From Music to Non-Invasive Therapies Via COMSOL Multiphysics® Models

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Abstract

Either from the exposure to environmental stimuli or from the existing non-invasive medical therapy models [1] there are strong evidences on the effects of Low Intensity Vibrations [2] and low-frequency electromagnetic field [3] on humans, although the mechanism that modulate the cellular responses is largely unclear.

Having evidences on the meaningfulness of the non-equilibrium processes and about the long range interactions from both electromagnetic field and acoustic field this study aims at designing of an analysis model able to corroborate these complex phenomena acting upon and within different human body parts and systems.

In order to map the effective acoustic density of energy impacting on the different parts of the human body, nonlinear vibration stimuli having average frequencies ranging from 10 Hz to 16 kHz were focused towards a body contour thus simulating some specific environmental exposure condition. A Human Body model and a Human Skull model contour (2D) were imported from SolidWorks® into the COMSOL Multiphysics® software through the use of the LiveLink™ to SolidWorks® add-on.

For the low-frequency electromagnetic radiation the density of energy was considered as a function of the average quantity of energy absorbed in the tissue (SAR) and it was analyzed using RF Module and Heat Transfer Module.

The superposition of field effects (Figure 1) was analyzed aiming to reach a model able to explain the plethora of the associated effects reported on the medical literature, from those values considered able to damage the brain tissue, up to those used on different non-invasive medical therapies.

The models selected for the environmental stimuli varied from the focalized ones that mimic the lab therapeutic exposure, to the complex nonlinear ones occurring in concert halls or at the indoor use of different home appliances able to generate associated electomagnetic and vibrational field effects. For this purpose the Acoustics Module and Equation-Based Models interfaces

have been used to define the interactions between human 2D model and the eigenmodes of therapy room or of spectacle hall.

Based on the present analysis performed using COMSOL simulations and according to the cellular proactive energy harvesting model [4] the previously achievements on non-invasive treatments for osteoporosis and for systemic and regional blood flow [2] fit well to the simulation model. Thus the existing local different values of the density of energy (Figure2, Figure 3) are able to explain the effective production of growth factors, modulating stem cells proliferation and differentiation and increasing bones mass.

Similar results were obtained reassessing on objective experimental data basis the effectiveness of music therapies, as well as the potentially damaging effects of too low or too high acoustic pressure levels signals.

Far from being just a collection of analytic methods, COMSOL modelling clarifies the interdisciplinary models associated to non-invasive acoustic-electromagnetic therapies thus giving a real multiphysics support to the acknowledged therapeutically results.

Moreover, unexpectedly COMSOL becomes an effective tool at the reassessing meaningfulness of the environmental stimuli upon humans and reopens a millenary debate related to the Music: Music for soul or Music for body?

Reference

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2. Weinheimer-Haus EM, Judex S, Ennis WJ, Koh TJ (2014) Low-Intensity Vibration Improves Angiogenesis and Wound Healing in Diabetic Mice, PLoS ONE 9(3): e91355. doi:10.1371/journal.pone.0091355
3. Adey RW (2005) Electromagnetic fields, the modulation of brain tissue functions-A possible paradigm shift in biology, International Encyclopedia of Neuroscience, Elsevier, NY
4. Lacatus E (2014) Ion Channel Path of Cellular Transduction During Acoustic Stimulation, J. Biochimica et Biophysica Acta (BBA)- Bioenergetics, Supplement EBEC 2014 Abstracts, ISSN0005-2728, Elsevier

Figures used in the abstract

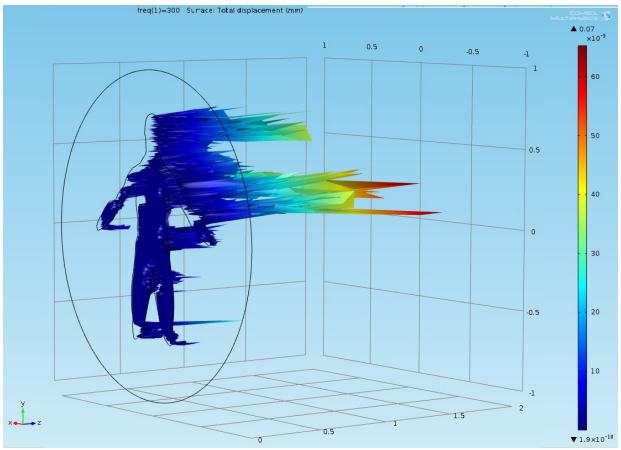

Figure 1: Environment stimuli (intensity amplitude) at 300 Hz

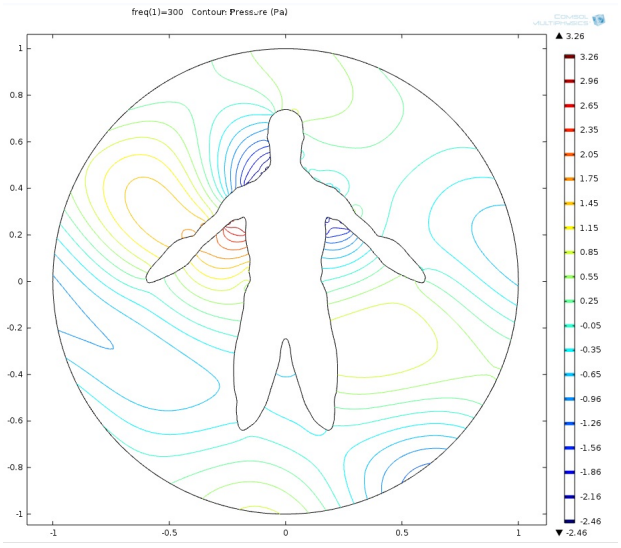

Figure 2: Human Body contour pressure at 300 Hz

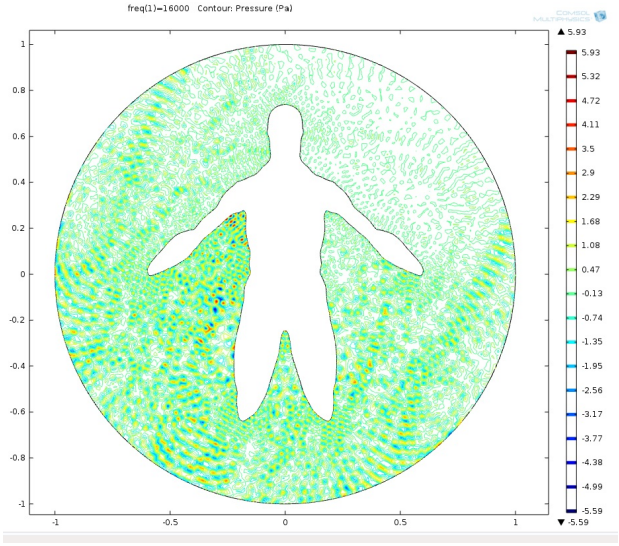

Figure 3: Human Body contour pressure at 16 kHz