

Precautionary measures based on reproducible, so-called non-thermal effects of HF-EMF

wilhelm.mosgoeller@meduniwien.ac.at

International research results justify risk reduction measures for persons exposed to HF-EMF (high-frequency electromagnetic fields).

The following findings and insights are relevant.

In vitro findings

DNA strand breaks. DNA strand breaks associated with HF-EMF exposure were first described in laboratory animals [1-2]. Interestingly, in cell cultures (*in vitro*), discontinuous exposure (cycles of 5 min ON, 10 Minutes OFF) produced more breaks than continuous irradiation [3-4]. Although DNA strand breaks occur in healthy individuals, an increased incidence due to HF-EMF exposure is a risk indicator for cancer.¹ Indeed a court of law recently recognized the link between a brain cancer and extensive HF-EMF exposure.²

Changes in HF-EMF-exposed cells have, in some cases, been investigated using two complementary methods, i.e. by parallel analysis of both DNA strand breaks and proteomic changes. The plausibility of exposure-related DNA strand breaks in sensitive cells is supported by modified protein findings of in the exact same cells (see Gerner *et al.* [5]). Exposure-related DNA breaks have moreover been observed by independent teams, i.e. the findings have been replicated several times internationally [6-8].

The fact that intermittent exposure (cycles of 5 min 'on', 10 min 'off'), or so-called modulated HF-EMF, produces DNA strand breaks more effectively than continuous exposure is a challenge to our understanding of mechanisms. The association of lower (intermittent exposure) or identical (modulated signal) power absorption per mass of tissue with an increased frequency of DNA strand breaks means that the effect cannot be solely attributed to the absorbed energy.

DNA strand breaks after exposure to HF-EMF have, however, not only been observed *in vitro*, but also in different live animals (see below).

Consistency of findings. To date, many *in vitro* studies using short HF-EMF exposures (< 2 hours) have published negative results [9-12]. These negative findings with short term exposures, also confirmed by the EU REFLEX project, do not however contradict those investigations that found effects after longer exposure times [6, 8].

¹ The chairman of the Committee on 'Non-ionizing Radiation' of the German Radiological Protection Commission (SSK, Alexander Lerchl) wrote 'The results gave rise to concern. Should they be confirmed, then this would not simply constitute an alarm signal, but be the beginning of the end of mobile communications, as damage to DNA is the first step in cancer development.' (Source: Lerchl A (2008) Fälscher im Labor und ihre Helfer: Die Wiener Mobilfunk-Studien – Einzelfall oder Symptom? Books on Demand GmbH, ISBN-13: 978-3837063417, p. 43.

Comment by the author: This verdict may be exaggerated, but nevertheless underlines the importance of preventative and precautionary measures for the safe use of HF-EMF-emitting devices, especially since the DNA strand breaks findings have subsequently been reproduced several times and confirmed in animal experiments.

² In Italy, a court of appeal decided in favor of the plaintiff, following the argument that a brain cancer could be related to frequent mobile phone use (La Corte d'Apello, Brescia, R.Gen.N. 361/08).

The following findings resolve assumed contradictions:

Cell type dependency. In vitro studies most commonly use 'lymphocytes' [11, 13-21]. In agreement with the results of the EU REFLEX project and Ruediger's research group in Vienna, lymphocytes consistently exhibit no exposure-related DNA strand breaks [15, 22] and have thus often been described as being resistant to HF-EMF exposure. The resistance of one cell type does not however compensate for the sensitivity of another cell type if this contains exposure-related DNA strand breaks. Fibroblasts, neurons, trophoblasts, CHL cells and lymphoblastoid cells, for example, have been found to be sensitive to HF-EMF exposure [3-4, 6, 8-9, 23-24].

The existence of further sensitive cells or conditions is moreover highly likely.

Latency period. In contrast to radioactive irradiation, short term exposure to HF-EMF produces no detectable effects. The variable time periods from the start of exposure to the occurrence of positive findings in sensitive cells reported by different research groups can be attributed to the use of different models and cell types. Published exposure times include twenty minutes [7], 2 hours (in the EU REFLEX project), 4 hours [5], and 16 hours [6].

Cell activity. The sensitivity of cells to HF-EMF is dependent on their metabolic activity. The results of the ATHEM project demonstrated that an increase in metabolic activity can cause an increase in sensitivity, even in inactive (insensitive) lymphocytes [5]. This suggests that active cells are more vulnerable than resting cells.

Recovery time. Following exposure, the cells require a certain time for the disappearance of the exposure induced effects (= recovery time). A recovery time of 2 hours has been described for both DNA strand breaks and proteome changes [5-6]. Systematic research would be required to assess whether sufficient recovery occurs during shorter time periods.

Effects of low intensity. Exposure-related DNA strand breaks were also observed after the latency period in sensitive cells exposed to low intensities (1.2 & 0.1 W/kg) substantially below the current EU Council recommendations [3-4]. Our own preliminary proteomic findings confirm this sensitivity of cells to low field strengths.

In vivo findings (animal experiments)

The *in vivo* findings in different laboratory animals confirm and strengthen the conclusions of the EU REFLEX study and of recently published *in vivo* investigations of DNA damage.

Kesari *et al.* [25] exposed young rats for 2 hours per day (35 days) to an unmodulated high-frequency electromagnetic field of 2450 MHz. The power flux density was 0.34 mW/cm² (threshold: 1 mW/cm²) which corresponds to an estimated whole body SAR of 0.11 W/kg.

The rate of DNA strand breaks in the brains of irradiated rats was significantly higher than in the control groups, showing that the genotoxic effects of HF-EMF can also be demonstrated in whole-body irradiated laboratory animals.

Guler G. *et al.* [26] exposed pregnant and non-pregnant rabbits to 1800 MHz signals similar to GSM signals at an electric field strength of 14 V/m (threshold: 58 V/m) for 15 minutes per day for 7 days. After irradiation, a significant increase in oxidative DNA damage and lipid peroxidation levels was observed in the brain tissue of both experimental groups when compared with the controls. No changes of this type were observed in the newborn animals. This work thus demonstrates for a further species of animal (i.e. in addition to laboratory rats) that modulated high-frequency electromagnetic fields that are far below the currently valid European guidelines can cause genotoxic changes in the brains of whole-body irradiated laboratory animals. The findings reported by Tomruk *et al.*, [27] also based on rabbits, are similar to those reported above (Guler *et al.*) [26].

Relevance of modulation

As the specific absorption rate (SAR) is comparable for modulated and non-modulated fields, the observed different effects of modulated and non-modulated fields demonstrate that simply limiting irradiated and absorbable energy does not reliably prevent cellular reactions. The following publications suggest that the signal modulation (radio application) may cause DNA strand breaks more effectively than the carrier frequency alone.

1. Franzellitti *et al.* [6] demonstrated that DNA strand breaks were no longer observed when cells were exposed to a non-modulated carrier frequency.
2. Campisi *et al.* [7] found an exposure-dependent increase in free oxygen radicals associated with cleavage of DNA strands after a 20 minute exposure to modulated fields. No effects were found after exposure to the same field strength but with the non-modulated carrier frequency.

Summary

Following Henry Lai's (USA) description of increased DNA strand breaks in rat brains following microwave exposure, more readily accessible lymphocytes became the preferred cell type for replication experiments. In the meantime it has been repeatedly shown that lymphocytes are fairly resistant to moderate intensity microwave exposure, i.e. that DNA strand breaks were (and continue to be) barely detectable in this particular cell type. Exposure of other cell types to HF-EMF in contrast generates a measurable increase in cleaved DNA strands. Whether sensitive cells contain DNA strand breaks after exposure or not is dependent on several factors:

1. A so-called latency period, after which DNA strand breaks can be determined, occurs following the start of exposure. The shorter the exposure time, the less likely it is that damage will occur.
2. Further exposure parameters, in addition to the effective radiation power due to energy absorption per unit mass (SAR value), are also relevant. Sensitive cells for example, respond more markedly to rhythmic interruptions (intermittent exposure) than to continuous exposure. Cellular reactions can thus occur independently of the specific absorption rate (heat generation).
3. There are repeated indications that exposure to modulated signals causes more cleaved DNA strand breaks to be generated than exposure to a non-modulated carrier wave at the same intensity. This confirms that the cellular reactions are not solely dependent on the specific absorption rate (heat generation).
4. DNA strand breaks may disappear within about 2 hours after the end of exposure ("recovery time"). This finding suggests that breaks in exposure could be a tool to protect against the consequences of exposure. A more precise determination of the recovery time will require further systematic research.

Conclusions

Precaution is a strategy to minimize possible risks until the exposure conditions that cause undesirable DNA strand breaks are sufficiently defined to constitute a valid basis for new exposure limits. The risks of exposure can be reduced by simple measures based on the principle of 'prudent avoidance' when installing and/or using devices that emit HF-EMF.

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