CRITERIA FOR SELECTING SPECIFIC EMF EXPOSURE CONDITIONS FOR BIOEXPERIMENTS IN THE CONTEXT OF HEALTH RISK ASSESSMENT

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Abstract: The choice of exposure conditions is one of the most important selections to be made in bioexperiments related to health risk assessments, an issue which has often been strongly underestimated in the past. The objective of this paper is to develop and discuss the basis and rationale for selecting particular signals for specific biological endpoints in the context of health risk assessments.

1. Introduction

Several programs related to the question of potential health risks from electromagnetic (EM) exposure will be conducted in the near future. These studies are mainly driven by the increasing health concern of the public with respect to weak electromagnetic exposure. Examples are PERFORM A and REFLEX, both of which are projects of the 5th Framework of the European Research Program. PERFORM A is devoted to evaluating GSM with respect to carcinogenesis and co-carcinogenesis. REFLEX is a set of *in vitro* experiments to investigate molecular and functional responses of living cells to ELF and RF by applying state-of-the-art methods of molecular biology and toxicology.

While the thermal effects due to RF exposures as well as nerve excitations for exposures below 10 MHz are generally considered to be well understood, the public is increasingly concerned about possible adverse biological effects far below the threshold values of the established effects which are often categorized into athermal and non-thermal effects. The current understanding is that these effects might greatly depend on the signal characteristics, especially on the ELF components. Under this hypothesis, health risk assessment programs are faced with severe methodology problems, since exposures in daily life vary to a large extent, not only in strength but also with respect to the ELF spectral content.
In view of this, experiments resulting in negative findings which have been conducted with purely sinusoidal 50 Hz or 60 Hz fields or RF signals only simulating the main frame (217 Hz pulsed) of the GSM signal for health risk evaluations have little relevance for the health risk discussion. The reason is that although the dominant components with respect to spectral power have been applied, there is little scientific rationale for assuming that the biological significance of the other components can be neglected beforehand. For example, the famous PIM1 study [1] would only have marginal significance for the safety of GSM if it had produced negative findings. However, the positive finding caused a strong debate about the safety of GSM. Furthermore, it is of great importance that the exposure for the target organs or cell cultures should be as well defined and as homogenous as possible [2].

2. Objective

The objective of this contribution is to develop and discuss the basis and rationale for selecting particular signals for specific biological endpoints in the context of health risk assessments. This shall be evaluated under the premise of maximizing the significance of negative findings with respect to the safety of the tested technology and minimal number of experiments.

3. Rationale

Radio Frequency (RF) Dependent Effects: Neither the experimental results nor the discussed interaction mechanism suggests any evidence of biological dependence on the RF frequency other than different penetration depth. The latter, however, has the significant consequence that certain tissues are more or less exposed depending on the carrier frequency. This should always be kept in mind when selecting the exposure frequency.

Extreme Low Frequency (ELF) Dependent Effects (ELF/Modulation): A considerable number of publications have reported modulation frequency dependent effects. The strongest indications for such effects are for frequencies below 100Hz. However, the results are controversial, such that no solid conclusion about the most effective frequencies can be drawn. Preferences are reported for lower frequencies, especially around 16Hz. It is further noted that frequencies above 100 Hz and below 1 Hz have been evaluated to a much lesser degree. There is little knowledge about the dependence of the effect as a function of the spectral power of these modulation components, although a masking effect has been claimed for cell culture exposures to noise-modulated RF fields that compete with concurrent exposures to fields with coherent ELF modulation. Even less is known about modulation depth or specific signal characteristics in the time domain. However, the authors are not aware of any biophysical rationale that would expect increased sensitivity for decreased spectral power. However, there are many arguments for maximized spectral power. This leads to the consequence of generally testing those signals which provide the highest spectral content.

Exposure Strength Dependent Effects: The results of the previous studies are even less conclusive about the dependence of the effects upon the field strength below the thermal threshold. In many studies, unsuitable exposure setups have been used, resulting in poorly defined exposures ranging over several magnitudes. Furthermore, the dosimetry reported does not enable a detailed analysis of the findings. Despite

the promotion of amplitude windows by some authors, monotonic dose dependence with thresholds should still be the initial model when no other evidence is available. This suggests that several dose levels are preferably applied, whereby the highest dose level applied should be as high as feasible but below the threshold for thermal effects. At least the user exposure should be averaged. The separation between the dose levels should be considerably larger than the standard deviation of the non-homogeneity of exposure [2].

On-/Off-Cycle Dependent Effects (ELF/RF): Several authors have emphasized the importance of the On-/Off cycles since intermittency is a generally accepted factor in the action of cancer promoting agents. Although typical on/off cycles can be derived from daily exposures, the experiment should preferably be driven by the biological experiment, i.e., cell cycles, etc.

4. Conclusion

All elements of the exposure conditions must be carefully evaluated and selected. Any shortcoming will strongly reduce the significance of negative findings with respect to the safety of the tested technology and minimal number of experiments. This would not be in the interest of public health and the funding bodies.

5. References

[1] Repacholi MH, et al. 1997. Lymphomas in Eμ-Pim1 Transgenic Mice Exposed to Pulsed 900 MHz Electromagnetic Fields. Radiation Research 147:631-640

[2] Kuster N, Schönborn F. 2000. Recommended Minimal Requirements and Development Guidelines for Exposure Setups of Bio-Experiments Addressing the Health Risk Concern of Wireless Communications. Bioelectromagnetics 21:508-514