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HARMFUL EFFECTS OF ELECTROMAGNETIC FIELD ON DIFFERENT TISSUES: A REVIEW

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Abstract

Studies about the potential effects of the electromagnetic field on the human body are increasing day by day. In this study; new investigations on this field were tried to be explained by the help of literature. It is shown in many studies that electromagnetic waves as well as the electromagnetic field that is given out by some of the equipment we use, create negative effects on biological systems of humans. Moreover; it had concluded that there are roles of molecular pathways such as oxidative stress on electromagnetic field induced diseases. These effects are the short term effects and long term effects. Preventitive measures should be high priority and risks should be minimized.

Key words: *Cell degeneration, electromagnetic wave, cell phone, harmful effect.*

Rezumat

Efectele nocive ale câmpului electromagnetic asupra diferitor ţesuturi: o revizuire

Studiile privind efectele potenţiale ale câmpului electromagnetic asupra corpului uman cresc în fiecare zi. Această lucrare încearcă să explice noile cercetări din domeniu pornind de la literatura relevantă. În multe studii se arată că undele electromagnetice, precum şi câmpul electromagnetic oferit de unele dintre echipamentele pe care le folosim, creează efecte negative asupra sistemelor biologice ale oamenilor. În plus, s-a stabilit că există o influenţă a căilor moleculare, cum ar fi stresul oxidativ asupra bolilor induse de câmpul electromagnetic. Sunt efecte pe termen scurt şi efecte pe termen lung. Măsurile preventive ar trebui să fie prioritare, iar riscurile ar trebui reduse la minimum.

Cuvinte-cheie*: Degenerare celulară, undă electromagnetică, telefon mobil, efect nociv.*

Резюме

Вредное воздействие электромагнитного поля на разные ткани: обзор

Исследования о потенциальном воздействии электромагнитного поля на человеческий организм увеличиваются день ото дня. В этом исследовании; новые исследования в этой области пытались объяснить с помощью литературы. Во многих исследованиях показано, что электромагнитные волны, а также электромагнитное поле, излучаемое некоторым оборудованием, которое мы используем, оказывают негативное воздействие на биологические системы человека. Более того; был сделан вывод о роли молекулярных путей, таких как окислительный стресс, в заболеваниях, вызванных электромагнитным полем. Эти эффекты представляют собой краткосрочные и долгосрочные эффекты. Превентивные меры должны быть приоритетными, а риски должны быть сведены к минимуму.

Ключевые слова*: клеточная дегенерация, электромагнитная волна, сотовый телефон, вредное воздействие.*

Introduction

Especially in the last decade; electromagnetic field (EMF) and the potential harmful effects on the human body are heavily researched in the medical field and engineering all around the world. All the electronic equipment used in our daily lifes create EMF. Electromagnetic sources can be classified into two; Natural electromagnetic sources (sun, some distant stars, atmospheric discharges like thunder, or human body) and unnatural or human-made sources (cables that carry electrical currents, television (TV) and computers, electrical home gadgets, radio and TV base stations, cell phones, mobile phone base stations, and phone equipment) [1, 2].

Nowadays, the variety of the communication equipments as well as the equipment that uses different frequencies are increasingly emerging. Frequency, is number of vibrations of electromagnetic waves in a particular time, at certain points. One cycle of an electromagnetic wave in one second is 1 Hertz (Hz), and one megahertz (MHz) is equal to one million cycles in 1 second. Analog phones work at frequencies between 800 and 900 MHz whereas digital phones work at 1850 to 1990 MHz [3].

In this study; a review of biological effects of electromagnetic field on tissues in human and experimental animals are investigated by the help of literature.

Harmful effects of EMF sources

There are many EMF sources that has harmful effects on human body. Cell phones have a unique place in EMF studies. Furthermore; computer monitors generate EMF between the frequencies of 0 and 1015 Hz. Recent findings indicate that chatode ray tube (CRT) monitors have high risk, while liquid crystal display (LCD) monitors has less EMF generation. Measurements indicate that with distance from the monitor EMF looses its strength [4]. Moreover; one of the important sources for the EMF generation is microwave ovens. They are commonly used at homes, since they are very practical.

Decreasing of the area of vision, loosing of consentration, heavy stress and feeling of tiredness, voices in the ears and warming of ears, reversable hearing problems, headache, electrical burn [5] and such can be seen as the short term effects. The long term effects are; irreversible hearing problems, increasing risk of miscarriage, decrease in the number of sperms, damaging of the embriyonic development and the brain tissue, weakening of the memory, heart related problems, lymphoma and damaging of the genetic structure [6, 7].

EMF and ear:

Related with EMF originated from cell phones; head and the neck are the most important areas [8]. One of the major hearing problems that is caused by cell phones is the acustic neurinoma [9]. The results support that long-term exposure to a GSM-like 2100 MHz electromagnetic fields causes an increase in neuronal degeneration and apoptosis in the auditory system [10].

EMF and eye:

To investigate the adverse effects of mobile-phone on the antioxidant balance in corneal and lens tissues and to observe any protective effects of vitamin C in this setting. The results of this study suggest that mobile telephone radiation leads to oxidative stress in corneal and lens tissues and that antioxidants such as vitamin C can help to prevent these effects [9].

EMF and testise:

The prelimanary results of the studies conducted so far about EMF and testise, have shown symptoms of oligospermy in men [11]. In a recent study by Masood Sepehrimanesh and his collegues, their results indicate that exposure to radiofrequency-electromagnetic field produces increases in testicular proteins in adults that are related to carcinogenic risk and reproductive damage [12]. And another study about sperm cell said that Rats exposed to 6 hours of daily cellular phone emissions for 18 weeks exhibited a significantly higher incidence of sperm cell death than control group rats [13].

EMF and urinary system:

The studies involving the effects of cell phones on kidneys showed that renal tubules are mostly effected (cortical renal tubular epitelium is effected more then the medular tubules [14, 15]. The study was to investigate oxidative stress and apoptosis in kidney tissues of male Wistar rats that pre- and postnatally exposed to wireless electromagnetic field (EMF) with an internet frequency of 2.45 GHz for a long time may cause chronic kidney damages; staying away from EMF source in especially pregnancy and early childhood period may reduce negative effects of exposure on kidney [16]. And another study say that, they conclude that continuous exposure to the effect of 900-MHz EMF for 1 h a day on postnatal days 22-59, inclusive, causes an increase in oxidative stress and various pathological changes in male rat kidney and bladder tissues [17].

EMF and cancer:

The literature related with tumors show that electromagnetic fields do not directly advance cancer growth. Besides; they increase the flow of materials into the cell that cause cancer. Therefore it worsens the stage of the cancer [18]. Studies conducted in Swetzerland and in Mexico showed that there is a relation between living close to base stations and the occurance of cancer in children specifically leucemia [19, 20].

EMF and skin:

Human skin emerge as a protective barrier toward the harmful effects of the mobile phones. However, there are studies report that there might be changes even on the skin due to the effcets of the mobile phones [21].

EMF and brain:

Human brain is a structure that functions with electricity, therefore an electromagnetic field can directly effect the function of the brain. Mechanism may be related with the increase of chemical materials known as the free radicals, in the brain, in the presence of electromagnetic field over normal levels. In a recent study; total purkinje cell numbers calculated using stereological analysis werefound significantly lower. Additionally, some pathological changes such as pyknotic neurons with dark cytoplasm were observed in EMFG sections under light microscopy [22]. Another study showed that EMF inhibit the formation and differentiation of neural stem cells during embryonic development and also affect reproductive and neurological health of adults that have undergone prenatal exposure [23].

EMF and complicated birth:

In some studies, it is shown that pregnant women who have stayed in magnetic fields for long periods experienced more complicated births. It is also stated that high magnetic fields increase the

chances of miscarriage compared to regular pregnancies [24]. Even though the data is not conclusive, it is recommended for pregnancy women to restrict the use of cell phones during pregnancy [25]. In a study, transmission electron microscopy showed pathological changes in cell morphology in the thymic and splenic tissues of newborn rats exposed to EMF. Exposure to 900 MHz EMF during the prenatal period can cause pathological and biochemical changes that may compromise the development of the male rat thymus and spleen [26].

EMF and neurological diseases:

DNA damage can cause diseases that effect the nervous system or induce the progress of these diseases. One of the distinctive features of neuron cells that seperates them from the other cells is the fact that they can not divide. DNA damage in cells that perform cell division can cause the occurrence of cancerous cells. However, since the neuron cells can not divide, the damage in the neuron cell DNA mostly effects the function of the cells or causes deaths of the cells. On the other hand, glia cells that are the support tissue of nervous systems can divide. Therefore, DNA damage in these areas can cause cancer [27]. A study about the potential effects of electromagnetic field on spinal cord showed that biochemical alterations and pathological changes may occur in the spinal cords of male rats following exposure to 900MHz EMF for 1h a day on PD 21-46 [28].

EMF and hematopoietic system

A study about the potential effects of electromagnetic field on hematopoietic system showed that; significantly increase in the carbonyl content of the plasma was demonstrated in the presence of EMF and lead ions. Additionally, there was a positive correlation between the carbonyl content of plasma and the oxidative modifications to Hb [29]. Moreover; another study showed exhibited several morphological changes, including increased distribution of blood vessels along with the appearance of red blood cells and hemorrhagic reticuloepithelial cells [30].

EMF and hormones and enzymes:

Iit has been observed that electromagnetic waves propogating from monitors tends to reduce melatonin levels and increasre adrenocorticotropic hormone (ACTH) levels in the human body [31]. RF exposure is reported to induce lipid peroxidation, accompanied by decreased activity of superoxide dismutase (SOD), myeloperoxidase (MPO) and glutathione peroxidase (GSH-Px), in various organs, such as guinea pig liver and rat kidney [32].

Table 1

Effects of EMF on different tissues in animal and humans

Tissue	Effect	Reference
Ear	Acustic neurinoma Neuronal degeneration and apoptosis in the auditory system	Salahaldin, Bener, 2006 Balcı et al., 2007 Deepinder, 2007 Oktem et al., 2005 Kang et al., 1997 Ozguner et al., 2005 Pyrpasopoulou et al., 2004 Sanchez et al., 2006 Ozguner et al., 2004 Hardell et al., 2007 Kan et al., 2007 Brain, 2009 Arnetz, Berg, 1996 Çeliker et al., 2017 Yan et al., 2007 Sepehrimanesh et al., 2017 Kaplan et al., 2016 Kuybulu et al., 2016 Türedi et al., 2017 Ansarihadipour et al., 2016 İkinciet al., 2016 Kaplan et al., 2016 Özgur et al., 2010
Eye	Corneal and lens tissues damages	
Testise	Oligospermi and sperm cell death Carcinogenic risk and reproductive damage	
Kidney	Tubuler epitelium damage Chronic kidney damages Pathological changes at kidney and bladder tissues	
Skin	Harmful changes	
Blood and hematopoietic system	Leucemia Oxidative modifications to Hb Several morphological changes at thymus tissue	
Neurological system	Cancer Pathological changes in the spinal cords Neurological systems damages	
Hormones and enzymes	Melatonin ↓ ACTH ↑ SOD, MPO and GSH-Px ↓	
Intracelluler	DNA damage, oxidative stress	

Role of antioxidants:

As a result of the normal functions of the cells small amounts of these compounds are produced and they are broken up by the antioxidant defence system of the cell. If these compounds can not be broken up they damage the structures of many compounds that are structurally crucial like deoxirebonukleic acid (DNA) in a cell. In addition, free radicals also cause changes that radically effect the functions of a cell such as releasing calcium ions from the cell to the cell liquid. Electromagnetic field reduces the speed of destroying free radical compounds [27]. The studies involving the effects of the link between radiofrequencies emitted from wireless technologies and oxidative stress indicated that mobile phones and similar equipments can be thought as a factor, which cause oxidative stress. Even some of them claimed that oxidative stress originated from radiofrequencies can be resulted with DNA damage [33].

Table 2

Effects of antioxidants on electromagnetic field-induced oxidative stress in animal models

Antioxidants	Frequency of EMF, animal and tissue	Effect	Reference
Vitamin E and C (50 mg/kg IM and 20 mg/kg IP) Melatonin (100 g/kg) Cape (10μMml−1 kg−1 day−1)	900 MHz, rat and endometrial tissue 900 MHz, rat and kidney 900 MHz, rat and kidney	Protective Protective Protective	Oral et al., 2006 Oktem et al., 2005 Ozguner et al., 2005

Besides these antioxidants; L-carnithine and selenium seemed to have protective effects on the 2.45 GHz induced decrease of vitamins A, C and E. L-carnitine seemed to be more protective than the selenium administration [34].

Conclusion

It can be seen from literature that; EMF has potential harmful effects on tissues in human and experimental animals. Moreover, it had concluded that there are roles of molecular pathways such as oxidative stress on electromagnetic field-induced diseases. Besides; some antioxidants exhibits a protective effect on EMF induced impairment.

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