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Regulation of cellular function via electromagnetic field frequency and extracellular environment: A theoretical- experimental approach[1]
TOLOO TAGHIAN, Univ of Cincinnati, ABDUL SHEIKH, Yale University, DARIA NARMONEVA, ANDREI KOGAN, Univ of Cincinnati — Application of external electric field (EF) as a non-pharmacological, non-invasive tool to control cell function is of great therapeutic interest. We developed a theoretical-experimental approach to investigate the biophysical mechanisms of EF interaction with cells in electrode-free physiologically-relevant configuration. Our numerical results demonstrated that EF frequency is the major parameter to control cell response to EF. Non-oscillating or low-frequency EF leads to charge accumulation on the cell surface membrane that may mediate membrane initiated cell responses. In contrast, high-frequency EF penetrates the cell membrane and reaches cell cytoplasm, where it may directly activate intracellular responses. The theoretical predictions were confirmed in our experimental studies of the effects of applied EF on vascular cell function. Results show that non-oscillating EF increases vascular endothelial growth factor (VEGF) expression while field polarity controls cell adhesion rate. High-frequency, but not low frequency, EF provides differential regulation of cytoplasmic focal adhesion kinase and VEGF expression depending on the substrate, with increased expression in cells cultured on RGD-rich synthetic hydrogels, and decreased expression for matrigel culture.

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Toloo Taghian
Univ of Cincinnati

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