

Exposure to Electromagnetic Fields and Users' Health

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Abstract

Aims: This study has examined exposure to electromagnetic fields (EMFs) and its effect on the general health of computer users. **Materials and Methods:** This cross-sectional study was performed by participating 73 employees. A calibrated galactooligosaccharide meter model HI-3603 was used to measure EMF and a general health questionnaire examined their health status. **Statistical Analysis Used:** For analyzing data, the *t*-test and Chi-square test were applied. **Results:** The electric field intensities in desktop monitors and laptops were 0.26–1.2 and 0.28–0.87 volts/m, respectively, which is higher than the standard levels. The results from the public health questionnaire revealed that 39% of computer users had some problems in general health status. A significant difference was observed between the general health of the two groups ($P < 0.001$). **Conclusions:** The role of using electronic equipment for communication and daily activities became more prominent. Therefore, it is clear that with the widespread use of this equipment, all members of society will be exposed to some kind of EMF. Therefore, people who work with computers due to their job will use this equipment to do things during other nonworking hours. As a result of this increase in the time of using electronic equipment, their health will be at risk.

Keywords: Electromagnetic, field, health, user-computer

INTRODUCTION

Concerns have grown since the use of electronic equipment increased on the possible health effects associated with exposure to radiofrequency electromagnetic fields (RF-EMFs).^[1] These concerns increase with the rapid increase in numbers of electronic equipment users such as computers, mobile phones users around the world because these users work with computers for a long time in the workplace and therefore are constantly exposed to the electric and magnetic fields produced by this equipment.^[2-4] The EMFs around the monitor are of the extremely low-frequency type with a frequency range of 3–3000 Hz.^[5] These equipment emit low levels of RF-EMF, which no exact biological health impact is not yet identified resulting from them. Recently, the International Organization for Cancer Research, affiliated with the World Health Organization, reported that exposure to these fields is likely being carcinogenic to humans.^[6] Furthermore,

sleep disturbance is one of the most common symptoms in people who consider themselves sensitive to low-level EMFs exposure.^[7] Auvinen *et al.* in a study reported that long-term exposure to RF-EMF leads to headaches and hearing impairment in users of electronic equipment.^[8] Findings of studies evaluating the effects of RF-EMF on sleep-related parameters have shown that macro sleep structures are less consistent.^[9,10] Monazzam *et al.* examined the general health and sleep quality of workers in a petrochemical industry under exposure to ultra-low frequency EMF. The results showed that 28% of participants who have been exposed to these fields had a general health problem and 61% of them suffered from sleep disorders. However, a control group showed good general health and 4.5% suffered from inappropriate sleep quality.^[11] Another study examined the effect of exposure to

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ultra-low frequency EMF on the incidence of cancer in the Netherlands. The results showed no significant relationship between lungs, breast, and brain cancer with exposure to the magnetic field of these waves in both male and female groups. However, a significant relationship was observed between males and leukemia.^[4,12] Furthermore, another studies indicated that employees who work with video monitor terminals for a long time every day are more prone to sleep disorders such as waking up early, poor quality of sleep, suffering from some problems during sleep, especially difficulty in sleeping, staying awake at night, and drowsiness during the day.^[13]

Therefore, regarding the use of computers in work processes leading to user's exposure to electric and magnetic fields caused by these systems, the present study examined the intensity of EMF and their effect on computer users' health.

MATERIALS AND METHODS

This study was performed as a descriptive-analytical study. Inclusion criteria for Group A: using the computer in their working shift as a part of their job task, with at least 1 year of job experience. Inclusion criteria for Group B: not working with computer in their working hours, with at least 1 year of job experience. Exclusion criteria: workers with a general health problem such as headaches, eye problems, and use of pain killer drugs. All health information related to these participants has been recorded by the physician in their health records. In addition, all participants state their health through self-declaration. The working time of all participants in the study was 8 h during the day, of which 1 h was related to rest time. In addition, all ethical standards and organization permits have been observed. To evaluate the levels of participants' exposure to electric and magnetic fields, the intensity of these fields at specified distances based on the proposed distances for working with monitors from an ergonomic point of view that was at least 30 cm, 50, and 60 cm distances were selected.^[14] Therefore, measurements have been made in the four directions of front, back, and sides of the computers by using the calibrated Gauss meter device model (HI-3603). In addition, the relationship between exposure to EMF and users' general health has been examined through the standard public health questionnaire (Goldberg and Hiller). This questionnaire has some questions related to age, occupation, duration of work with a computer per day, the experience of work with computer, and health problems. Moreover, this questionnaire examined physical symptoms, anxiety, social dysfunction, and depression.^[15] The validity and reliability of this questionnaire have been evaluated in other studies and its overall Cronbach's alpha was 0.92. The study was performed in a branch of a governmental organization, and all the eligible staff participated in the study were included in the study so the sample size calculation follows the census method. Hence, it included 46 employees (computer users as Group A) and 23 employees (without computer as Group B). To analyze the data, IBM SPSS Statistics for Windows, Version 20.0. Armonk, New York, USA was used. Descriptive statistics were used to categorize workers' demographic parameters. Independent *t*-test

was used to compare the mean general health and the Chi-square test was used to assess exposed and nonexposed individuals to electric and magnetic fields during work in the two groups. The value of statistical significance was set at $P \leq 0.05$ for all tests. The study's ethical code was IR. AJUMS. REC.139446.

RESULTS

Table 1 shows participants' demographic characteristics. The results showed that there was a significant difference between the two groups in education level. Moreover, other variables include age, job experience, and body mass index in Group A and Group B were not significant difference. Electric and magnetic fields intensities were measured on 46 screens consisting of 20 laptops and 26 desktops [Figures 1 and 2]. The intensity of the mentioned fields with the standard total cost of ownership: the Swedish Confederation of Professional Employers for the amount of radiation allowed by monitors and various computer devices were compared. The permissible limit of magnetic field intensity is equal to 20 mA/m and the electric field intensity is equal to 1 v/m.^[14] According to the results of measuring electric fields in 4 directions, the minimum and maximum intensities of this field in desktop monitors were equal to 0.26 and 1.2 v/m, respectively. These measured values in the front, rear, and right at a distance of 30 cm were 1.07, 1.2, and 1.09 v/m, respectively, which are all above the standard limits. In addition, the minimum and maximum electric field intensities in the laptops were 0.28 and 0.78 v/m, respectively. The results of measuring the minimum and maximum magnetic fields in desktop monitors were 3.9 and 22 μ T, respectively. Furthermore, similar results in laptops were 3.1 and 21.3 μ T, respectively. Table 2 presents the results of mean, standard

Table 1: Demographic characteristics of participants

Characteristic	Group A (n=46)	Control B (n=23)	P*
Age range (years)			
25-30	8 (14.4)	5 (21.7)	0.11
31-36	9 (19.5)	5 (21.7)	
37-42	19 (41.3)	7 (30.5)	
>43	10 (21.7)	6 (26)	
Job experience (years)			
<10	15 (32)	10 (43.5)	0.19
11-20	22 (47.8)	8 (34.7)	
>21	9 (19.5)	5 (21.7)	
BMI (kg/m ²)			
Underweight (<18.5)	1 (2.2)	1 (4.3)	0.09
Normal (18.5-24.9)	24 (52.2)	12 (52.2)	
Overweight (25.0-29.9)	16 (34.7)	8 (34.7)	
Obese (\geq 30)	5 (10.8)	2 (8.6)	
Education			
Diploma	2 (2.2)	8 (34.7)	0.05**
Associate degree	9 (19.5)	12 (52.2)	
Bachelor degree	24 (52.2)	2 (8.6)	
Master degree	11 (24)	1 (4.3)	

**T*-test, ** $P < 0.05$. Values are presented as *n* (%). BMI: Body mass index

deviation, minimum, and maximum scores of general health and its 4 subscales in two groups. According to the results, it was found that 39% of the participants in the Group A had a score which indicates a lack of satisfactory general health. Moreover, 4% of the participants in the Group B had the same score. The results of data analysis by *t*-test showed a significant difference between two groups about general health [Table 2]. According to the Chi-square test in two groups, it was found that among the symptoms related to general health, there is a significant difference between lack of sleep, fatigue, and headache in two groups [Table 3]. Furthermore, comparison between desktop

users and laptop users in Group A revealed that they were significantly different in case of insomnia ($P < 0.05$).

DISCUSSION

The findings indicated that the intensity of the magnetic field in both laptop and desktop monitors is less than the standard recommended level by the American Conference of Governmental Industrial Hygienists. It should be noted that the maximum EMF measured in this study was 22 μ T. Similar to the findings of this study, Titov *et al.*, stated that the intensity of EMF is not consistent in every direction.^[16] In another

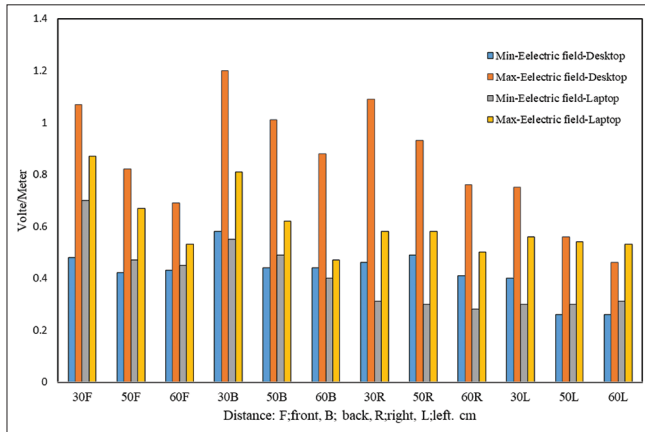


Figure 1: The measured electric field in different distances from desktops and laptops

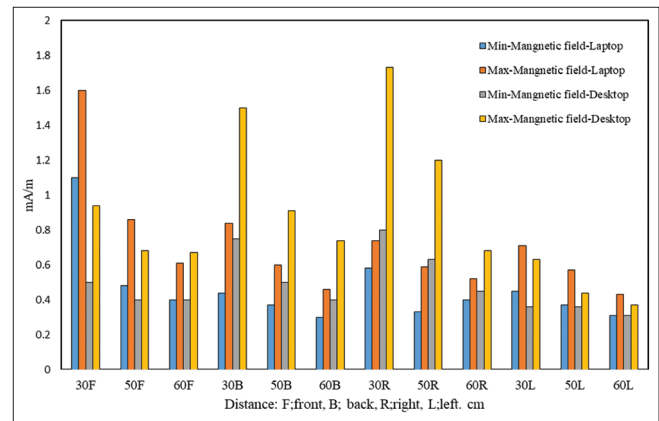


Figure 2: The measured magnetic field in different distances from desktops and laptops

Table 2: Mean, standard deviation, minimum and maximum of general health score and its 4 subscales in two groups

Group	n	Variable	Mean±SD	Minimum	Maximum	P
A	46	Physical symptoms	5±1.7	3	16	0.001*
		Anxiety	5.1±3.3	2	17	
		Social dysfunction	10.9±3.8	2	22	
		Depression	2.6±2.4	0	17	
		Total	19.5±9.7	9.2	22.2	
B	23	Physical symptoms	2.5±1.7	1	11	
		Anxiety	3.4±2	1	13	
		Social dysfunction	8.3±6.1	1	16	
		Depression	2.2±1.9	0	8	
		Total	12.6±5.6	6.1	18.2	

* $P < 0.05$. SD: Standard deviation

Table 3: Comparison of general health symptoms in two groups

Group	Symptom													
	Headache		Lack of sleep		Insomnia		Bad mood		Flushing		Fatigue			
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No		
A														
	Working with laptop		15	5	13	7	12	8	15	5	9	11	19	1
	Working with desktop		17	9	16	10	28	8	15	11	10	16	26	0
	p*		0.7		0.5		0.05		0.8		0.6		0.3	
B														
	Working with laptop		7	16	13	10	15	8	14	9	7	16	14	9
	p**		0.001		0.05		0.91		0.7		0.29		0.001	

* P value comparison between two subgroups of A, ** P value comparison between Groups A and B

study by Fard *et al.*, no indication of inadmissible EMF at any of the measured points was found; also, the highest values recorded were 0.69 T and 9.15 μ T.^[17] Their results showed no significant difference between the case and the control groups with regard to mental disorders.^[17] Another study on the influence of extremely low frequency EMF on the quality of sleep in high-voltage substations reported that although a higher percentage of poor quality of sleep was observed in the case group, no statistically significant difference was seen between two groups.^[18] The results of this study also showed that individuals who were exposed to magnetic fields at work may have poorer quality sleep and poorer health than the other group. However, no significant correlation was observed between the level of exposure and the quality of sleep and the general health of the employees ($P < 0.01$).^[18] Küçer and Pamukçu reported that users of electrical devices such as computers stated more complaints of headache, dizziness, and other anxiety symptoms regarding the daily use of these devices.^[19] In another study by Cinemre *et al.*, it was revealed that exposure to EMF by students for a long time duration in every day caused health problem such as sleep disorders and stress.^[20] These findings are similar to the results of the present study. The results of a study on power plant workers which were exposed to extremely low frequency EMFs (ELF-EMFs) reported that burnout syndrome and depression were significantly higher in exposed individuals to EMFs than in those in the control group.^[21] The results of study by Monazzam *et al.* indicated that 72% of participants exposed to the ultra-low frequency electromagnetic waves lacked general health, and all participants in the control group had proper health conditions.^[11] Furthermore, several studies have reported that EMF emitted by electric devices such as mobile phones and computers exert adverse impacts on the health and quality of life of the users.^[22-26] Examining general health symptoms in this study confirms that the prevalence of lack of sleep, headache, and fatigue symptoms was much different between the two groups.

The results of this study on the insignificant correlation between exposure levels and sleep disturbances and general health can be attributed to the small sample size of the study groups. As a result, further studies on larger populations are needed. Despite the similarity of the working conditions and the level of exposure of the participants working with laptops/desktops, the insomnia showed a significant difference ($P < 0.05$). Zamanian *et al.* also showed that people exposed to ELF-EMFs had lower levels of mental health than the control group.^[27] Despite numerous studies on the effects of EMFs on humans, scientists have not yet been able to reach a consensus on the actual side effects. Given the complexity of biological, psychological, and social factors affecting human health, a detailed study of the effects of EMFs requires further research on a larger scale.^[22-26]

CONCLUSIONS

Computer users of this study are continuously exposed to EMF emitted from electronic equipment related to their job

at least for 7 h in the workplace. Regarding the standards of exposure to these fields, the time factor is not considered and only a limitation is mentioned that the measured values should not exceed this value. This study showed that the measured values of electric and magnetic fields in most cases are less than the standard limits. Although with respect to a long time of using this equipment and unlimited time of work, the effects of exposure on the health of computer users can be assumed to have a cumulative manner. In addition, their health can be threatened in comparison to other workers. Headaches, lack of sleep, and fatigue were also more common among computer users in the exposed group than the control group. The role of using electronic equipment for communication and daily activities became more prominent. Therefore, it is clear that with the widespread use of this equipment, all members of society will be exposed to some kinds of EMF. Therefore, people who work with computers due to their job will use this equipment to do things during other nonworking hours. As a result of this increase in the time of using electronic equipment, their health will be at risk. Because in these conditions, in addition to EMF, there will be exposure to wireless and Wi-Fi waves simultaneously. However, today, the evidence for the health effects associated with exposure to wireless technology is inconclusive.

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Conflicts of interest

There are no conflicts of interest.

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