Indian J. Applied & Pure Bio. Vol. 37(3), 789-794 (2022). **ISSN: 0970-2091**
A web of Science Journal

Effect of cell phone radiation on major Human organ systems- A review

Abhilash Achary[1], Aryan Gupta[1], Nityananda Ghosh[2] and Sushma Patkar[1*]

[1]Department of Genetics and Biotechnology
Bhavan's Vivekananda College of Science, Humanities and Commerce
Sainikpuri-500094 (India)
[2]Department of Chemical Technology
Loyola Academy Old Alwal-500078 (India)
*sushma.ghosh@gmail.com

Abstract

Mobile phones are part of our lives. However they can be potentially the most dangerous sources of Electromagnetic radiation. They may lead to DNA damage and cancer. Studies have showed evidence of increased alpha, beta and gamma frequencies; all three of which induce attentiveness, focus and anxiety upon usage of mobile phones. Other effects include induced hormonal imbalance, alteration in skin proteins, decreased sperm count and motility, distortion of blood RBC and platelet structure and cellular damage associated with muscle and nervous tissue. Since one may not always be certain to keep mobiles at a recommended distance (10cm), it is best to avoid or limit their usage.

Mobiles and other portable devices have become a common affair. We are constantly weaving a new tech-dependent environment where our daily motives require usage of these innovations in one way or the other.

A study in 2014 showed that the percentage of mobile phone users around the world increased from 12% in 2000 to 96% in 2014, which approximated 6.8 billion subscriptions[30]. A survey by Sun (2021) showed that in India alone, 748 million people used mobile phones and estimates to reach 1.5 billion users[29] by 2040.

Mobile phones are potentially the most dangerous sources of Electromagnetic radiation. An electromagnetic field (EMF) comprises both electrical and magnetic components. Both fields are known to have an impact on the biological system but the magnetic field is more damaging as it penetrates living tissues more easily. Mobile phone radiations, also called as radio frequencies, comprise the frequency range of 450-2700 MHz [34] and lie between FM Radio waves of 87-108 MHz and Microwaves of frequency 3-30 GHz [16]. Since they have lower frequency than microwaves, they do not have detrimental thermal effects. Extremely low frequencies (ELF) are more harmful when compared to higher frequency

radio waves when pulsed or amplitude modulated at a lower frequency. Commonly used GSM cell phones or PDAs emit both pulsed radio waves and ELFs and hence are observed as a potential threat[2]. The effects of EMF can be classified into Thermal (EM waves are absorbed by the body which raises temperature) and Non Thermal (EM waves generate mutations or DNA damage)[27]. Non-Ionising Radiations have low energy and cannot directly break covalent bonds. However, they increase the entropy of the molecules that results in vigorous vibrations and breakage of covalent bonds[33]. This results in DNA damage, loss of regular cellular functions and possibly cancer. The International Agency for Research on Cancer (IARC) concluded in 2011 that these radiations are possibly carcinogenic[4]. Thus we understand that mobile phone radiation emitted can be toxic to human health in the long run.

The deleterious effects of mobile phone radiation is mainly related to its genotoxicity (the property that enables radiation to cause structural damage)[9].

The present study aims to understand the effect of radiation on human health. We referred many articles from PubMed, Google Scholar, National Digital Library of India, Statista and official pages of WHO and FDA and limited our study to the effects of radiation emitted by cell phones on various human body systems including Nervous System[8,25,26,35], Endocrine System[5-7,15,20,32], Reproductive System[1,3,10,11,13,14,18,21,22] Integumentary System[23,24,28], Circulatory System[12,17] and Skeletal System[28].

The exact mechanism for damage, effects on other vital organs and effects on mental health of humans leaves scope for further research.

There is not much evidence on the thermal effects of RFs in existing literature. The effect of cell phone radiation on various human organ systems is summarized below.

1. Nervous System :

Zhao *et al* (2007) cultured astrocytes and neurons (both being cells of the nervous system) and exposed them to mobile phone radiations of 1900MHz[31]. Their study revealed an increased expression of Caspase-2, Caspase-6 and Asc proteins in both neurons and astrocytes. Additionally, astrocytes showed expression of Bax genes. Caspase-2 upregulates expression of apoptosis effectors. Caspase-6 plays a key role in human neuronal degeneration. Bax genes are core regulators that cause perforations in the outer mitochondrial membrane during apoptosis. However they could not identify the exact component of the electromagnetic radiation considering its long range. Rauscher *et al*.,[25] reported that apoptosis can also be induced by EMFs by activation of Egr-1 protein. Egr-1 protein is a transcriptional activator of a cascade of proteins involved in cell death mechanism[25]. EMFs have shown to increase Egr-1 gene expression in neuroblastoma cells. Proteins of this gene target other genes like TNFa, p53 and Bax genes, all of which translate into proteins that have apoptotic or growth inhibiting function[8]. Roggeveen *et al.*[26] recorded the effect of cell phone radiation on brain activity. Since the brain functions with electrochemical processes, EM

waves tend to interfere with them. The EEG observations changed by a 15 minute exposure of RF-EMFs[26] and showed evidence of increased alpha, beta and gamma frequencies; all three of which induce attentiveness, focus and anxiety.

2. Endocrine System :

Most studies carried out in humans used limited time exposure for ethical reasons. Touitou *et al.,*[32] performed studies on effects of EMF on melatonin and cortisol. Melatonin is a neurohormone, secreted by the pineal gland which regulates the diurnal rhythm of our body (sleep-wake cycle, body temperature). Cortisol is a steroid hormone responsible for regulation of blood sugar levels and body metabolism. This study analyzed workers dealing with EMF radiation for 20 years and showed no effect on melatonin and cortisol production[35]. This disproved the Melatonin Hypothesis (which stated that ELF-EMFs decrease melatonin levels in blood plasma) and also explained the probable causes of cancer related to ELF-EMF [32]. In a study performed on 83 undergraduate students of Malankara Orthodox Syrian Church Medical College (71% participants had no family history while the remaining had relatives with first and second degree thyroid dysfunction), there was found a significant correlation between exposure of EMF radiation and TSH levels. Among the 83 students, about 79.5% students showed no effect while 13.6% students reported thyroid swelling, 3.6% reported thyroid dysfunction and remaining 3.6% of students reported both the symptoms[5]. The anatomical position of the thyroid gland at the anterior region of the neck makes it most vulnerable to constant EMF exposure[6]. Mortavazi *et al.,*[20] reported minor degrees of thyroid dysfunction in 77 university students, where mobile phone users showed higher TSH levels and low T4 levels[20].

Among studies on other hormones like LH, FSH, Prolactin, Growth Hormone, Thyrotropin and Adrenocorticotropin no effect of EMFs was reported on their production or function[7].

3. Reproductive System :

Glaser[15] analyzed effects of EMF exposure on testis and observed decreased testosterone levels and spermatogenesis, reduction in testis size and histological changes in epithelial structure[15]. Reports of lowered fertility in both males and females because of EMF exposure is due to VGCC activation along with increased Calcium ions that prevent sperm from fertilizing eggs. Lowered libido due to low levels of estrogen and testosterone was also observed[18]. Radiation from mobile phones leads to the formation of ROS (free radicals formed from oxygen metabolism) in human semen[11]. A study by Agarwal *et al.*[1] on 361 male patients who had consulted a fertility clinic analyzed and stated the adverse effects of RF-EMFs on sperm count, motility, viability and thereby fertility in men[1]. Fejes *et al.,*[13] similarly conducted a study on 371 men and observed inverse correlation between exposure of cell phone radiation and sperm motility[13]. Davoudi *et al.,*[10], in a small study, analyzed semen of 13 men before and after exposure to cell phone radiations. They observed decreased rapid progressive motility of spermatozoa when exposed for 6 hours per day for 5 days[10].

An in vitro study[3] on human sperm culture suggested that radiations further can cause DNA fragmentation in sperm cells[3]. Since cell phones are carried in pant pockets or clipped to waist belts, this increases the chance of exposure to high power density mobile phone radiations on the male reproductive system. Similar results are observed when a person speaks using bluetooth headset with the cell phone in the pocket. Hands-free accessories thus decrease exposure of radiation to the human head but male reproductive system might be at risk[21].

Grigert *et al.,*[14] showed that these radiations reduce estrogen-receptor cofactor expression in MCF-7 that reduces effectiveness of tamoxifen (a receptor modulator used to prevent breast cancer) and hence promotes breast cancer[14].

4. Integumentary System :

Study of EMF radiation on skin proteins[23] was done with epithelial cell lines EA.hy926 and EA.hy926v1. 38 different proteins examined were observed to have altered expression. Two of the proteins were identified to be isoforms of the structural protein Vimentin[22]. Vimentin plays a key role in cell adhesion, migration and motility. However, when overexpressed, it can drive epithelial-mesenchymal transition and finally metastasis (indicating risk of cancer)[28]. The EM waves emitted by smartphones affect the gene expression to synthesize protein and also the structure of transcribed proteins. Thus the effect of EM waves was said to be genome and proteome dependent[23].

5. Circulatory System :

Peterson[24] showed that mobile phone radiations resulted in significant distortion in blood platelet structure and function. Citrated blood samples (to prevent coagulation of blood samples) were taken from 16 healthy volunteers and exposed to 900MHz radio frequencies at a distance of 1cm from the smartphone that is on call mode for 30 minutes. Observations made were an increase in collagen-epinephrine aggregation and mean platelet volume (indicating structural distortion)[24]. Diem *et al.,* (2005) observed structural changes in human RBC culture that were exposed to 2.45GHz RF-EMF but concluded that there is no hemolysis or potassium ion efflux[24].

6. Skeletal System :

Kumar *et al.,*[17] reported DNA strand breaks due to the effect of RF-EMF on cultures of human fibroblast cells. This study also compares the effect of EMF on muscle and bone tissue. Mobile phone radiations tend to affect the muscle tissue to a depth of 0.5mm when placed at a distance of 10-12cm away from the body. Since bones are more dense when compared to muscles, the latter observes higher damage due to EMFs. The advisable distance of mobile phones from the human body was seen to increase with frequency of radiation emitted. In India, mobile phones emit radiation of frequencies 800 or 900MHz. The prescribed safety limit is a distance of 10cm from the muscle tissue[17]. Miller *et al* (2019) have shown RF-EMFs to affect young people more than adults. Since children have thin skulls their bone marrow tends to absorb 10 fold higher local doses compared to adults[19].

Radiations from mobile phones have shown to cause significant damage in humans. They have been associated with increased risk of cancer. Other effects include induced hormonal imbalance, alteration in skin proteins, decreased sperm count and motility, distortion of blood RBC and platelet structure and cellular damage associated with muscle and nervous tissue As a limitation, most of the studies performed are not on humans but on human cell cultures, hence the results obtained may vary from observations in real life situations. Studies till date only give an explanation to certain symptoms and probable threats. Since one may not always be certain to keep mobiles at a recommended distance (10cm), it is best to avoid or limit their usage. Since studies have shown lesser damage to cells when phones are kept in stand-by mode, one may as well put mobiles in flight mode or switch them off when not in use.

No studies have yet been done on the exact mechanism of cell damage by RF-EMFs, leaving scope for further research.

Abbreviations

1. EMF- Electromagnetic field
2. MHz - Megahertz
3. GHz- Gigahertz
4. FM - Frequency modulation
5. ELF- Extremely Low Frequencies
6. GSM - Global System for Mobile Communication
7. PDA - Personal Digital Assistant
8. IARC- International Agency for Research on Cancer
9. SAR - Specific Absorption Rate
10. FCC - Federal Communications Commision
11. TRAI - Telephone Regulatory Authority of India
12. WHO - World Health Organisation
13. FDA - Food and Drug Administration
14. RF - Radio Frequencies
15. TNF - Tumor Necrosis Factor
16. EEG - Electroencephalogram
17. LH - Luteinizing Hormone
18. FSH - Follicle Stimulating Hormone
19. VGCC - Voltage Gated Calcium Channel
20. ROS - Reactive Oxygen Species
21. MCF - Michigan Cancer Foundation

References :

1. Agarwal A, F Deepinder, RK Sharma, G Ranga, and J. Li (2008) *Fertil Steril, 89*(1): 124-128.
2. Andrew Goldsworthy (2007) The Biological Effects of Weak Electromagnetic Fields.
3. Avendaño C, A Mata, CA Sanchez Sarmiento, and GF. Doncel (2012) *Fertil Steril, 97 :* 39-45.e2.
4. Baan R, Y Grosse, B Lauby-Secretan, F El Ghissassi, V Bouvard, L Benbrahim-Tallaa, *et al.* (2011) *The Lancet Oncology 12:* 624–626.
5. Baby NM, G Koshy and A. Mathew (2017) *Indian J Endocr Metab; 21:* 797-802.
6. Bernal J. (2007) *Nat Clin Pract Endocrinol Metab; 3:* 249–59.
7. Bortkiewicz A. (2001) *Med Pr; 52:* 101–106.
8. Buttiglione M., L. Roca, E. Montemurno, F. Vitiello, V. Capozzi, and G. Cibelli. (2007). *J. Cell. Physiol. 213:* 759–767, Wiley-Liss, Inc.
9. Chinar Shah, Anu Nair, Mehul Naik, and Sonal Bakshi (2015) *Cell Phone Radiation and Genomic Damage: In Vitro Exposure and Assessment.* Vol. *4,* Issue 2, February.

10. Davoudi M, C Brossner, and W Kuber (2002) The influence of electromagnetic waves on sperm motility. *Urol Urogynacol, 19*(22):
11. De Iuliis GN, RJ Newey, BV King, and RJ Aitken (2009) *PLoS One, 4*(7): e6446.
12. Elisabeth Diem, Claudia Schwarz, Franz Adlkofer, Oswald Jahn and Hugo Rudiger, (2005) *Mutation research/genetic toxicology and environment mutagenesisnesis, 583* (2): 178-183.
13. Fejes I, Z Zavaczki, J Szollosi, S Koloszar, J Daru, L Kovacs, and A Pal (2005) *Arch Androl, 51*(5): 385-393.
14. Girgert R., C. Grundker, G. Emons, and V Hant (2008) *Bioelectromagnetics., 29:* 169–176.
15. Glaser, Z.R., (1971) Naval Medical Research Institute Research Report, June 1971. Report No. 2 Revised.
16. https://www.cancer.org/cancer/cancer-causes/radiation-exposure/radiofrequency-radiation.html
17. Kumar Vijay, A. Sharma, Arvind Kumar, Mustaq Ahmad and G. K. Gupta. (2012). *IOSR Journal of Pharmacy and Biological Sciences (IOSRJPBS) ISSN*: 2278-3008 *1*(6): 06-16.
18. Martin L Pall. (2018) *Elsevier Environmental Research Volume 164:* 405-416.
19. Miller AB, ME Sears, LL Morgan, DL Davis, L Hardell, M Oremus and CL Soskolne (2019) *Front. Public Health 7:* 223.doi: 10.3389/fpubh.2019.00223.
20. Mortavazi S, A Habib, A Ganj-Karami, R Samimi-Doost, A Pour-Abedi and A Babaie *et al*. (2009) *Oman Med J., 24:* 274–8.
21. Nisarg R Desai, Kavindra K Kesari and Ashok Agarwal. (2009) *Reproductive Biology and Endocrinology, 7:* 114.
22. Nylund R, and D. Leszczynski (2004) *Proteomics, 4:* 1359-1365.
23. Nylund R, and D. Leszczynski (2006) *Proteomics, 6:* 4769-4780.
24. Peterson, DJ. (1979). *IEEE TransBiomed Eng 26:* 428–436.
25. Rauscher F, Jr., JF Morris, OE Tournay, DM Cook, and T. Curran (1990). *Science 250:* 1259–1262.
26. Roggeveen S, van Os J, Viechtbauer W, and R. Lousberg (2015). *PLoS ONE 10*(6): e0129496. doi:10.1371/journal. Pone.0129496.
27. Rothman KJ. (2000) *Lancet*; *356:* 1837-40.
28. Satelli Arun and Li Shulin (2011) C*ell Mol Life Sci. September, 68*(18): 3033–3046. doi:10.1007/s00018-011-0735-1.
29. Shangliao Sun. Smartphone users in India 2010-2040. Sep 3, (2021).
30. The world in (2014). ICT facts and figures. International Telecommunication Union. http://www.itu.int/
31. Tian-Yong Zhao, Shi-Ping Zou and Pamela E. Knapp. (2007) *Neurosci Lett. 412*(1): 34–38.
32. Touitou Y., J. Lambrozo, F. Camus, and H. Charbuy (2003) *Am J Physiol Regul Integr Cornp Physiol., 284*: 1529–535.
33. Vasant Natarajan, "The myth of cell phone radiation"
34. World Health Organization. (2014) Electromagnetic fields and public health: mobile phones.
35. Yvan Touitou, Brahim Selmaoui, (2012) *Dialogues in Clinical Neuroscience - 14*(4) :