Hazardous Genomic Bioeffects of Home Wi-Fi Systems

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ABSTRACT

Objective of this study is to investigate the changes of whole genom gene expression levels in rat brain induced by 2,4 GHz Wireless Fidelity Radiofrequency Electromagnetic Field (WiFi RF-EMF). Total RNA was extracted immediately and purified from the rat brain, after 12 hours/day exposed or sham-exposed to a frequency of 2,4 GHz WiFi RF-EMF for 14 days. Roche-Nimblegene-Agilent Microarray System was applied to investigate the changes of gene expression in rat brain. Roche-Nimblegene-Agilent Genespring Software for Microarray Analysis was used in bioenformatic analysis. After 14 days of WiFi RF-EMF exposure, 69 genes in experimental group showed statistical significant down regulation compared with the control group. Ten genes in experimental group showed statistical significant up regulation compared with the control group. In this study, it was detected that WiFi RF-EMF exposure to brain cells resulted with the down and up regulation of transcription level of some important genes.

Key Words: Wireless Radiofrequency, Electromagnetic Field, Gene Expression, mRNA

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Introduction

Wireless Fidelity (Wi-Fi) communication technology was significantly developed in last two decades. Some of the epidemiological studies were stated that long-term exposure to RF-EMF may lead to moderate increases in certain types of cancers or other diseases (Abdel-Rassoul *et al.,* 2007 and Hardell *et al.,* 2008). On the other hand, some other studies did not support such claims (Kundi *et al.,* 2004; Ahlbom *et al.,* 2004). Nevertheless, public anxiety was become apparent on the possible health effects of exposure to RF-EMF.

Operating frequency spectrums of GSM (Global System for Mobile) and DECT (Digital European Cordless Telecommunications for Mobile) carriers are typically in ranges of 800 to 900 MHz and 1.8 to 2.2 GHz. Wi-Fi systems have an operating frequency range of 2.4 to 4 GHz and their prominence in everyday life was significantly increased mostly in last decade. While humans are in exposure to various sources, cellular phones and wireless systems are the main suspects for causing hazardous effects.

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It was stated in some studies that head absorbs a certain portion of the generated microwave energy to gradually produce the concept known as "hotspots" in the brain. Possible biological effects were stated mostly as headaches, eye injuries and cancer. Biological effects that were resulting from the acute exposure to such fields are mostly consistent with the induced heat responses where cellular, tissue or body temperature exceeds 38°C or more. This situation is also complying with SAR values that are above 1-2 W/kg. Most of the time, experimental thermic conditions are not reflecting situations that can be occurred in daily life or correspond to a worst-case situation that may occur for short periods of time.

Our cellular functions have an electrochemical basis. Nerve impulses for large muscles are in the milliVolt (mV) ranges and brain waves are in the microVolt (μV) ranges. However, artificial electrical fields in some areas are known to exceed 87,000 mV (87 volts). Specific absorption rate *(*SAR*)* value is used to measure the energy absorbance rate of the human body in cases of exposure to RF EMFs. Organisms are composed of complex systems and *SAR*-value indication is a relatively simple to understand the effects of RF-EMF exposure. Therefore, non-thermal effects need to be investigated.

Certain studies were investigated the possible epigenetic effects of RF-EMF exposure in heat shock protein (HSP) family, ornithine decarboxylase (ODC), p38 mitogen activated protein kinase (MAPK), c-jun, c-myc, p21, bax, GADD45, and Nurr1 and were stated that these proteins or genes might be radiofrequency susceptible (Cotgreave *et al.,* 2005; Czyz *et al.,* 2004; Nikolova *et al.,* 2005).

There is little information about exposure to Wi-Fi RF-EMF systems in terms of headache, cancer or other serious impairments and therefore investigations in these fields are necessary. In this study, exposure effects of Wi-Fi RF-EMF on whole genom gene expression profiles were investigated in rat brains.

Methods

In vivo studies

A total of 8 albino Wistar rats (180 ± 10 g body weight), 12 ± 2 weeks of age were kept in Animal Experimentation Unit of Cumhuriyet University Faculty of Medicine. Rats were housed in 24 ± 2 C^0 temperature with a 12 h light/dark cycle and in 60 ± 5 % relative humidity. They were provided with standard pellet feed and ad libitum fresh water. Experiments were carried out in accordance with the guidelines of Ethical Committee for the Purpose of Control and Supervision of Experiments on Animals, of Cumhuriyet University Faculty of Medicine.

Exposure system

The exposure system was designed as daily home or office life for Wi-Fi exposure. RF generator was a common wireless internet router (Zyxel NBG-418N V2 wireless Access Point/Router), which was generating RF-EMF in 2.4 GHz frequency and with transmission speeds up to 300 Mbps.

Wireless internet router device was located one meter away from rat cages. Both the router and the cages were situated in a Faraday Cage in order to prevent external RF-EMF interferance. In the exposure group (Group A), rats (n=4) were exposed to 2.4 GHz RF EMF for 12 hours/day for 14 days. In control group (Group B), rats (n=4) were also situated in a Faraday Cage, but were not exposed to RF EMF.

RNA isolation

After 14 days of exposure, rats were sacrificed and brain tissue of the rats were removed from the animals of control and experimental groups. Then total cellular RNA of each brain tissue of rats were isolated by TRIzol (Gibco-BRL, Grand Island, NY, USA) and were further purified with the RNeasy Mini Kit (Qiagen, Germany). RNA yields were quantified by spectrophotometric analysis with DeNowix and Implen nanophotometer (Munich, Germany), and the integrity of the RNA was evaluated with Agilent RNA 6000 nano kit by Agilent 2100 Bioanalyzer System (Agilent Technologies, CA, USA).

Labeling and Purify the Labeled/Amplified RNA

The Agilent One-Color Microarray-based Gene Expression Analysis which uses cyanine 3-labeled targets was used to measure gene expression in experimental and control samples. The Low Input Quick Amp Labeling Kit, One-Color was generated fluorescent cRNA (complimentary RNA) with a sample input RNA range between 10 ng and 200 ng of total RNA or a minimum of 5 ng of poly A+ RNA for one-color processing. The method is using T7 RNA Polymerase Blend (red cap), which simultaneously amplifies the target material and incorporates Cyanine 3-CTP. Amplification was typically at least a 100-fold from the total RNA to cRNA with the use of Low-Input Quick Amp

Labeling Kit, One Color (Agilent). After labeling, the samples were purified with using Absolutely RNA Nanoprep Kit (Agilent).

Hybridization and Washing

After purification, the samples were hybridized with using Hybridization Kit (Agilent). Then the array slide (SurePrint G3 Rat Gene Expression Microarrays) was used. The samples were hybridized at 65°C for 17 hours. Hybridized samples were washed with using Wash Kit (Agilent).

Array Scaning and Data Analysis

After washing and assessing the quality control, the labeled cRNA array slide immediately was put into the Roche- NimbleGen slide holder. After generating the microarray scan images, tif images were extracted using the Feature Extraction Software (FE) 4.0.1.21 (Agilent). After the FE, raw datas for each array (sample) were analyzed with Agilent Genespring Software for Microarray Analysis which provides powerful and accessible statistical tools for intuitive data analysis and visualization. Volcano Plot Analysis (p=0.05 and fold change cut-off=2.0) and Westfall-Young correction method were performed on the data.

Results and Discussion

Due to the widespread distribution of electric power transmission and distribution systems in the human environment, there is public concern about potentially hazardous effects of non-ionising radiation of wireless (2,4 GHz) electromagnetic fields.

Downregulated genes that are taking important roles in apoptosis and cancer mechanisms after EMF exposure are as follows:

Taok2, Rattus norvegicus TAO kinase 2, which encodes a serine/threonin protein kinase that is involved in many different processes like cell signaling, microtubule organization, stability, and apoptosis.

Spi1, Rattus norvegicus spleen focus forming virus proviral integration oncogene encodes an ETS-domain transcription factor that activates gene expression during both myeloid and B-lymphoid cell developments. Diseases associated with Spi1 include inflammatory diarrhea and interdigitating dendritic cell sarcoma. Among its related pathways are pathways in cancer and IL-4 signaling pathway.

Fgr, Rattus norvegicus feline Gardner-Rasheed sarcoma viral oncogene, is known to promote mast cell degranulation, release of inflammatory cytokines and IgE-mediated anaphylaxis. Fgr contributes to the regulation of immune responses, including neutrophil, monocyte, macrophage and mast cell functions, cytoskeleton remodeling in response to extracellular stimuli, phagocytosis, cell adhesion and migration. Diseases associated with FGR is known to include sarcoma.

Nfia, Rattus norvegicus nuclear factor I/A, encodes a member of the NF1 (nuclear factor 1) family of transcription factors. Diseases associated with NFIA include the Chromosome 1P32-P31 Deletion Syndrome and the Leukemia. Prkaca, Rattus norvegicus protein kinase-cAMP-dependent catalytic activity, plays an important role in cellular responses to glucose stimuli, mRNA processing and positive regulation of cell cycle arrest. Adrm1, Rattus norvegicus adhesion regulating molecule 1, encodes a member of the adhesion regulating molecule 1 protein family. Proteasome related with this gene is known to be participating in numerous cellular processes including cell cycle progression, apoptosis and DNA damage repair. Dysregulation of this gene was implicated in carcinogenesis.

Ucp2, Rattus norvegicus uncoupling protein 2 (mitochondrial, proton carrier). Uncoupling proteins are proteins that create proton leaks across the inner mitochondrial membrane which contribute to the uncoupling of oxidative phosphorylation from ATP synthesis. As a result, energy dissipates as heat. Therefore, downregulation of this gene negatively affects various systems of the organism including the apoptosis.

Zfp36L1, Rattus norvegicus zinc finger protein 36, C3H type-like 1, is one of the members of the TIS11 family of early response genes. This gene is well conserved across different species and has a promoter that is containing motifs seen in other early-response genes. This putative nuclear transcription factor most likely functions in regulating the response to growth factors. Diseases known to be associated with ZFP36L1 include Sotos Syndrome 1.

Fgfr2, Rattus norvegicus fibroblast growth factor receptor 2, is known to be important in regulation of the responses to growth factors. Plekhh1, Rattus norvegicus pleckstrin homology domain containing, family

H1, is associated with the diseases including Gestational Trophoblastic Neoplasm.

Ozgur *et al*., reported that rabbits, which were exposed to EM EMF of 1800 MHz had oxydative stress and defects in serum lipid peroxydation (Ozgur *et al.,* 2013). Czyz *et al*., were stated that non-thermal responses might be induced in mouse pluripotent embryonic stem cells by exposure to intermittent EMF with extremely low frequency (50 Hz) (Czyz *et al.,* 2004). They were reported that after exposure, significant up-regulation in c-jun, p21, and egr-1 mRNA levels were detected in p53-deficient cells.

Buttiglione et al., pointed out that exposure to a 900 MHz-modulated RF radiation affect both Egr-1 gene expression and cell regulatory functions, involving apoptosis inhibitors like Bcl-2 and survivin (Buttiglione *et al.,* 2007). In this study also, it was detected that some important genes, which are involved in apoptosis and cancer mechanisms, were negatively affected and this would lead to possible defects in apoptotic mechanisms and cancer progress.

Downregulated genes that are taking roles in different syndromes due to EMF exposure were found as follows:

Abcd1, Rattus norvegicus ATP-binding cassette, subfamily D (ALD), member 1, is known to be associated with adrenoleukodystrophy, which is an X-chromosome recessively inherited demyelinating of nervous system. Tuba3b, Rattus norvegicus tubulin, alpha 3B, is associated with both microlissencephaly and growth retardation. Phykpl, Rattus norvegicus 5-phosphohydroxy-L-lysine phospho-lyase. Defect of this gene result as phosphohydroxylysinuria.

S100a9, Rattus norvegicus S100 calcium binding protein A9, encodes a protein that is a member of the S100 family of proteins and contain 2 EF-hand calcium-binding motifs. S100a8, Rattus norvegicus S100 calcium binding protein A8, was also detected as downregulated. S100 proteins are involved in the regulation of different cellular processes including cell cycle progression and differentiation. They are known to be associated with various diseases such as cystic fibrosis and verruciform xanthoma of skin.

Lca5, Rattus norvegicus Leber congenital amaurosis 5, encoding a protein that is possibily involved in centrosomal or ciliary functions. Defects in this gene cause Leber congenital amaurosis type V. Cuedc1, Rattus norvegicus CUE domain containing 1, associated with the Smith-Magenis Syndrome. Megf8, Rattus norvegicus multiple EGF-like-domains 8. Mutations in this gene have been found to cause Carpenter Syndrome.

Bas *et al.,* were reported that a significant reduction in pyramidal cell counts in the Cornu ammonis achieved by postnatal exposure of 16 weeks old female rats to 900 MHz EMF ($P<0.05$) (Bas *et al.,* 2009). Zeng *et al.,* indicated that the protein expression changes induced by RF radiation might depend on exposure duration and mode. Many biological processes might be affected by RF exposure (Zeng *et al.,* 2006). In this study, it was also detected that some important genes were negatively influenced which are known to be involved in important mechanisms and associated with different syndromes.

Downregulated genes which function in cell signalling, protein binding, and receptor activities are as follows:

Arsg, Rattus norvegicus arylsulfatase G, encodes a protein that is belonging to the sulfatase enzyme family. Sulfatases are involved in endocrine biosynthesis, the modulation of cell signaling and the degradation of macromolecules. Erc2, Rattus norvegicus ELKS/RAB6-interacting/CAST family member 2, is responsible for encoding a regulatory protein that is affecting the neurotransmitter release. AF435963, Rattus norvegicus ligand-independent activating molecule for estrogen receptor mRNA, partial cds, encodes a protein that is taking roles in estrogen receptor activity.

Olr1411, Rattus norvegicus olfactory receptor 1411 and Olr1454, Rattus norvegicus olfactory receptor 1454, are both encode proteins that are exhibiting G-protein coupled receptor activities and are involved in detection of chemical stimuli in sensory perception of odour. Htr5b, Rattus norvegicus 5-hydroxytryptamine (serotonin) receptor 5B, functions in drug and serotonin binding. Npb, Rattus norvegicus neuropeptide B, gene functions in protein neuroendocrine system, memory and learning systems. Armc9, Rattus norvegicus armadillo repeat containing 9, encodes a protein that involves in protein binding mechanisms.

Paulraj *et al.,* were stated that significant increases in DNA single strand breaks in rat brains achieved by chronic exposure to microwave radiation in 2.45 to 16.5 GHz frequency ($p<0.001$) (Paulraj *et al.,* 2006). Zhang

et al., pointed out that 1800 MHz RF EMF (SAR, 3.0 W/kg) for 24 hours might induce DNA damage in CHL cells (Zhang *et al*., 2006). In this study, 2.4 GHz Wi-Fi RF-EMF exposure was detected to downregulate some important genes which are involved in cell signaling, protein binding mechanisms and receptor activity. These effects might lead to important adverse effects.

Downregulated genes that are taking roles in other important mechanisms after EMF exposure are as follows:

Atxn2l, Rattus norvegicus ataxin 2-like, is responsible for encoding an ataxin type 2 related protein that is a member of the spinocerebellar ataxia (SCAs) family. This protein is known to be associated with a complex group of neurodegenerative disorders and involved in the regulation of stress granule and P-body formations. Acoxl, Rattus norvegicus acyl-CoA oxidase-like, is functioning in acyl-CoA oxidase activity. Slc4a2, Rattus norvegicus solute carrier family 4 (anion exchanger), member 1, is associated with regulation disorders of intracellular pH in cases of gene defects.

Tcp11, Rattus norvegicus t-complex protein 11, plays a role in the process of sperm capacitation and acrosome reactions. Plg, Rattus norvegicus plasminogen gene encodes a protein plasmin. This protein dissolves the fibrin of blood clots and acts as a proteolytic factor in a variety of other processes including embryonic development, tissue remodeling and inflammation.

Srd5a2, Rattus norvegicus steroid-5-alpha-reductase, is known to be central in gender differentiation and associated with androgenic physiology. Selplg, Rattus norvegicus selectin P ligand, plays an important role inleukocyte adhesive activation and leukocyte migration.

Myo1e, Rattus norvegicus unconventional myosin-Ie, is essential in motor activity, actin filament binding, endocytosis, and hemopoiesis.

RatNP-3b, Rattus norvegicus defensin RatNP-3 precursor, and RatNp4, Rattus norvegicus defensin NP-4 precursor, are both known to have activities inantibacterial and antifungal humoral responses. Dpf1, Rattus norvegicus (Rat) Zinc finger protein neuro-d4, is speculated to have an important role in neural development by participating in the regulation of cell survival, possibly by acting as a neurospecific transcription factor. Scaf1, Rattus norvegicus (Rat) Splicing factor, arginine/serine-rich 19, is thought to be functioning in pre-mRNA splicing.

Mcf2l, Rattus norvegicus MCF2 cell line derived transforming sequence-like guanine nucleotide exchange factor, is catalyzing the guanine nucleotide exchange on RHOA and CDC42 that is consequently contributing to the regulation of RHOA and CDC42 signaling pathways. Zdhhc19, Rattus norvegicus zinc finger, DHHC-type containing 19, is functioning in protein-cysteine S-palmitoyltransferase activity.

She, src homology 2 domain-containing transforming protein E, involved in the signal transduction pathways of neurotrophin-activated Trk receptors in cortical neurons. Insl3, Rattus norvegicus insulin-like 3, seems to play a role in testicular function. May be a trophic hormone with a role in testicular descent in fetal life.

Myh9, Rattus norvegicus myosin, heavy chain 9, plays an important role in cytoskeleton reorganization, focal contacts formation and lamellipodial retraction during the cell spreading. Dbp, Rattus norvegicus D site of albumin promoter, which is thought to have effects in circadian rythm and sleep regulation. Hbb, Rattus norvegicus hemoglobin beta, gene is involved in oxygen transport from the lungs to the various peripheral tissues. Rap2a, Rattus norvegicus RAS related protein 2a, is functioning in GDP binding and in cellular responses to drug.

Erc2, Rattus norvegicus ELKS/RAB6-interacting/CAST family member, is thought to have effects in the organization of the cytomatrix at the nerve terminal active zones (CAZ) that regulates the neurotransmitter release.

Pabpc1l2a, Rattus norvegicus poly(A) binding protein, cytoplasmic 1-like 2A, has functions in RNA binding. Alox15, Rattus norvegicus arachidonate 15-lipoxygenase, is thought to have important roles in the immune and inflammatory responses. Pth2, Rattus norvegicus parathyroid hormone 2 receptor, which is responsible for encoding a protein that binds the parathyroid hormone and induces cAMP accumulation. Nfia, Rattus norvegicus nuclear factor I/A, encodes a protein that is capable of activating both transcription and replication.

Ap5z1, Rattus norvegicus, Adaptor-related protein complex 5, zeta 1 subunit, function in repairing double-strand breaks by homologous recombination and endosomal transport. Efna2, Rattus norvegicus ephrin A2, encodes a protein that exhibits ephrin receptor binding. It is involved in axon guidance, olfactory bulb

development and bone remodeling. Maz, Rattus norvegicus MYC-associated zinc finger protein, is known to be functioning in the positive regulation of transcription from RNA polymerase II promoter and in the termination of RNA polymerase II.

Tuba3b, Rattus norvegicus tubulin, alpha 3B, is encoding for Tubulin which in turn is the major constituent of microtubules. It functions by binding of two moles of GTP, one at an exchangeable site on the beta chain and one at a non-exchangeable site on the alpha chain. Srrm2, Rattus norvegicus serine/arginine repetitive matrix 2, have functions in C2H2 zinc finger domain binding, protein N-terminus binding and RNA binding.

Vbp1, Rattus norvegicus (Rat) Protein LOC681825 Prefoldin subunit 3, promotes folding in an environment in which there are many competing pathways for non-native proteins. Begain, Rattus norvegicus brain-enriched guanylate kinase, sustain the structure of the postsynaptic density and function in protein homodimerization activity. Abcd1, Rattus norvegicus ATP-binding cassette, subfamily D, functions in ATPase activity and in peroxisome organization. Slc15a3, Rattus norvegicus solute carrier family 15 member 3, is responsible for protein transport and protein catabolic process. Dusp28, Rattus norvegicus dual specificity phosphatase 28, functions in phosphatase activity and in protein tyrosine/serine/threonine phosphatase activity.

Atp1a3, Rattus norvegicus ATPase, Na+/K+ transporting, alpha 3 polypeptide, which is the catalytic component of the active enzyme that catalyzes the hydrolysis of ATP is coupled with the exchange of sodium and potassium ions across the plasma membrane. This action creates the electrochemical gradient of sodium and potassium ions and thus provides the energy for active transport of various nutrients.

Adra2b, Rattus norvegicus adrenoceptor alpha 2B, encodes for Alpha-2 adrenergic receptors that are mediating the catecholamine-induced inhibition of adenylate cyclase by G protein actions. Gapdh, Rattus norvegicus glyceraldehyde-3-phosphate dehydrogenase-like, function in ferric iron binding and in cellular iron ion homeostasis. Bin2, Rattus norvegicus bridging integrator 2, promote cell motility and migration possibly through interactions with the cell membrane and with podosome proteins that mediates interactions with the cytoskeleton.

Zfp36l1, Rattus norvegicus zinc finger protein 36, C3H type-like 1, plays a role in the in the regulation of keratinocyte proliferation, differentiation, myoblast cell differentiation and in apoptosis. Prss27, Rattus norvegicus protease, serine 27, functions in serine-type endopeptidase activity and in serine-type peptidase activity. Gsk3a, Rattus norvegicus glycogen synthase kinase 3 alpha, regulate glycogen metabolism in the liver.

Odaci *et al.* were reported that the cellular developments of Purkinje cells located in the cerebellum of female rats affected by the prenatal exposure to 900 MHz EMF and were stated that consequent pathology persisted in the postnatal period (Odacı *et al.,* 2016). Zhang *et al.,* also reported that the changes of many genes transcription levels were involved by the effect of 1.8 GHz RF EMF on rat neurons; Down-regulation of Egr-1 and up-regulation of Mbp, Plp indicated the negative effects of RF EMF on neurons. (Zhang *et al*., 2008).

After EMF exposure upregulated genes that are taking roles in other important mechanisms are as follows:

Fezf1, Rattus norvegicus Fez family zinc finger 1, encodes a protein that is exhibiting a RNA polymerase II proximal promoter sequence-specific DNA binding domain and transcription regulatory region in DNA binding. Gpr63, Rattus norvegicus G protein-coupled receptor 63, is responsible for the largest and catalytic component of RNA polymerase II which synthesizes mRNA precursors and many functional non-coding RNAs by taking roles in DNA-dependent RNA polymerase. This catalyzes the transcription of DNA into RNA using the four ribonucleoside triphosphates as substrates.

Selplg, Rattus norvegicus selectin P ligand, is functioning in the cellular responses to interleukin-6, leukocyte adhesion activation, and leukocyte migration. Zn rf4, Rattus norvegicus zinc and ring finger 4, is responsible for encoding a protein that is exhibiting metal ion binding and transferase activities and also involved in protein ubiquitination and in ubiquitin-dependent protein catabolic processes.

Ghr, Rattus norvegicus growth hormone receptor, functions in receptor activities of pituitary gland growth hormone, that is involved in regulating the postnatal body growth. Tshb, Rattus norvegicus thyroid stimulating hormone, is responsible for encoding a protein that exhibits

hormone activity and is involved in responses to calcium ion, estrogen and vitamin A.

Pik3ca, Rattus norvegicus phosphoinositide-3-kinase, catalytic, participates in the vasculogenesis in embryonic stem cells through the actions of PDK1 and protein kinase C pathway. Nostrin, Rattus norvegicus nitric oxide synthase trafficking, function in a multivalent adapter protein that might decrease the NOS3 activity by translocating away from the plasma membrane.

Grhl3, Rattus norvegicus grainy head-like 3, have functions in DNA binding, RNA polymerase II transcription factor activity, sequence-specific DNA binding, cochlea morphogenesis, central nervous system, ectoderm and epidermis development. Hsp60, Rattus norvegicus similar to 60 kDa heat shock protein, mitochondrial precursor, which is a chaperonin that is implicated in the mitochondrial protein import and in macromolecular assembly. Together with Hsp10, facilitates the correct folding of imported proteins.

Li *et al.,* were reported upregulation of 439 and downregulation of 874 genes in D. melanogaster by exposing the male flies to short-term exposure to low frequency EMF and were reported upregulation of 514 and downregulation of 1206 genes by exposing to long term exposure to EMF (Li *et al.,* 2013). Authors were stated that D. melanogaster differentially expressed genes affected by the short-term EMF exposure were genes that are involved in metabolic processes, cytoskeletal organization, mitotic spindle organization, cell death, protein modification and proteolysis. They also reported that, long-term exposure affected some important genes which were involved in metabolic processes, response to stress, mitotic spindle organization, aging, cell death and cellular respiration.

The proliferation and differentiation of embryonic neural stem cells (eNSCs) is essential for brain development during the gestation period. Ma Q *et al.,* reported that their results support that 50 Hz ELF-EMF induce molecular changes during eNSCs differentiation (Ma Q *et al.,* 2008). In this study, it was also detected that some important genes were negatively influenced which are known to be involved in important mechanisms.

Conclusion and Future Perspective

Possibly hazardous bioeffects of home Wi-Fi RF-EMF exposure on genomic mRNA expressions were provided with this research. Since the wireless communication technology and devices are becoming indispensable in the modern daily life, this subject should be investigated with more detailed studies. In conclusion, it is suggested that the exposure of humans to EMF sources should be minimized whenever possible.

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