

RADIOFREQUENCY AND MICROWAVE RADIATION HEALTH EFFECTS AND OCCUPATIONAL EXPOSURE

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In the recent years, there have been considerable discussion and concern about the possible hazards of RF/MW radiation. More recently, the growth and development in personal mobile communications have focused attention on the frequencies associated with this technology. A number of studies have examined the health effects of RF/MW electromagnetic fields (EMFs), originating from occupational exposure, hobbies, or residence near the radio or television transmitters. Particularly controversial are the biophysical mechanisms by which these RF fields may affect biological systems. General health effects reviews explore possible carcinogenic, reproductive and neurological effects. Health effects by exposure source have been observed in radar traffic devices, wireless communications with cellular phones, radio transmission, and magnetic resonance imaging (MRI). Several epidemiological surveys have suggested associations with non-specific complaints such as headache, tiredness, sleep disturbance, loss of memory, and dizziness. These findings, which echo reports of illness associated with other types of radiofrequency (RF) radiation, relate not only to the use of mobile phones, but also to residence near the mobile phone base stations and other settings involving occupational exposure. The biological effects suggest that some precautions are necessary, and preventive approaches are highly recommended. Further researches are required to give more information about the effects of microwave radiation on our health, especially in occupational setting and professionally exposed workers. *Acta Medica Medianae* 2011; 50(4):74-78.

Key words: occupational exposure, microwave radiation, health, effect

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Introduction

Radiofrequency (RF) and microwave (MW) radiation are kinds of electromagnetic radiation in the frequency ranging from 3 kilohertz (kHz) - 300 Megahertz (MHz), and from 300 MHz to 300 gigahertz (GHz), respectively. The researches are being undertaken on possible biological effects of exposure to RF/MW radiation from radios, cellular phones, the processing and cooking of foods, heat sealers, vinyl welders, high frequency welders, induction heaters, flow solder machines, communications transmitters, radar transmitters, ion implant equipment, microwave-drying equipment, sputtering equipment and glue curing.

In the recent years, there have been considerable discussion and concern about the possible hazards of RF/MW radiation. Extensive researches on this topic are currently underway in many countries. Natural low-frequency EM fields

come from two main sources: the sun, and thunderstorm activity, but man-made fields at much higher frequencies have altered this natural EMF. At sufficiently high power densities, RF/MW energy can cause thermal effects that can cause blindness and sterility. Non-thermal effects, such as alteration of the human body's circadian rhythms, immune system and the nature of the electrical and chemical signals communicated through the cell membrane have been demonstrated (1).

More recently, the growth and development in personal mobile communications have focused attention on the frequencies associated with this technology. A number of studies have examined the health of people exposed to RF EMFs through the use of mobile phones, occupational exposure, hobbies, or residence near radio or television transmitters.

Health effects

Electric and magnetic fields are complex physical agents whose potential health effects are the subjects of numerous researches. Particularly controversial are the biophysical mechanisms by which these RF fields may affect biological systems. General health effects reviews explore

possible carcinogenic, reproductive and neurological effects. Health effects by exposure sources have been noted in radar traffic devices, wireless communications with cellular phones, radio transmission, and magnetic resonance imaging (MRI).

Concerns about possible adverse health effects of mobile telephony have focused mainly on the risk of brain tumors in users of mobile phones, but other types of illness have also been linked with the technology. In particular, several epidemiological surveys have suggested associations with non-specific complaints such as headache, tiredness, sleep disturbance, loss of memory, and dizziness. These findings, which echo reports of illness associated with other types of radiofrequency (RF) radiation (2), relate not only to the use of mobile phones, but also to residence near mobile phone base stations (3). Further evidence on the latter is provided in a paper by Hutter *et al* (4). They found that symptoms such as headache, fatigue, and difficulty concentrating were more common in people with higher potential exposures to radiation from nearby base stations, and that the association remained significant after adjustment to various possible confounding factors, including regular personal use of mobile phones.

There are many reports on non-thermal biological effects from pulsed, low-intensity, microwave radiation, using both in vivo and in vitro models. In vitro studies include increases in chromosome aberrations and micronuclei in human blood lymphocytes (5), increased ornithine decarboxylase activity, single and double strand DNA breaks (6), increases in cell proliferation, increased levels of the stress protein *hsp70* (7) and nonthermal activation of the *hsp27/p38MAPK* stress pathway (8).

Studies using in vivo models provide additional examples, including increased permeability of blood-brain barrier in rats, promotion of lymphoma in transgenic mice (9), and pathological effects induced by embryonic and post-natal exposure to EMF radiation by cellular mobile phones (NPRB).

Although biological effects are well established, the possibility of adverse health effects from exposure to the radiation of GSM cell phones is still under discussion (10). The biological effects suggest that some precautions are necessary, and the current safety guidelines for GSM cellular telephones specify limited radiation intensity to prevent tissue heating based on the body's thermoregulatory mechanisms. However, it is now clear that the low intensity pulsed microwave radiation currently emitted by GSM telephones exerts non-thermal influences on living organisms long before heating occurs. The pathways activated by both ELF and RF fields do not respond to changes in temperature, so they must be activated by the EM fields. Studies using ELF stimulation have shown that there are two distinct regions on the *hsp70* promoter—one

responds to EM fields and a different region to thermal stimulation (11).

Occupational hazards

In its recent review, AGNIR (2003) (12) concluded that while there have been positive findings in some studies for risks of specific cancers in relation to mobile phone use or to occupational or residential RF field exposure (or potential for exposure), no relation has been shown consistently. Several cohort studies of occupational groups exposed to RF EMFs have examined non-cancer mortality and, in some instances, morbidity. IEGMP (2000) (13) concluded that these studies did not provide any overall evidence of a hazard. However, AGNIR noted that the design of the studies has often been deficient. Hence, although the studies do not suggest a raised risk of cancer, they do not rule one out, especially in relation to large cumulative exposures to mobile phones and possible effects occurring many years after their use.

Research related to RF/microwave exposure has generally focused on brain tumors and cancer. However, research should also be focused on hearing functions of persons working or living in RF/microwave fields such as radio broadcasting. Employees who have both been working at and living in the surrounding areas of broadcasting stations constitute one of the major groups occupationally exposed to RF and microwave. The results of traditional audiometer indicated that RF promotes sensorineural hearing loss and affects cochlea parts (14)

Cancers related to occupational exposure

Information on cancer risks in relation to occupational RF exposure comes from three types of epidemiological study: cohort studies, investigating a wide range of cancer (and non-cancer) outcomes in groups with potential RF exposure; case-control studies of specific cancer sites, investigating occupational RF as well as other exposures and analyses of routinely collected datasets on cancer incidence or mortality, in which risks of cancer have been assessed in relation to job title. The most extensive literature addresses brain tumors and leukemia.

The recent study (15) has provided evidence of an association with either brain tumors or leukemia. In addition, there are data about increased risk of non-lymphocytic leukemia in radar-exposed aviation electronics technicians. Two US case-control studies of brain tumor etiology have shown elevated odds ratios of around 1.5 in relation to jobs believed to have RF exposure. It is important to mention that the cohort studies generally lack data on other relevant exposures, including non-RF frequencies of radiation, as well as on RF exposures outside the workplace (e.g., mobile phones) which make difficulties in data interpretation.

Several studies have investigated the risk of breast cancer in relation to RF exposure. A cohort study conducted with 50 women who work as radio and telegraph operators found increasing of relative risk for breast cancer (16). An elevated relative risk found also for endometrial cancer suggests that reproductive and hormonal factors (for which full adjustment could not be made), not RF, may have been responsible for the raised breast cancer risk. A case-control study conducted in US showed an elevated risk for breast cancer in male radio and communication workers (17). The available data are insufficient to reach any conclusion on whether RF exposure is related to breast cancer risk, but the results support continued evaluation of the possibility.

A significantly raised risk for testicular cancer and lung carcinoma was found for self-reported occupational exposure to microwave and other radio waves, but not for self-reported radar exposure nor for radar or other microwave exposure assessed by an occupational hygienist based on job history. A cluster of testicular cancer was reported in six police officers in Washington State, US, who routinely used hand-held traffic radar guns (18).

Ocular melanoma was associated with self-reported exposure to microwaves (excluding domestic microwave ovens) or radar. An increased risk of ocular melanoma was detected in subjects with self-reported occupational exposure for at least 6 months and several hours per day to RF (14% of cases, 10% of controls) and for occupational exposure several hours per day to radio sets (19).

Adverse reproductive outcomes

A wide range of potential reproductive consequences of RF exposure has been investigated, with a focus on exposures of physiotherapists to therapeutic short-wave diathermy (typically 27.12 MHz). There are isolated suggestions of an association between RF exposure and delayed conception, spontaneous abortion, stillbirth, pre-term birth with exposure to fathers, birth defects in aggregate and increased male to female sex ratio (20).

Semen parameters have been examined among men with varying forms of military exposure to microwaves and radar. There was found reductions in sperm density, but results are not consistent (21).

There were no differences in the numbers of children born to exposed men and their unexposed counterparts despite some positive associations with reported difficulty in conceiving (22). Furthermore, there were no associations between paternal occupational exposure to RF and poor obstetric outcomes or overall occurrence of birth defects (23).

Cardiovascular Disease

Several methodologically weak studies from the Soviet Union addressed microwave exposure and acute effects on cardiovascular physiology (e.g., hypotension, bradycardia, tachycardia) as part of a set of ill-defined conditions (24). Additional studies of indirect relevance considered symptoms among a range of potentially exposed groups including radar workers, pilots, radio broadcasting workers, and electronics industry workers. The variability in research methods, exposure characteristics, and outcome measures makes it difficult to draw conclusions: there are sporadic reports of symptoms among some groups of workers, but no obvious pattern is present.

In a mail survey of US physical therapists men more highly exposed to microwave and shortwave radiation, report a significantly greater prevalence of heart disease. All-cause mortality among Belgian military personnel who were radar operators for many years showed no increase compared with their counterparts who were never exposed to radars (25).

Protection and hazards reduction

There are many open questions about protection and health hazards reduction. Some of them are simple to answer but many connected to occupational exposure remain unanswered. Some of the answers are presented in this paper (26).

How can I obtain the Specific Absorption Rate (SAR) value for my wireless phone?

The SAR for a specific phone model can be obtained for many recently manufactured phones using the FCC identification (ID) number for that model. The FCC ID number is usually printed somewhere on the case of the phone. Sometimes, it may be necessary to remove the battery pack to find the number. Once you have the ID number, go to the following Web address: www.fcc.gov/oet/ea/fccid

What steps can I take to reduce my exposure to radiofrequency energy from my wireless phone?

- It is recommended that users who conduct extended conversations by wireless phone every day make more distance between their bodies and the source of the RF, since the exposure level drops off dramatically with distance. For example, use a headset and carry the wireless phone away from the body or use a wireless phone connected to a remote antenna.

- Limit the duration of calls.
- Use a digital handset instead of an older analog model. In most, but not all cases, digital handsets operate at lower power levels than analog models. (The actual power level, however, depends on local conditions and can vary greatly.)

- Use "hands-free kits", which move the handset away from the body.

In occupational settings, there is some preventive measure that could be applied. One of them requires employers who have people working around devices, which produce radiofrequency/microwave radiation, ensure that those devices are properly shielded to prevent leakage of radiation. In addition, there is time limitation of using such devices. Some European countries recommend that precautionary measures be instituted to minimize the risk to workers from unwarranted exposure to RF energy. The following controls are recommended: (27)

- Properly design and install shielding material.
- Maximize the distance between the worker and the source of RF energy emission. Examples of means to accomplish this include the use of automatic feeding devices, rotating tables, and remote materials handling.
- Tune the equipment electronically to minimize the stray power emitted.
- Whenever possible, switch off equipment when it is not being used. Maintenance and adjustment of the equipment should be performed only while the equipment is not in operation.
- Take exposure measurements at regular intervals.

- Warnings should be posted to keep everyone away from the source of radiation except for those workers who are essential for performing the job.

Conclusion

The electromagnetic radiations present important pollution in occupational environment. The effects on human health are cumulative and they are not visible in short time. The pathogenetic mechanisms involved in microwave disorders development are still under investigation. Because of many unknown aspects of the biological effects, it is suggested that some precautions are necessary, and preventive approach is highly recommended. Further researches are necessary to give more information about the effects of microwave radiation on our health, especially in occupational setting and professionally exposed workers.

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BIOLOŠKI EFEKTI RADIOFREKVENTNOG I MIKROTALASNOG ZRAČENJA U USLOVIMA PROFESIONALNE IZLOŽENOSTI

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Štetni efekti radiofrekventnog i mikrotalasnog (RF/MW) zračenja na ljudsko zdravlje postali su predmet brojnih istraživanja i diskusija poslednjih godina. Posebna pažnja je usmerena na štetne efekte mikrotalasnog zračenja mobilnih teflefonija jer ova tehnologija pokazuje eksponencijalni rast. Brojne studije analiziraju efekte RF/MW zračenja u uslovima profesionalne izloženosti, korišćenja telekomunikacionih tehnologija, kod osoba koje žive u blizini radio i televizijskih emitera. Posebno su kontroverzni biološki mehanizmi koji stoje u osnovi štetnog delovanja RF/MW zračenja. Ovi efekti se generalno mogu ispoljiti na reproduktivnom sistemu, neurovegetativnom, kardiovaskularnom i drugim sistemima a mogu imati i kancerogeni efekat. U profesionalnom okruženju najveća ekspozicija registrovana je u blizini radarskih postrojenja, bežičnih komunikacionih uređaja, radio emitera i uređaja magnetne rezonance koji se koriste u medicini. Nekoliko epidemioloških studija navodi udruženost ekspozicije RF/MW zračenju sa nespecifičnim zdravstvenim tegobama i simptomima kao što su glavobolja, umor, poremećaji sna, rasejanost, mučnina i dr. Ovi nalazi registrovani su ne samo kod korisnika mobilne telefonije već i kod osoba koje žive u blizini baznih stanica mobilne telefonije i kod radnika profesionalno izloženih ovoj vrsti zračenja.

Biološki efekti RF/MW zračenja koji zbog svog kumulativnog delovanja nisu vidljivi u kratkom periodu ukazuju na potrebu preventivnog pristupa pri korišćenju ovih novih tehnologija u životnom i radnom okruženju. Dalja ispitivanja su neophodna da bi se rasvetlili patogenetski mehanizmi koji stoje u osnovi poremećaja izazvanih mikrotalasnim zračenjem i da bi se razvile metode zaštite posebno u radnom okruženju kod profesionalno izloženih radnika. *Acta Medica Medianae* 2011;50(4):74-78.

Ključne reči: profesionalna ekspozicija, mikrotalasno zračenje, zdravlje, efekat