What is the Level of Detriment to Healthy and Radiosensitive People?

My background is Medical Research and here I make comments on the relevant studies in the 30-300 GHz range cited in the *Scientific Committee on Emerging and Newly Identified Risks Opinion on Potential health effects of exposure to electromagnetic fields (EMF) 2015.* The Australian Radiation Protection and Nuclear Safety Agency referred me to this document stating its relevance to 5G telecommunications.

In summary, I found that data from studies for biomedical use are insufficient and incomparable for determining risk to health from 5G communications. Some studies show these radio waves alter the structural components of DNA but there is yet to be determined a threshold level of detrimental dose in the context of communications.

What we need to know.
What is the detriment from radiation of this super to extreme high radio frequency level that 5G uses? *Detriment* is a term used to measure of the total harm that will result after exposure to radiation. What is the threshold dose for biological damage from the 30 to 300GHz bandwidth of radio frequency radiation?

The document that the Australian Radiation Protection and Nuclear Safety Agency referred me to when I made enquiries to them is *An Opinion on Potential health effects of exposure to electromagnetic fields (EMF) 2015* by the Scientific Committee on Emerging and Newly Identified Health Risks on 2015. My more detailed comments on studies in the 30-300 GHz range cited in this document can be found below under the **Limitations of Studies** heading.

Nearly all of these studies show detriment to health of exposure in the 30-300GHz range. The ones that do not, either have limitations in methodology or do not seem relatable to the mechanics of 5G wave length usage. In the latter, this is most likely because the context of these studies is not for investigating the detrimental effects of radio waves but rather aimed at investigating the effects of radio waves for therapeutic biomedical use. This results in incomparable data. The data is relevant for the field of biomedicine but not the field of communications. The positive side of the biomedical studies is that there is potential for this particular radiation like other radiation types (once the physical parameters are fully understood and described) to have a useful biomedical role. However, until threshold levels of detriment (especially to DNA) in the context of 5G use are known in the context of communications, I remain concerned with the short and long effect of the high frequency radio waves on human health and also other biological organisms.

In a brief broader literature search I found a study of military men (10,497 respondents) in the Norwegian Navy exposed to radio frequency fields that disturbingly found *"In all age groups there were significant linear trends with higher prevalence of involuntary childlessness with higher self-reported exposure to radiofrequency fields"* (Baste 2008). There are studies that suggest significant harm from Radio frequency radiation from mobile phone towers, phone and other communications but there is an absence of research into very high radio frequency waves, especially how these affect tissue when emitted across vast space such is how 5G operates.

What is the level of detriment to healthy and radiosensitive individuals.
My main concern is there are no existing studies to enable us to know the *level of detriment* to the human body, especially one that is radiosensitive from photon therapy as mine is now having undergone cancer treatment of radiotherapy. (Radiotherapy has made my body more susceptible to all radiation exposure including UV radiation damage). Also, there is no knowledge of the level of detriment to host related factors that alter the susceptibility to radiation injury such as age, smoking and co-morbidities such as infections, malignancy, collagen

vascular disease, diabetes and hypertension. There is no knowledge on the level of detriment to those individuals with rare genetic conditions such as Bloom's Syndrome, Fanconi's anaemia and ataxia telangiectasia. These people have advanced cellular radiosensitivity due to mutations in their repair genes. Until rigorous studies investigating the risk to human health of this specific radiation proposed for the 5G communications, I am concerned for myself, my family's and my community's short and long-term health. Our government has a duty of care to its people and we expect as a democratic society for this to be upheld.

References

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Cleveland, R.F. and Ulcek, J.L (1999) *Questions and answers about biological effects and potential hazards of radiofrequency electromagnetic fields*. OET Bulletin 56 Fourth Edition, Office of Engineering and Technology, Federal Communications Commission Washington, D.C.
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International Commission on Radiological Protection (2007) *Human alimentary tract model for radiological protection*. ICRP Publication 100. (Ed.CH Clement) Elsevier.
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Scientific Committee on Emerging and Newly Identified Health Risks SCENIHR (2015) *Opinion on Potential health effects of exposure to electromagnetic fields* (EMF)
https://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf

Limitations of Studies

My Comments on studies in the 30-300 GHz range cited in Scientific Committee on Emerging and Newly Identified Risks Opinion on Potential health effects of exposure to electromagnetic fields (EMF) 2015

Scientific Committee on Emerging and Newly Identified Health Risks SCENIHR (2015) *Opinion on Potential health effects of exposure to electromagnetic fields* (EMF)
https://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf

Study 1

Beneduci A (2009). Evaluation of the potential in vitro antiproliferative effects of millimeter waves at some therapeutic frequencies on RPMI 7932 human skin malignant melanoma cells. Cell biochemistry and biophysics, 55, 25-32.

Abstract

The potential antiproliferative effects of low power millimeter waves (MMWs) at 42.20 and 53.57 GHz on RPMI 7932 human skin melanoma cells were evaluated in vitro in order to ascertain if these two frequencies, comprised in the range of frequency used in millimeter wave therapy, would have a similar effect when applied in vivo to malignant melanoma tumours. Cells were exposed for 1 h exposure/day and to repeated exposure up to a total of four treatments. Plane wave incident power densities <1 mW/cm(2) were used in the MMWs-exposure experiments so that the radiations did not cause significant thermal effects. Numerical simulations of Petri dish reflectivity were made using the equations for the reflection coefficient of a multilayered system. Such analysis showed that the power densities transmitted into the aqueous samples were < or = 0.3 mW/cm(2). Two

very important and general biological endpoints were evaluated in order to study the response of melanoma cells to these radiations, i.e. cell proliferation and cell cycle. Herein, we show that neither cell doubling time nor the cell cycle of RPMI 7932 cells was affected by the frequency of the GHz radiation and duration of the exposure, in the conditions above reported.

Limitations of Study

This study found that very high frequency radiation doesn't increase proliferation of cancer cells in vivo which is not surprising as it is the microenvironment of the host that effects growth of cancer cells and the risk from radiation is in causing DNA damage that *begins* the proliferation process.

Study 2

Clothier RH and Bourne N (2003). Effects of THz exposure on human primary keratinocyte differentiation and viability. Journal of Biological Physics, 29, 179–85.

Abstract

Primary human keratinocytes can be driven, *in vitro*, to differentiate, viaactivation of transglutaminases, by raising the culture medium calcium concentration above 1 mM. This results intransglutaminase regulated cross linking ofspecific amino acids with resultant cornified envelope formation. The differentiation was monitored via the incorporation of fluorescein cadaverine into the cornified envelops. This differentiation assay was combined with assessment of reductive capacity ofresazurin, as a measure of cellactivity/viability. One primary aim is to assess the effects of THz radiation on human skin, since medical imaging of the body through the skin is envisaged. Human keratinocytes, at passage 2 from isolation, were grown to confluence, and transported in a buffered salt solution at22 $^{\circ}$C. The exposure to the THz source was for 10, 20 or 30 minutes at room temperature. No donor specific inhibition or stimulation of cell activity, compared with non-exposed cells, was noted following exposure in the range 1 to 3 THz, at up to 0.45J/cm^2.The differentiation also occurred in a normal way, for exposed and non-exposed cells, with the FC incorporation increasing between day 3 and day 8, as previously noted.

Limitations of Study

1. There are only three donors used when assessing THz radiation on the differentiation of skin cells. Three is perhaps not a large enough sample size to draw conclusions from. What race were these people? There is not enough methodology information to evaluate this further.
2. This study was funded by Engineering and Physical Sciences Research Council (EPSR) which states on their website their strategic focus is;

"This research area is expected to contribute significantly to the full realisation of 5G and to advances in telecommunications further into the future."

This statement shows a conflict of interest.

Study 3

Hintzsche H, Jastrow C, Kleine-Ostmann T, Stopper H, Schmid E, Schrader T (2011). Terahertz radiation induces spindle disturbances in human-hamster hybrid cells, Radiat Res, 175(5), 569-74.

Abstract

The aim of this study was to investigate and quantify the production of spindle disturbances in A(L) cells, a human-hamster hybrid cell line, by 0.106 THz radiation (continuous wave). Monolayer cultures in petri dishes

were exposed for 0.5 h to 0.106 THz radiation with power densities ranging from 0.043 mW/cm(2) to 4.3 mW/cm(2) or were kept under sham conditions (negative control) for the same period. As a positive control, 100 µg/ml of the insecticide trichlorfon, which is an aneuploidy-inducing agent, was used for an exposure period of 6 h. During exposure, the sample containers were kept at defined environmental conditions in a modified incubator as required by the cells. Based on a total of 6,365 analyzed mitotic cells, the results of two replicate experiments suggest that 0.106 THz radiation is a spindle-acting agent as predominately indicated by the appearance of spindle disturbances at the anaphase and telophase (especially lagging and non-disjunction of single chromosomes) of cell divisions. The findings in the present study do not necessarily imply disease or injury but may be important for evaluating possible underlying mechanisms.

Detrimental health effects found
This study found significant DNA damage by THz radiation.

"Based on a total of 6,365 analyzed mitotic cells, the results of two replicate experiments suggest that 0.106 THz radiation is a spindle-acting agent as predominately indicated by the appearance of spindle disturbances at the anaphase and telophase (especially lagging and non-disjunction of single chromosomes) of cell divisions".

Study 4
Hintzsche H, Jastrow C, Kleine-Ostmann T, Kärst U, Schrader T, Stopper H (2012). Terahertz electromagnetic fields (0.106 THz) do not induce manifest genomic damage in vitro, PLoS One, 7(9), e46397.

Abstract

Terahertz electromagnetic fields are non-ionizing electromagnetic fields in the frequency range from 0.1 to 10 THz. Potential applications of these electromagnetic fields include the whole body scanners, which currently apply millimeter waves just below the terahertz range, but future scanners will use higher frequencies in the terahertz range. These and other applications will bring along human exposure to these fields. Up to now, only a limited number of investigations on biological effects of terahertz electromagnetic fields have been performed. Therefore, research is strongly needed to enable reliable risk assessment.Cells were exposed for 2 h, 8 h, and 24 h with different power intensities ranging from 0.04 mW/cm^2 to 2 mW/cm^2, representing levels below, at, and above current safety limits. Genomic damage on the chromosomal level was measured as micronucleus formation. DNA strand breaks and alkali-labile sites were quantified with the comet assay. No DNA strand breaks or alkali-labile sites were observed as a consequence of exposure to terahertz electromagnetic fields in the comet assay. The fields did not cause chromosomal damage in the form of micronucleus induction.

Comments
Although not significant this study did find that after the long exposure, the DNA in the tail region was increased in comparison to the sham-exposed sample. They conclude that "No induction of DNA strand breaks or chromosomal damage was observed. Very small alterations might not have been detectable because the cells showed considerable background level of DNA damage".

[They used an assay known as a Comet Assay. Definition of tail moment: term incorporates a measure of both the smallest detectable size of migrating DNA (reflected in the tail length) and the number of relaxed/broken pieces (represented by the intensity of DNA in the tail. The tail moment indicates the degree of the genotoxic effect on the DNA.]

Study 5

Hwang Y, Ahn J Mun J Bae S Uk Jeong Y,Vinokurov NA and Kim P. In vivo analysis of THz wave irradiation induced acute inflammatory response in skin by laser scanning confocal microscopy. Optic Express 2014, 22 (10), 11465.

Abstract
The recent development of THz sources in a wide range of THz frequencies and power levels has led to greatly increased interest in potential biomedical applications such as cancer and burn wound diagnosis. However, despite its importance in realizing THz wave based applications, our knowledge of how THz wave irradiation can affect a live tissue at the cellular level is very limited. In this study, an acute inflammatory response caused by pulsed THz wave irradiation on the skin of a live mouse was analyzed at the cellular level using intravital laser-scanning confocal microscopy. Pulsed THz wave (2.7 THz, 4 μs pulsewidth, 61.4 μJ per pulse, 3Hz repetition), generated using compact FEL, was used to irradiate an anesthetized mouse's ear skin with an average power of 260 mW/cm(2) for 30 minutes using a high-precision focused THz wave irradiation setup. In contrast to in vitro analysis using cultured cells at similar power levels of CW THz wave irradiation, no temperature change at the surface of the ear skin was observed when skin was examined with an IR camera. To monitor any potential inflammatory response, resident neutrophils in the same area of ear skin were repeatedly visualized before and after THz wave irradiation using a custom-built laser-scanning confocal microscopy system optimized for in vivo visualization. While non-irradiated control skin area showed no changes in the number of resident neutrophils, a massive recruitment of newly infiltrated neutrophils was observed in the THz wave irradiated skin area after 6 hours, which suggests an induction of acute inflammatory response by the pulsed THz wave irradiation on the skin via a non-thermal process.

Detrimental health effects found
" a massive recruitment of newly infiltrated neutrophils was observed in the THz wave irradiated skin area after 6 hours, which suggests an induction of acute inflammatory response by the pulsed THz wave irradiation on the skin via a non-thermal process".

Study 6
Kirichuk VF, EfimovaN, Andronov E (2009). Effect of High Power Terahertz Irradiation on Platelet Aggregation and Behavioral Reactions of Albino Rats. Bull Exp Biol Med, 48(5), 746–9.

Abstract
Intensive terahertz irradiation at the nitric oxide emission and absorption spectrum frequencies (150.176-150.664 GHz) applied for 60 min to male albino rats subjected to acute immobilization stress enhanced platelet aggregation and induced signs of depression.

Detrimental health effects found
This study on behavioral reactions and aggregation activity found enhanced platelet aggregation and induced signs of depression.

Study 7
Kirichuk VF, Tsymbal AA (2009). Use of Terahertz Electromagnetic Waves for Correcting Hemostasis Functions. Biomedical Engineering, 44(1), 11–14.

Abstract

The influence of terahertz range waves at 129.0 GHz (frequency of the molecular spectrum of radiation and absorption of atmospheric oxygen) on faulty coagulation hemostasis and its fibrinolysis potential was studied under conditions of experimental stress. Considerable hypercoagulation and the suppression of fibrinolysis of blood were observed in experimental animals exposed to experimental stress. The influence of 129.0 GHz radiation was studied in animals under conditions of immobilizing stress. No considerable changes in the faulty indicators of hemostasis and fibrinolysis were observed for 5-min exposure duration. In case of 15-min exposure, partial normalization of indicators characterizing the coagulation cascade and fibrinolysis was observed. The influence of terahertz radiation on the specified frequencies within 30 min caused full normalization of hemocoagulation and fibrinolysis as the studied indicators of a coagulation link of the system of hemostasis and fibrinolysis. Thus, on the basis of the presented data it is possible to draw a conclusion about positive effect of terahertz radiation at the frequency of the molecular spectrum of radiation and absorption of atmospheric oxygen (129.0 GHz) on the coagulation properties and fibrinolysis of blood in animals under conditions of immobilizing stress. A 30-min exposure proved to be especially effective for restoration of the indicators of hemocoagulation and fibrinolysis activity of blood.

Comments
This study found Terahertz range waves alters hemocoagulation and fibrinolysis activity of blood. My intpretation of this finding is that shows detriment to health however the authors conclude that this is a positive effect under conditions of stress.

Study 8
Le Quement C, Nicolaz CN, Zhadobov M, Desmots F, Sauleau R, Aubry M, Michel D, Le Drean Y (2012). Whole-Genome Expression Analysis in Primary Human Keratinocyte Cell Cultures Exposed to 60 GHz Radiation. Bioelectromagnetics, 33, 147-58.

Abstract

Human corneal epithelial (HCE-T) and human lens epithelial (SRA01/04) cells derived from the human eye were exposed to 60 gigahertz (GHz) millimeter-wavelength radiation for 24 h. There was no statistically significant increase in the micronucleus (MN) frequency in cells exposed to 60 GHz millimeter-wavelength radiation at 1 mW/cm^2 compared with sham-exposed controls and incubator controls. The MN frequency of cells treated with bleomycin for 1 h provided positive controls. The comet assay, used to detect DNA strand breaks, and heat shock protein (Hsp) expression also showed no statistically significant effects of exposure. These results indicate that exposure to millimeter-wavelength radiation has no effect on genotoxicity in human eye cells.

Comments
This provides promising results of no detriment to eyes from 60 HGz radiation.

Limitations of study
The authors describe the limitations;
“Overall, it appears that exposure to millimeter-wavelength radiation has no genotoxicity effect, and does not alter Hsp expression in the absence of thermal effects. However, our study was performed on specific conditions. It has been shown that the effects of microwaves including millimeter-wavelength radiation strongly depend on a number of physical parameters such as frequency, modulation, polarization, background extremely low-frequency and static magnetic fields [28,29]. We have to be more careful in comparing the data which were performed at different conditions. In addition, we have to consider rigid statistical calculations which we might

be missing. In this study, we obtained high statistical power in the MN test; however, we could not obtain enough statistical power in the comet assay. We should be carefully aware of these statistical issues."

Study 9

Nicolaz CN, Zhadobov M, Desmots F, Ansart A, Sauleau R, Thouroude D, Michel D, Le Drean Y (2009). Study of narrow band millimeter-wave potential interactions with endoplasmic reticulum stress sensor genes. Bioelectromagnetics, 30(5), 365-73.

Abstract

The main purpose of this article is to study potential biological effects of low-power millimeter waves (MMWs) on endoplasmic reticulum (ER), an organelle sensitive to a wide variety of environmental insults and involved in a number of pathologies. We considered exposure frequencies around 60 GHz in the context of their near-future applications in wireless communication systems. Radiations within this frequency range are strongly absorbed by oxygen molecules, and biological species have never been exposed to such radiations in natural environmental conditions. A set of five discrete frequencies has been selected; three of them coincide with oxygen spectral lines (59.16, 60.43, and 61.15 GHz) and two frequencies correspond to the spectral line overlap regions (59.87 and 60.83 GHz). Moreover, we used a microwave spectroscopy approach to select eight frequencies corresponding to the spectral lines of various molecular groups within 59-61 GHz frequency range. The human glial cell line, U-251 MG, was exposed or sham-exposed for 24 h with a peak incident power density of 0.14 mW/cm(2). The average specific absorption rate (SAR) within the cell monolayer ranges from 2.64 +/- 0.08 to 3.3 +/- 0.1 W/kg depending on the location of the exposed well. We analyzed by quantitative reverse transcription-polymerase chain reaction (RT-PCR) the level of expression of two endogenous ER-stress biomarkers, namely, the chaperones BiP/GRP78 and ORP150/GRP170. It was found that exposure to low-power MMW does not significantly modify the mRNA levels of these stress-sensitive genes suggesting that ER homeostasis is not altered by low-power MMW at the considered frequencies.

Comments

They state results of the effect of low power waves on homeostasis of cells. I do not know how relevant low power is in mimicking the mechanics of 5G power waves.

Study 10

Ostrovskiy NV, et al. (2005) Application of the terahertz waves in therapy of burn wounds. in Infrared and Millimeter Waves and 13th International Conference on Terahertz Electronics, IRMMW-THz 2005.

Comments

This relates to using terahertz waves as a biomedical imaging tool. Like other radiation types, under controlled conditions development of terahertz waves may have a beneficial role in medicine.

Study 11

Swanson ES (2011). Modeling DNA response to THz radiation, Phys Rev E Stat Nonlin Soft Matter Phys, 83(4 Pt 1), 040901.

Abstract

Collective response of DNA to terahertz electric fields is studied in a simple pair bond model. We confirm, with some caveats, a previous observation of destabilizing DNA breather modes and explore the parameter dependence of these modes. It is shown that breather modes are eliminated under reasonable physical conditions and that thermal effects are significant.

Comments
DNA "breathing" is defined as a thermally driven process in which base-paired DNA sequences transiently adopt local conformations that depart from their most stable structures.
From my limited understanding of this study, I interpret the results to indicate the modeled response of DNA to terahertz electric fields is to alter DNA pair bonds. This suggests detriment to health but it is limited as it is reliant on a model.

Study 13
Titova LV, Ayesheshim AK, Golubov A, Fogen D, Rodriguez-Juarez R, Hegmann FA, Kovalchuk O. (2013a). Intense THz pulses cause H2AX phosphorylation and activate DNA damage response in human skin tissue. Biomed Opt Express, 4(4), 559-68.

Abstract
Recent emergence and growing use of terahertz (THz) radiation for medical imaging and public security screening raise questions on reasonable levels of exposure and health consequences of this form of electromagnetic radiation. In particular, picosecond-duration THz pulses have shown promise for novel diagnostic imaging techniques. However, the effects of THz pulses on human cells and tissues thus far remain largely unknown. We report on the investigation of the biological effects of pulsed THz radiation on artificial human skin tissues. We observe that exposure to intense THz pulses for ten minutes leads to a significant induction of H2AX phosphorylation, indicating that THz pulse irradiation may cause DNA damage in exposed skin tissue. At the same time, we find a THz-pulse-induced increase in the levels of several proteins responsible for cell-cycle regulation and tumor suppression, suggesting that DNA damage repair mechanisms are quickly activated. Furthermore, we find that the cellular response to pulsed THz radiation is significantly different from that induced by exposure to UVA (400 nm).

Detriment to health found
Authors state; "we have observed that exposure to intense THz pulses induces phosphorylation of H2AX, indicative of the formation of DNA double strand breaks, and at the same time profoundly activates DNA damage response in artificial human skin tissues.
They also found "Simultaneous upregulation of multiple important tumor suppressor proteins in the exposed skin".
They found DNA damage and then repair.

Study 14
Zeni O, Gallerano GP, Perrotta A, Romanò M, Sannino A, Sarti M, D'Arienzo M, Doria A, Giovenale E, Lai A, Messina G, Scarfì MR (2007). Cytogenetic observations in human peripheral blood leukocytes following in vitro exposure to THz radiation: a pilot study. Health Phys, 92(4), 349-57.

Abstract
Emerging technologies are considering the possible use of Terahertz radiation in different fields ranging from telecommunications to biology and biomedicine. The study of the potential effects of Terahertz radiation on biological systems is therefore an important issue in order to safely develop a variety of applications. This paper describes a pilot study devoted to determine if Terahertz radiation could induce genotoxic effects in human peripheral blood leukocytes. For this purpose, human whole blood samples from healthy donors were exposed for 20 min to Terahertz radiation. Since, to our knowledge, this is the first study devoted to the evaluation of possible genotoxic effects of such radiation, different electromagnetic conditions were considered. In particular,

the frequencies of 120 and 130 GHz were chosen: the first one was tested at a specific absorption rate (SAR) of 0.4 mW g-1, while the second one was tested at SAR levels of 0.24, 1.4, and 2 mW g-1. Chromosomal damage was evaluated by means of the cytokinesis block micronucleus technique, which also gives information on cell cycle kinetics. Moreover, human whole blood samples exposed to 130 GHz at SAR levels of 1.4 and 2 mW g-1 were also tested for primary DNA damage by applying the alkaline comet assay immediately after exposure. The results obtained indicate that THz exposure, in the explored electromagnetic conditions, is not able to induce either genotoxicity or alteration of cell cycle kinetics in human blood cells from healthy subjects.

Comments

The authors note some alteration to DNA; “a slight increase in comet parameters appears in some cases in exposed samples with respect to sham-exposed ones; however, this difference was not statistically significant.”

Limitations of Study

The authors describe limitations; “several critical points have to be considered, and among them the amplitude modulation and the irradiation modulation condition deserve particular attention”.

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