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The microwave syndrome or electro-hypersensitivity: historical background

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Abstract: Microwave generating equipment first became common during World War 2 with the development of radar. Soviet bloc countries reported that individuals exposed to microwaves frequently developed headaches, fatigue, loss of appetite, sleepiness, difficulty in concentration, poor memory, emotional instability, and labile cardiovascular function, and established stringent exposure standards. For a variety of reasons these reports were discounted in Western countries, where the prevailing belief was that there could be no adverse health effects of electromagnetic fields (EMFs) that were not mediated by tissue heating. The reported Soviet effects were at lower intensities than those that cause heating. However, there were several accidental exposures of radar operators in Western countries that resulted in persistent symptoms similar to those described above. The Soviets irradiated the US Embassy in Moscow with microwaves during the period 1953–1975, and while no convincing evidence of elevated cancer rates was reported, there were reports of "microwave illness". Officials passed these complaints off as being due to anxiety, not effects of the microwave exposure. There is increasing evidence that the "microwave syndrome" or "electro-hypersensitivity" (EHS) is a real disease that is caused by exposure to EMFs, especially those in the microwave range. The reported incidence of the syndrome is increasing along with increasing exposure to EMFs from electricity, WiFi, mobile phones and towers, smart meters and many other wireless devices. Why some individuals are more sensitive is unclear. While most individuals who report having EHS do not have a specific history of an acute exposure, excessive exposure to EMFs, even for a brief period of time, can induce the syndrome.

Keywords: cognitive dysfunction; electromagnetic fields; headache; insomnia.

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Introduction

Electro-hypersensitivity (EHS) is a syndrome that may include some or all of the following: excessive fatigue, headache, tinnitus, insomnia, photophobia, a feeling of cognitive dysfunction and impaired memory, irritability, pain at various sites and often cardiovascular abnormalities (1). However, these are all relatively common complaints. All of us have on occasion suffered from headaches and insomnia. Because the symptoms are relatively non-specific, and because the adverse health effects of electromagnetic fields (EMFs) is a contentious issue, and also because primary care physicians have no objective diagnostic algorithms by which to diagnose EHS, patients suffering from EHS are often referred to a psychiatrist. There is, however, a body of evidence, both old and more recent, that indicates that these symptoms are triggered by exposure to EMFs in sensitive individuals. This is the case for exposure to both the extra low electromagnetic fields (ELF) coming from electricity and the radiofrequency (RF) EMFs coming from radar, communication devices, WiFi, smart meters and many other forms of wireless devices.

The symptoms of EHS have a number of commonalities to those of several other syndromes, including chronic fatigue, fibromyalgia, multiple chemical sensitivity, Gulf War Illness and others. These are sometimes collectively identified as "idiopathic environmental intolerance". They have in common symptoms of fatigue, weakness, headaches, difficulty concentrating, multiple aches and pains, difficulty with sleep, and often difficulties with balance and vertigo. While the triggering events vary for each of these syndromes, many people suffer from more than one. A critical question is why some develop these sensitivities while others do not.

There are conflicting estimates on what percent of the population suffers from EHS, with some suggesting that between 5 and 10% of people have the syndrome, and that the incidence is increasing with time (2). However, there are several reports of tests of individuals taken into a laboratory and their responses recorded when they were unaware of whether or not an EMF field was being applied. Some of these studies have not shown that individuals who report that they are electro-sensitive are in

fact able to discern if the EMFs are present or not (3–6). However, these reports are balanced by others that show that at least some individuals do respond with adverse symptoms when exposed to EMFs in a blinded fashion (7, 8). Thus not everyone who believes they are electrosensitive really is, but it is also likely that some have the symptoms of EHS but have not identified the cause. Thus the true incidence of EHS is currently not known.

Table 1 lists the symptoms reported in two studies by individuals who believe that they suffer from EHS. These are self-reported symptoms, and because all occur commonly in the general population they illustrate the difficulty in confirming that the cause is exposure to EMFs.

Microwave sickness

Soviet and Eastern European standards for exposure to EMFs have long been much more stringent than those in Western countries (11). As shown in Table 2 the Soviet countries' standard for maximal permissible exposure during the workday is 1,000 times lower than that in the US. These lower standards were set based on concern for the "asthenic syndrome", characterized by fatigue, pain, depression, blood pressure lability, fainting, and "apathic ambulic" disorders consisting of hypersomnia, hypokinesis, hypothalamo-pituitary-suprarenal weakness, and inhibition of sexual and digestive reflexes [reviewed by references (12) and (13)]. Memory and general mental function was also described as being impaired. Frey (14) has reviewed other studies by Soviet scientists who report a variety of behavioral and nervous system affects in animals and humans with EMF exposures much below the levels that cause tissue heating.

Table 1: Reported symptoms from Röösli et al. (9) and Lamech (10).

	Röösli et al. (n=429)	Lamech (n=92)
Insomnia	58%	48%
Headaches	41%	45%
Fatigue	18%	32%
Concentration difficulties	16%	30%
Nervousness	19%	13%

Table 2: US Armed Forces and Soviet standards for maximum permissible exposure to microwaves (10 mW/cm^2=0.01 mW/m^2) [Data from reference (15)].

USDOD standard	USSR standard
10 mW/cm^2	0.01 mW/cm^2 over an entire workday No more than 0.1 mW/cm^2 for more than 2 h No more than 1.0 mW/cm^2 for more than 15–20 min

The strength of the evidence supporting the lower standards in Soviet and Eastern European countries is difficult to evaluate because most publications lack sufficient experimental details regarding exposure parameters and documentation of experimental results. None-theless these symptoms are very much those that comprise the syndrome of EHS.

During the period 1953–1975 the Soviets irradiated the US Embassy in Moscow with microwaves (2.5–4.0 GHz) at intensities up to 18 μW/cm^2 (16, 17). A health study of 1,800 employees who worked at the Moscow embassy and more than 3,000 dependents was performed by AM Lillienfeld from the Johns Hopkins University, as compared to employees at other embassies in Eastern Europe. The study was never published although he summarized some of the results briefly in a review article (18). The study was reported to not show an excess risk of cancer or early death, but did find significantly more depression, irritability, difficulty in concentrating and more memory loss among the exposed Embassy staff, especially in men. While the intensity of symptoms did not correlate well with the intensity of exposure (19), this could reflect differences in individual susceptibility. However, as emphasized by Johnson-Liakouris (20), the health conditions that were reported match those of the microwave sickness syndrome.

Serious questions (21) have been raised about how the results were reported and interpreted. Goldsmith examined the original report as compared to the information that was released by the US State Department, and found that the conclusions of Prof. Lillienfeld had been altered and in some cases deleted, and found that this was at the request of his contracting officer. Goldsmith concluded that there had been a persistent cover-up and deliberate distortions of the conclusions made by the author of the report. Among other findings he concluded that there was an elevated rate of leukemia among the highly exposed group, and that information on some of the cancers was withheld from Dr. Lillienfeld until after the report was submitted. In a later publication Goldsmith (22) reported that there were more lymphocyte chromosomal changes in the Moscow workers as well. Unfortunately we will probably never know the actual results of this study.

This is, however, other evidence that EHS is a real disease. Djordjevic et al. (23) investigated the health status of 322 radar workers all of whom had 5–10 years of occupational exposure to microwave fields. They did not find

significant differences in clinical or laboratory findings, but did report that the radar operators had more subjective complaints than a control group. This was particularly true for headache, fatigue, irritability, sleep disturbances and inhibition of sexual activity. However, the authors concluded that the subjective complaints likely reflected factors other than microwave exposure, however.

Some of the strongest evidence that EHS is a real syndrome comes from cases of acute high intensity exposure to microwaves of healthy people, which resulted in prolonged illness. Williams and Webb (24) reported effects of two airmen exposed to high levels of RF radiation. After an immediate sensation of heat, they later developed nausea, lightheadedness and extreme apprehension with poor appetite and photosensitivity. Forman et al. (25) reported on two men who were accidentally and acutely exposed to microwave radiation. Both exhibited symptoms of headaches, insomnia, irritability and emotional lability even after a 12-month follow-up. Both also developed hypertension several months after exposure. Schilling (26) reported on three men accidentally exposed to 785 MHz RF radiation. All experienced immediate sensations of heating, followed by pain, headache, numbness and parasthesiae, malaise, diarrhea and skin erythema. The first man, age 44, experienced lassitude, lack of stamina, drowsiness and chronic headache. The symptoms gradually improved over 3 years follow-up, but he still had chronic headaches at 3 years. The second man, age 47, also had lassitude, lack of stamina, drowsiness and chronic left sided frontoparietal headache, which was made worse by exposure to sun or heating. The symptoms improved somewhat over 3 years follow-up but the headaches remained. The third man had a lower exposure and his symptoms almost disappeared after 18 months. Schilling (27) reported on six antenna engineers exposed in two separate incidents. All experienced acute headache, parathesias, diarrhea, malaise and lassitude. Four of the men showed no improvement in symptoms after follow-up for 3 or 4 years, with headache, loss of stamina, several malaise and lassitude being the major symptoms.

Reeves (28) reported on 34 US Air Force personnel who were at some point exposed to RF at intensities greater than the permissible exposure limits. Acute symptoms included a sensation of heat, headaches, muscle pain and photophobia. An unspecified number of these subjects exhibited longer lasting symptoms, but these were dismissed as being due to factors other than the exposure. Two-thirds of the subjects were given psychometric testing and found to have "abnormalities including antisocial personality, mild organic brain syndrome, anxiety, tendency toward hypochondriasis and somatization, and in one case, frank malingering in an individual described as being 'emotionally invested in maintaining symptoms for the purpose of meeting emotional needs'". The author concluded that the several subjects who complained of prolonged fatigue, generalized weakness, irritability, decrease memory and concentration and weight changes "seem to reflect a personal 'coping style' of long duration or else manifestation of pre-exposure organic dysfunction, rather than an acute change attributable to RFR overexposure." This general attitude of dismissal of prolonged symptoms in young, otherwise healthy males is indicative of the general response to EHS. Is seems very unlikely that 2/3rd of young, otherwise healthy US Air Force personnel suffer from serious psychiatric disease!

Does some acute exposure trigger EHS? Case studies

The author has also had opportunity to review the exposure and medical history of several individuals whose history is similar to that of the radar operators. Brief summaries of their exposures and symptoms are given below.

JG was a technical expert at repair of RF generating equipment who prior to an accidental RF exposure was healthy. In 2011 he was called to a site to troubleshoot three radios and antenna cables in a facility where all other RF generation equipment was supposed to be shut down. After 1–2 h of work within the facility he began to feel hot and developed a headache, dizziness and nausea. He left the room and was taken a hospital, where he was found to have mild burns on his face, head and neck. It was subsequently determined that not all of the equipment had been turned off and that he had been exposed to concentrated RF for the whole period of time he was in the room. When seen by a neurologist 1 month later he was found to suffer from headaches, dizziness, photosensitivity, nausea, confusion and difficulty with cognition. His gait was unsteady and he was easily disoriented. He noted that he was more irritable, less spontaneous, had decreased sex drive and memory problems. When he and the author met two and a half years after the exposure he complained of constant headaches, confusion and memory loss, lower back, hip and stomach pain, nausea, weight loss, vertigo and constant anxiety and depression. Thus an acute excessive exposure to RF radiation led to a syndrome of adverse health effects that continued essentially unabated for at least two and a half years, and had all of the characteristics of EHS.

JJ is a 41-year-old man who also was healthy prior to a near electrocution event while working at home. Upon contacting a live wire he froze, lost consciousness for about 30 s, but did not suffer from cardiac problems. He went to the hospital with a very bad headache, but was not found to have other abnormalities. Subsequently he was fatigued, had severe photophobia and very severe headaches, which he had never had before. Four year later he has constant dizziness, frequent headaches, vertigo, and nausea, and the symptoms are greatly increased when he is in the presence of EMFs, particularly RF. Again it appears that an acute exposure caused an increased sensitivity to EMFs which has not gone away over a period of several years. However, in this case the acute exposure was to electric current from the household electricity, including extremely lower frequency EMFs.

DL served multiple tours in the US Army in Afghanistan and Iraq as a gunner in a vehicle that used equipment to detect cell phone-detonated improvised explosive devices (IEDs). These electronic counter measures (ECMs) are vehicle-mounted high-power microwave systems that put out a wide range of frequencies at high wattage. He reported that these devices were put into the field rather quickly without any real studies conducted as to the long term effects on health. Gunners were directly exposed to the ECMs, and when they were running he could actually hear a buzzing sound inside the head phones he wore for internal vehicle communications. Upon returning home he suffered constant headaches, difficulty thinking clearly, nausea and tinnitus. He was treated for post-traumatic stress syndrome, but believes these symptoms arose because of the RF exposure. It is interesting and relevant that Westhoff et al. (29) recently published a report of six soldiers in two separate incidents who experienced nausea and headache during an ECM mission in southwest Asia. Their symptoms were dismissed by the military authorities who concluded "the symptoms could not be linked with exposure to the HPM (high-power microwave) systems in any manner 'consistent with current scientific literature'".

A different DL, age 34, worked in information technology but developed insomnia and headaches. He discovered the cause was a DECT cordless phone, which caused tinges in his vision and severe headaches. These symptoms disappeared within 12 h after the DECT phone was turned off. Shortly after that he noticed intolerance to his laptop, and then over a period of 6 months developed difficulties in concentration. He noticed heart palpitations when he was close to the cordless phone base or laptop. This evolved within a recent period of being intolerant of his neighbor's WiFi, but again he got relief when it was turned off. He is currently in good health as long as he stays away from sources of RF.

JJ, a civil engineer, and his wife live in California. Both were in excellent health. They went on vacation, and when they returned found that they both suffered from intense headaches, heart palpitations, tinnitus and insomnia while in their home, with relief when they left their home. Without their knowledge while they were away a rack of wireless smart meters had been installed directly below their bedroom. It took 4 months to get the utility to remove the smart meters, but by that time both had become electro-hypersensitive. This resulted in splitting headaches if using a cell phone, and it was painful to be in a WiFi environment or use a computer. The symptoms have not diminished over time if either is in an RF environment.

Discussion

EMFs are almost never simple sine waves. Powerline EMFs also have many higher frequency RF components, transients, harmonics and resonance frequencies (30–33). Furthermore most RF EMFs are pulse-modulated and often on carrier waves (34). Some applications of RF EMFs, such as in smart meters, use atypical short pulses of RF of very high intensity but very brief duration of individual pulses.

Recent years have seen a marked increase in overall exposure to EMFs. Urbinello et al. (35) monitored RF exposures in several European cities and found that in 1 year there were increases of between 20.1 and 57.1%, with much of the increase coming from mobile phone base stations and public transport. In many countries "smart" meters are being placed on homes, apartments and business establishments which report electricity usage to the utility using RF EMFs. And the use of RF to monitor electrical usage is scheduled to increase significantly. As the "smart (or perhaps not-so-smart) grid" develops, each household application will have a Zigbee RF generator in every kitchen and laundry room appliance, with each appliance sending RF signals to the smart meter, which will send RF signals to the utility. This will significantly increase RF levels inside homes, adding to the WiFi and other existing sources.

The report by Lamech (10) raises the possibility that excessive exposure to RF, perhaps to some specific characteristic of the RF waveforms associated with smart meters, triggers the development of EHS. As stated in this paper "….since the beginning of installation of wireless smart meters in the state of Victoria, people from various regional and metropolitan areas, of all ages and during all

seasons have started to report symptoms from exposure to the meters' radiofrequency fields…, only 8% of cases stated that they had suffered from EHS prior to exposure to smart meters, which suggests that when it comes to wireless meters, the threshold for symptom development appears to be significantly lower compared to that for other wireless devices".

There has always been uncertainty over which characteristics of EMFs are most important with regard to human health effects. Because the mechanisms whereby these various adverse health outcomes arise are still not well understood, it is important to ask the question of which components pose the greatest risk, whether or not we are confident of the answer. Frey (36, 37) first suggested that peak power density was more important than average power density. Litovitz et al. (38) concluded that 60 Hz EMFs and RF EMFs do very much the same things, and later studies suggested that the low frequency, modulatory component of RF was particularly important (39). Others have implicated on-off transients, "dirty electricity" and other characteristics of the fields than the steady 50 or 60 Hz fields.

The typical exposure from a smart meter is less than that of use of a cell phone held to the head [see Table 1 in reference (40)], and like that from other sources of RF does decline rapidly with distance from the smart meter. However, the smart meter RF radiation is significantly different from many other forms of RF, in that it consists of brief but very high intensity pulses. Thus, whereas the average exposure over time is not excessive it appears possible that the high intensity pulses are responsible for the development of EHS. Brief intense pulses have been described as "dirty electricity" by Milham and Morgan (33), who suggest that many of the reported adverse effects of EMFs are due to these brief events, rather than the sine wave forms. Since brief transients are founds among all forms of EMFs, including power line frequencies, these events may be the more important variable.

Conclusion

The weight of evidence indicates that EHS is a real syndrome induced by exposure to either ELF or RF EMF. In some cases it results from a brief, high intensity exposure, whereas in others it appears to reflect ambient exposures, especially those of increasing intensity and perhaps of certain waveforms. Whether from acute high intensity exposure or ambient background exposure from cell towers, mobile phones, smart meters and other devices, it is clear that not everyone develops EHS, for reasons not well understood. Certainly more research is needed to understand exactly which of the components of EMF exposures pose the greatest danger to human health, and what biological mechanisms are responsible. But the important conclusion is that there is something about EMFs of various forms that do pose direct hazards to human health.

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