considered to pass through our body without interference with the cellular tissue.

Recent decades have seen a huge increase in the use of electronic devices that nowadays enable us to communicate with distant family, enjoy music everywhere or order food without leaving the house. However besides the benefits, this evolution has also resulted in increased public concern about potential adverse health effects of non-ionizing radiation that these devices emit. The symptoms attributed to continuous LF EMF exposure range from non-specific physical symptoms, such as fatigue, headaches, and redness of the skin to increased prevalence of childhood leukaemia. Although many theories regarding a potential mechanism of induction are put forward, to date no clear mechanism of action has been elucidated. Experimental evidence that could support an association between exposure and health status appears to be insufficient and inconsistent. Theoretical approaches and experimental studies indicate that it is highly unlikely that LF EMFs directly induce DNA damage and subsequent carcinogenetic effects, like ionising radiation is capable of. For this reason, many studies focus on other decisive fundamental biological processes and signal transduction pathways in the cell. One common pathway prevails: the mobilization of calcium within the cell, immediately after a stimulatory signal is perceived. In normal conditions this calcium mobilization is short-lived and is needed to induce several cellular cascades that promote cell activity upon physiological stimulation. Also for this parameter, the studies on potential effects of LF EMF are conflicting.

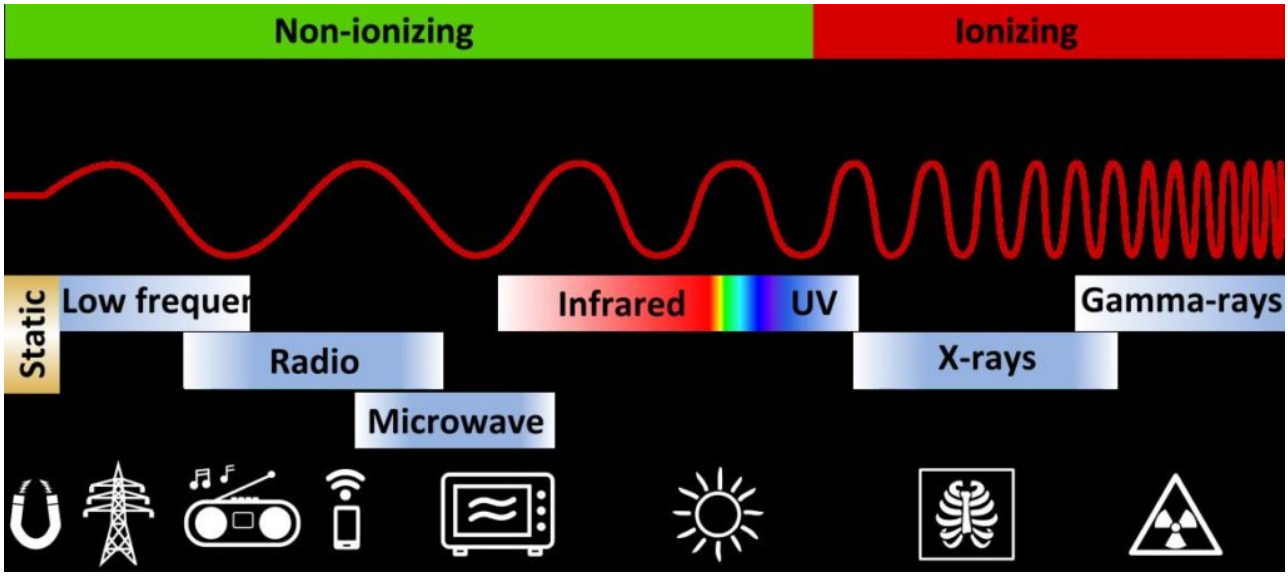

Fig. 1. The electromagnetic spectrum.

Therefore, we performed a systematic review and subsequent meta-analyses. In our systematic review, we investigated if there is already evidence in current literature regarding a modulation of the cellular calcium homeostasis by LF EMF exposure. Unlike most systematic reviews examining *in vivo* studies and clinical trial data, we evaluated studies that used *ex vivo* and *in vitro* cell cultures. For this, we selected a group of *in vitro* studies based on a strict set of quality criteria on both the biological and physical aspects of the reported data. From our comprehensive approach, we concluded that there is a very weak association between LF EMF exposure and intracellular calcium concentrations as well as the frequency of oscillating calcium waves. Furthermore, we reported that there might be EMF sensitive cell types that could explain the contradictory reports in literature. In addition, field strengths below 200 µT, frequencies other than 50/60 Hz, or exposure periods shorted than 60 minutes showed to also be associated with increased intracellular calcium. From the papers we also extracted all parameters required to calculate the induced electric fields in the experimental set-up. The strength of these fields showed to be associated to an increased intracellular calcium concentration. However, this correlation was dependent on the presence of parasitic fields. This indicated that also uncontrolled induced electric fields could unintentionally influence *in vitro* outcomes and cause discrepancy in literature.

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Publication

Calcium homeostasis and low-frequency magnetic and electric field exposure: A systematic review and meta-analysis of in vitro studies.
Golbach LA, Portelli LA, Savelkoul HF, Terwel SR, Kuster N, de Vries RB, Verburg-van Kemenade BM.
Environ Int. 2016 Feb 9