

# Electromagnetic Fields as a Health Risk Factor

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Original Article

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## Abstract:

This study is a collection of findings of published articles from the Department of Medical Biophysics and Department of Public Health at the Jessenius Faculty of Medicine in Martin, Comenius University Bratislava (JFM CU) with the topic on epidemiology of electromagnetic fields. During 14 years, 13 principal publications were created, of which 11 studies deal with radio frequency signals from mobile phones (mainly GSM900 and GSM1800 standard); one study describes the construction of a new exposure system and the other deals with the effects of low frequency electromagnetic fields. The results showed that the electromagnetic fields can affect heart rate

variability both in humans and animals; increasing the activity of the parasympathetic or sympathetic nerve systems depending on place of body exposure (head or thorax, respectively); may cause disorders of heart rhythm; loss of concentration; headaches; and/or burning sensations in the ear area. Parameters of exposition were compared with the values issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). They had not exceeded the permitted limits. However, compared to data of the Bio Initiative Report, in some cases, our measured values exceeded their limits.

## Introduction

The human body is constantly exposed to the electromagnetic field (EMF) from the environment. Solar activity, thunderstorms and the Earth's magnetic field are the natural sources of exposition. All technical man-made devices that produce electro smog are artificial sources. The massive development of science and technology in recent decades has caused a progressive increase in artificial sources, which significantly exceed natural sources in quantity and intensity and can be classified as the high and low - frequency EMFs [1]. Both the fields (pulsed or modulated) are bioactive, which means that they could have health impacts under both an acute and chronic exposure even at very low exposure levels.

High frequency (HF) EMFs (100 kHz- 300 GHz). Two decades ago has seen a dramatic increase of all means of mobile communications, which includes space signals, smartphones, and smart meters etc. radiating the HF EMFs. The number of mobile phones today is almost 8 billion users. The entire world population is exposed mainly to various radio frequency (RF) electromagnetic signals which are a part of the HF electromagnetic spectrum. The problem here is that the population has no knowledge on the exposure or the parameters of the received EMF. The scientific community should be interested in the impact on the public health of citizens. There are some data that confirm the harmfulness of exposure to EMFs and, conversely, those that completely deny these effects. The issue is even more serious and desirable to solve due to the development of new 5G networks and technologies that requirement to build more Base Stations, which is associated with higher exposure of residents to EMFs [2].

The most frequently discussed topics are mainly mobile phones and Wi-Fi routers, which

are part of the RF EMFs with a frequency range from 100 kHz to 300 GHz in the electromagnetic spectrum. Detrimental biological effect of RF EMFs on living systems has been confirmed by world organizations. In 2011, WHO/International Agency for Research on Cancer (IARC) classified RF EMFs as possibly carcinogenic to humans (Group 2B), based on an increased risk for glioma, a malignant type of brain cancer associated with wireless phone use [3,4].

Under acute exposition the human body responds to EMF with symptoms resembling the flu, such as loss of concentration, headache, muscle pain, general fatigue or insomnia, which are based on the thermal and/or non-thermal effects of EMFs. The first one is currently well known and acknowledged, however the effects of non-thermal radiation are underestimated.

Under chronic exposure of a body to HF EMF (even sub-limited i.e. non-thermal) taking longer time (weeks, months, years) the subjective symptoms may change in objective ones resulting in the electromagnetic hypersensitivity syndrome (EHS) and/or in a decrease in number of human sperm, fertility and immune responsiveness [2]. It is of interest that in experimental animals exposed to 1800 MHz used for GSM (Global System for Mobile Communications) signal had created iron deposits in brain tissue of rabbits accumulating just below a place of exposure [5]. Likewise, as reported by Hardel et al. [6, 39] frequent use of a mobile phone in everyday life can be a risk factor for malignant lymphoma in the central nervous system. Also the study by Crabtree et al. [7] considers that RF EMF from a mobile phone (power 1.563mW and 0.783mW) can disrupt the microbiota of human skin. However, RF EM signal was also used to solve health problems e.g. in cancer patients, where certain frequencies were found to block

the growth of cancer cells [8]. According to clinical studies RF EMFs can serve even as a safe and effective method for achieving soft tissue tightening in anesthetic medicine [9].

Some problems have arisen in respect to the health of a small, but very important fraction of the human population: children. This is even more important because mobile devices and cell phones may be seen in the hands of children as young as 1-3 years in age [2]. Children have a unique vulnerability to external adverse factors of the environment including the high and low frequency EMFs [1, 2]. Potential hazard of mobile communication seems to be related more to the non-thermal effects of RF EMFs.

A cellular phone delivers a power density of RF radiation that is 2 billion times greater than occurs naturally in the environment. The absorbed energy potentially could cause dangerous and damaging biological effects within the human brain [2]. It is known that the human head is a complex structure of many different tissue types. Each of the tissues - skin, bone, cerebrospinal fluid, fat, brain, dura, etc., absorbs and reflects RF energy in its own way. In addition, the human head is far from having a uniform shape, volume or structure. Therefore, the RF EMF interacts with the human head in a non-uniform way depending on the specific location of the brain areas/volumes. Humans and animals are now subjected to a variety of HF electromagnetic signals. Worse is that this situation is conducted without monitoring, and the possibility to produce any protections. In contrast the mobile communication industry creates newer tools in order to increase the speed of communications. Hundreds of Base Stations are constructed around the countries without the possibility for citizens to reduce their fast growth. Thus, billions of people are not informed about the fact that their homes and they themselves are subjected to the new and advanced technological developments, which under some occasions can be harmful for them [10].

ii) Low-frequency (ELF) EMFs (1 Hz to 100 kHz).

It is generally accepted that extremely ELF EMFs e.g. 50 and 60 Hz, can cause electrical current flows that may shock and even damage or destroy tissues. The sources are: railway or tram lines; indoor and outdoor electrical wiring; high

voltage power lines heaters [1]; but also some medical electrical devices and even a pocket phone itself. Likewise as in high-frequency EMFs, biological effects of ELF EMFs divide the scientific community into those who believe in their harmful effect on living systems, and thus also consider them as public health problem, and those who do not it.

First evidence published in 1979 had determined the relation between the ELF EMFs and leukemia in children [11]. The number of studies on this topic increased when the IARC classified the ELF EMFs in Group 2B, as a possible carcinogen to humans. This classification remains up to now [4, 12]. Two decades of the study confirmed the association between ELF EMFs and childhood cancers, especially leukemia (13). However, lately published studies did not show consistent results to support the association between ELF EMFs and some types of “non-blood” cancers, e.g. gliomas [14]. It was also found that ELF EMFs were able to change the growth of yeast in a frequency dependent manner [15, 16]. Data obtained on humans reported, stress, anxiety, depression, sleep, heartbeat, and brain disorders as a result of long-term occupational exposure to ELF EMFs [17, 18].

Comparable to RF EMFs, also ELF EMFs were used for medical purposes. Some studies highlight the positive effects of low frequency magnetic field therapy, mostly in the rehabilitation of post-stroke patients, and a cancer treatment, mainly in combination with an anticancer drug [19]. In clinical practice magneto-therapeutic devices with frequency up to several hundred Hz, are commonly used for the treatment of musculoskeletal disorders, pain, post-traumatic conditions or damaged tissue [20, 21]. Thus, health risk factors and mentioned above findings are a source of concern for potential risks to public health during exposure to high and low frequency EMFs. The aim of our survey study is to bring and evaluate our principal research findings dealing with possible detrimental effects of EMFs on public health.

### **Work methodology and research methods**

The study consists of scientific and full-text published articles created at Department of Medical Biophysics JFM CU over the last 14 years. All the articles were standardly revised and then

published in scientific journals with higher impact factors, mostly the Scopus and Web of Sciences. Our electromagnetic laboratory deals mainly with possible harmful effects of HF EMFs in students, experimental animals and model of brain phantom. Heart rate variability (HRV), temperature changes, changes in Fe<sup>2+</sup> content in the brain as well as possible cancer changes in tissues were investigated. Recently, the laboratory has expanded its research also to ELF EMFs employing the human head phantom, similarly as in the case of high-frequency model. The model of phantom enables to measure an intensity, frequency and penetration of electromagnetic signals (high or low) into the brain and perform the particular computer simulations. In the phase of data collection and processing, emphasis was given on parameters such as frequency and

intensity of electric stimulation, an exposure time, also distance from the source of EMFs. The studies seen in Results are listed in reverse chronological order – i.e. from the newest to the oldest.

## Results

A total of 13 studies focusing on EMFs were carried out at JFM CU. The study was performed at the Department of Medical Biophysics under cooperation with Department of Public Health of the JFM CU between years 2009 and 2022 (Table 1).

**Table 1** contains the name of author, year, measured parameters under specific conditions and principal findings of all studies involved in this study. 11 studies are related to RF EMFs, most of them analyze the effects of the GSM standard, where the frequencies 900 MHz and

**Table 1** Studies dealing with EMFs or the biological effects of EMFs

Authors, years / Parameters and conditions	Principal findings
Misek et al. (2022) E-field measurement in the frequency range 880 - 960 MHz, the distance of EMF source from the village was 500 meters [22].	The authors focused on the distribution of hot-spots and EMF power near base transceiver stations. The measured values were below the ICNIRP limits, but according to the BioInitiative Report, they were above the safe limits.
Hamza Sladicekova et al. (2022) GSM and UMTS standards (825 MHz, 1760 MHz, 2109 MHz) on the human head phantom [23].	The study evaluated the effectiveness of protective accessories of head against RF EMF exposure. The textile protective accessory containing silver provided the best shielding (6-16 dB) compared to conventional caps (below 1 dB)
Hamza Sladicekova et al. (2021) ELF EMF (frequency 900 Hz), magnetic flux density 2.3 mT, electric current 2 A, exposure time 0- 8 h [24].	The results of study indicated that low-frequency EMF has inhibitory effects on the reproduction and growth of the yeast cells. After 8 hours, a significant decrease in the number of yeast cells was observed. The exposed sample had 1/3 less cells than the control sample.
Misek et al. (2020) 21 rabbits, the first group exposed to device generated RF EMF source (frequency 1788 MHz), the second exposed to the real RF signal from the base stations (frequency 1805 – 1870 MHz), intensity 160 V/m, exposure time 150 min. [25].	Two groups of rabbits were exposed to the signal generated by a device and real RF EMF signal, to evaluate the effects of RF EMF on HRV in rabbits. The result was an increase in HRV parameters associated with a lower heart rate, which is related to increased cardiac vagal control during exposure to RF EMF.

Authors, years / Parameters and conditions	Principal findings
Kohan et al. (2020) Measurement in a building covered by 3G, 4G & WiFi signals, two mobile phones were used for data transfer, distance between the mobile phone and the meter was 0.2 cm [26].	The authors focused on E-field intensities during data transmission based on GSM and WiFi. They concluded that the highest E-field values were found for the 4G network, but the limits were not exceeded.
Misek et al. (2018a) 46 healthy students, frequency 1788 MHz with intensity $54 \pm 1.6$ V/m, exposure time 18 min. [27].	The study shows that even short exposure to RF EMF has an effect on the autonomic nerve system. During the ortho-clinostatic test in lying position, parasympathetic nerve activity was significantly increased compared to sham-exposition.
Misek et al. (2018b) Faraday cage (the specimen area 150 x 250 mm), E-field percent deviation < 18 % [28].	The result of the study was to build an unique exposure cage with real GSM/DCS/UMTS signal taken from Base Station. This RF exposure system is used for experiments on living organisms (in vivo studies) & on cells e.g. bacteria & other microstructures (in vitro).
Misek et al. (2018c) Measurements in the city center, residential area, rural area & extra-village area, each micro-environment measured 20 times [29].	Distribution of RF EMF was investigated in 4 environments. 1.85 V/m was the highest measured value of intensity of E-field in a residential area. According to the ICNIRP guidelines, all values were below the limits, but According to BioInitiative Report, our measured values exceeded the limits.
Habinakova et al. (2017) 44 adolescents, frequency 1788.5 MHz & max. intensity 30 V/m, exposure time 6 min for each position around the head [30].	The study monitored radiated RF power levels around the head of adolescents. The temporal area connecting both ears had the highest absorption. Tachycardia, headache or fatigue appeared during exposure in some adolescents.
Spiguthova et al. (2015) / HF EMF exposure from mobile phone (GSM standard), measurement in shielded places of the grammar school [31]	The results showed that the radiation from the mobile phone increased significantly during phone calls in the shielded area of the grammar school. The shielded space had a higher power flux density of EMF than the unshielded space.
Spiguthova et al. (2014) HF EMF exposure, dosimetry, measurement performed at different places at high school [32]	The intensity values of electric & magnetic field increased in the classrooms of the school during the increased HF EMF exposure.
Jakusova et al. (2010) / GSM standard (900 MHz, 1800 MHz), mobile call longer than 6 min/day [1, 33]	The study confirmed the connection between the duration of a mobile call & a burning sensation around the ear, loss of concentration & sleeplessness.
Jakusova et al. (2009) / GSM standard (900 MHz, 1800 MHz) [1, 34]	Based on the questionnaire, 99.4% of students use a mobile phone & 44.5% call for more than 10 min/day. University students have sufficient theoretical information about EMF, but not about the safe use of mobile phones.

Abbreviations: E-field – electric field, DCS – Digital Cellular System, UMTS – Universal Mobile Telecommunications System.

1800 MHz belong to its frequency bands. One study deals with the effects of ELF EMFs and one study describes the construction of unique exposure system serving for experimental purposes (Table 1).

## Discussion

The aim of our study was to show a progress made in research work on the biological effects of the HF and ELF EMFs and their health impacts on living systems. Our goal was to point out the diversity of workplace research that focuses on both types of EMFs. Most of our above-mentioned studies (see Results) employ a common exposure parameter, mainly the frequency of 1800 MHz or its close value, which belongs to the frequency band for GSM 1800 standard of mobile communication. All published articles were properly discussed in

the journals. Here we will restrict just to the most important findings. We found that HF (RF) EMF affects variability of heart rate in rabbits; increasing the activity of the parasympathetic nerve activity under exposure of the head [25]; and sympathetic nerve activity after exposure of chest [26]; similarly as we proved in humans [27].

As for electric field intensity, value 1.85 V/m was measured in a residential area [22] and significant increases of the power flux density were regularly measured in the shielded areas [31, 32]. Our findings clearly demonstrate a possible detrimental effect of microwave radiation spreading from cell phones operating in shielded areas. In comparison e.g. with an electromagnetic radiation from helicopter during landing had a higher value of electric intensity of EMF reaching 7.68 V/m [35]. Pall [36] summarized the neurological symptoms that are most often reported after exposure to RF EMF: sleep disturbances; insomnia; headache; fatigue; loss of concentration. It is not surprising that the probands included in our studies after exposure to GSM 1800 also had the similar health symptoms [30, 33, 34] due to the biological effects of microwave radiation from cell phones. The integration between the mobile devices, base stations emerging advances in mobile phone technology, including recent 5G modalities opened the discussions on the potential risk for the biosphere.

Unfortunately, the scientific, medical, and public health communities, after more than a

quarter of century of discussions, still do not have a common opinion on the issue of if, and to what extent, the EMF from mobile communications represents a hazard for Public health.

What is even worse, the new 5G mobile technology is being widely employed into a society even before the development of appropriate industrial standards [2]. It can be mentioned that all of the indicated studies in our survey, where intensities of electric field were measured, did not exceed the allowed ICNIRP limits. However, according to limits given by the BioInitiative Report they were exceeded in some of our studies [22, 29]. According to the limits set by the BioInitiative Report [38], intensities of electric field above 0.1 - 0.15 V/m for the frequency range 400 - 2000 MHz are considered as a risky value, whereas for ICNIRP it was 58.354 V/m (limits of ICNIRP are valid for Slovakia, too).

It is obvious that safe limits of exposure given by ICNIRP in 1998 (and updated in 2009) are too high, however still valid, not reflecting the latest scientific data. Even after update no changes in the safe limits for the specific frequency range were employed. ICNIRP limits consider only thermal effects, despite the fact that many scientific groups, including ours, proved an existence of non-thermal effects, as well. As to low frequency EMFs, we proved an inhibitory effect on yeast growth [24]. The same effect was confirmed by another study [37], where yeast of the same species after exposure to ELF EMF had a reduced number of cells and their growth was slower. It is interesting that in addition to RF EMF exposure during cell phone call, the human body is also exposed to extremely low-frequency EMF from cell phones and practically of all electronic equipment [10, 39]. This seems to be another goal for our interest, looking for extremely ELF of electric and magnetic fields during phone calls.

It is generally accepted that humans and animals are exposed at a same time to high and low frequency EMFs with their electric and magnetic components. It seems that different frequency of EMF exposure, even at lower intensities but with longer term of their duration; pulse wave form of radiation from Base Transceiver Stations; polarization; direction; modulation of signal; number of "hot spots" in signal trajectory; distance from the source of radiation; spreading of signal in shielded or not shielded objects; and another

physical entities; seems to be crucial for biological effects of EMF exposure (stimulatory or inhibitory) [10]. In order to properly elucidate the biological effects of ELF and HF EMFs on living subjects at various frequencies and intensities further experiments are needed. From the view of Public Health the group of people which needs higher protection against EMF radiation includes babies, elderly people, school children, teenagers and professionals. Thus, the problem of electromagnetic exposure is complex and has common health and social-economy impacts.

## Conclusion

Principal studies of this survey study from the Department of Medical Biophysics under cooperation with Department of Public Health of the JFM CU in Martin showed possible detrimental effects of HF and ELF EMFs on humans and animals. Either the studies dealt directly with the subjective feelings of the probands after EMF exposure (questionnaire form), or take into account the measured values of frequency and electric intensity of EMF, which were compared with the permitted limits. Probands after exposure described: feelings of ear burning; loss of concentration; stress; anxiety; depression; heartbeat disorder; and sleeplessness. Exposure to HF EMFs in shielded areas (resembling the effect of Faraday cage) can significantly increase the flux density of electric intensity of EMF, and are harmful to health. Serious research in this area requires a complex study of physical, biological and social phenomena, and their relationship for effective control and support of Public Health.

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## References

- JAKUSOVA V (2009) *Ultraviolet Radiation and Mobile Communication: physical properties, biological effects and health protection*. Bratislava: Samosato, 2009. (Slovak).
- MARKOV M (2019) *Mobile Communications and Public Health*. Boca Raton, Florida: CRC Press, 2019.
- IARC (2013) *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Non-Ionizing Radiation, Part 2: Radio frequency Electromagnetic Fields*. France, Lyon. 2013. Vol. 102. 405-419.
- IARC (2011) *IARC classifies Radio frequency electromagnetic fields as possibly carcinogenic to humans*. IARC, 2011 [cit. 2022-06-15]. Available from: [https://www.iarc.who.int/wp-content/uploads/2018/07/pr208\\_E.pdf](https://www.iarc.who.int/wp-content/uploads/2018/07/pr208_E.pdf).
- KOPANI M, FILOVA B, SEVCIK P, KOSNAC D, MISEK J, POLAK S, KOHAN M, MAJOR J, ZDIMALOVA M, JAKUS J (2017) Iron deposition in rabbit cerebellum after exposure to generated and mobile GSM electromagnetic fields. *Bratislava Medical Journal*. 2017. 118 (10): 575-579.
- HARDELL L, CARLBERG M, KOPPEL T, NORDSTRÖM M, HEDENDAHL L K (2020) Central nervous system lymphoma and radiofrequency radiation - A case report and incidence data in the Swedish Cancer Register on non-Hodgkin lymphoma. *Medical Hypotheses*. 2020. 144:110052.
- CRABTREE D P E, HERRERA B J, KANG S (2017) The response of human bacteria to static magnetic field and radiofrequency electromagnetic field. *Journal of Microbiology*. 2017. 55(10): 809 – 815.
- ZIMMERMAN J W, JIMENEZ H, PENNISON M J, BREZOVICH I, MORGAN D, MUDRY A, COSTA F P, BARBAULT A, PASCHE B (2013) Targeted treatment of cancer with radiofrequency electromagnetic fields amplitude-modulated at tumor-specific frequencies. *Chinese Journal of Cancer*. 2013. 32(11): 573-581.
- DAYAN E, BURNS A J, ROHRICH R J, THEODOROU S (2020) The Use of Radio frequency in Aesthetic Surgery. *Plast Reconstr Surg Glob Open*. 2020. 8(8):e2861.
- BELYAEV I (2019) *Health effect of chronic exposure to radiation from mobile communication*. In Markov M (2019) *Mobile Communication and Public Health*. Boca Raton, Florida: CRC Press, 66-92.
- WERTHEIMER N, LEEPER E (1979) Electrical wiring configurations and childhood cancer. *Am J Epidemiol*. 1979. 109(3):273-284.

12. IARC (2002) *IARC Monographs on the evaluation of carcinogenic risks to humans. Non-ionizing radiation, Part 1: Static and extremely low-frequency (ELF) electric and magnetic fields*. France: Lyon, 2002.
13. ICNIRP (2010) *Low Frequency. ICNIRP, 2010* [cit.2022-06-16]. Available from: <https://www.icnirp.org/en/frequencies/low-frequency/index.html>.
14. CARLBERG M, KOPPEL T, AHONEN M, HARDELL L (2018) Case-control study on occupational exposure to extremely low-frequency electromagnetic fields and the association with meningioma. *Biomed Res Int*. 2018. Jan 3;2018:5912394.
15. BARABAS J, RADIL R, MALIKOVA I (2015) Modification of *S. cerevisiae* growth dynamics using low frequency electromagnetic fields in the 1-2 kHz range. *Biomed Res Int*. 2015. (2):694713.
16. RADIL R, BARABAS J, JANOUSEK L, BERETA M (2020) Frequency dependent alterations of *S. Cerevisiae* proliferation due to LF EMF exposure. *Advances in Electrical and Electronic Engineering*. 2020. 18(2): 99-106.
17. TIRPAK A (2011) *Electromagnetizmus*. Bratislava: IRIS, 2011. 710 p. ISBN 9788089238460
18. HOSSEINABADI M B, KHANJANI N, EBRAHIMI M H, HAJI B, ABDOLAHFARD M (2019) The effect of chronic exposure to extremely low-frequency electromagnetic fields on sleep quality, stress, depression and anxiety. *Electromagn. Biol. Med*. 2019.38(1): 96-101.
19. CICHON N, CZARNY P, BIJAK M, MILLER E, ŚLIWINSKI T, SZEMRAJ J, SALUK-BIJAK J (2017) Benign effect of extremely low-frequency electromagnetic field on brain plasticity assessed by nitric oxide metabolism during post stroke rehabilitation. *Oxid Med Cell Longev*. 2017.2181942.
20. MANSOURIAN M, FIROOZABADI M, HASSAN ZM (2020) The role of 217-Hz ELF magnetic fields emitted from GSM mobile phones on electro-chemotherapy mechanisms. *Electromagn. Biol. Med*. 2020. Jul 2;39(3):239-249.
21. HUANG P, XU L, XIE Y (2021) Biomedical Applications of Electromagnetic Detection: A Brief Review. *Biosensors*. 2021. 11(7).
22. MISEK J, LAPOSOVA S, HAMZA SLADICEKOVA K, JAKUSOVA J, PARIZEK D, JAKUSOVA V, VETERNIK M, JAKUS J (2022) Measurement of Base Transceiver Station Exposure in the Extra-Village Environment – A Pilot Study. *Acta Medica Martiniana*. 2022. 22(1):15-23.
23. HAMZA SLADICEKOVA K, MISEK J, JAKUSOVA V, ULBRICHTOVA R, VETERNIK M, PARIZEK D, JAKUS J (2022) Attenuation properties of health protection accessories during mobile phone exposure on the human head phantom. *Przegląd Elektrotechniczny*. 2022. 98(8): 63-8.
24. SLADICEKOVA K, BERETA M, MISEK J, PARIZEK D, JAKUS J (2021) Biological effects of a low-frequency electromagnetic field on yeast cells of the genus *Saccharomyces Cerevisiae*. *Acta Medica Martiniana*. 2021. 21(2): 34-41.
25. MISEK J, VETERNIK M, TONHAJZEROVA I, JAKUSOVA V, JANOUSEK L, JAKUS J (2020) Radiofrequency Electromagnetic Field Affects Heart Rate Variability in Rabbits. *Physiological research*. 2020. 69(4): 633-643.
26. KOHAN M, SPRONGLOVA M, VISNOVCOVA N, MISEK J, SPANIKOVA G, JAKUSOVA V, JAKUS J (2020) Monitoring of data transmission and changes in values of electromagnetic field in living environment. *Communications*. 2020. 22(1): 71-6.
27. MISEK J, BELYAEV I, JAKUSOVA V, TONHAJZEROVA I, BARABAS J, JAKUS (2018a) Heart rate variability affected by radiofrequency electromagnetic field in adolescent students. *Bioelectromagnetics*. 2018a. 39(4): 277-88.
28. MISEK J, VOJTEK J, VETERNIK M, KOHAN M, JAKUSOVA V, SPANIKOVA G, BELYAEV I, JAKUS J (2018b) New radiofrequency exposure system with real telecommunication signals. *Advances in Electrical and Electronic Engineering*. 2018b.16(1): 101-7.
29. MISEK J, LAUKOVA T, KOHAN M, VETERNIK M, JAKUSOVA V, JAKUS J (2018c). Measurement of Low-level radio frequency electromagnetic fields in the



- human environment. *Acta Medica Martiniana*. 2018c. 18(2): 27-33.
30. HABINAKOVA H, JAKUSOVA V, KOHAN M, MISEK J, JAKUS J (2017) Measurement of the values of radio frequency electromagnetic fields around the head of adolescents. *Lékař a technika*. 2017. 47(2): 60-7.
31. SPIGUTHOVA D, HABINAKOVA H, MISEK J, JAKUSOVA V, JAKUS J (2015) Measurement of parameters of electromagnetic fields during mobile communication in the school environment. *Lékař a technika*. 2015. 45(4): 122-8.
32. SPIGUTHOVA D, HABINAKOVA H, JAKUSOVA V, JAKUS J (2014) Exposure of adolescents to electromagnetic fields. *Folia Medica Cassoviensia*. 2014.69(1-2): 29-31.
- JAKUSOVA V, POLIACEK I, OSINA O, VALACH M, JAKUS J (2010) Mobile communication - possible risks and health protection of university students. *Acta Medica Martiniana*. 2010. 7(2): 3-10.
33. JAKUSOVA V, KILIKOVA M (2009) Mobile communication and university students. *Kontakt*. 2009. 11(1): 178-86.
34. MICHAŁOWSKA J (2022) Prediction and Assessment of Exposure to Electromagnetic Field During a Helicopter Flight. *Przegląd Elektrotechniczny*. 2022. 98(1): 96-99.36.36.
35. PALL M L (2016) Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. *J Chem Neuroanat*. 2016. 75(Pt B): 43-51.
36. NOVAK J, STRASAK L, FOJT L, SLANI-NOVA I, VETTERL V (2007) Effects of low-frequency magnetic fields on the viability of yeast *Saccharomyces cerevisiae*. *Bioelectrochemistry*. 2007. 70(1): 115-121.
- BioInitiative (2012) The BioInitiative Report 2012. *A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Fields (ELF and RF)*. BioInitiative 2012 [cit. 2022-07-20]. Available from: <https://bioinitiative.org/>
37. HARDELL L, SAGE C (2008) Biological effects from electromagnetic field exposure and public exposure standards. *Biomedicine & Pharmacotherapy*. 2008. 62(2): 104-109.