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Electromagnetic Fields and General Health: A Case of LCDs vs. Office Employees

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Abstract

Background: Exposure to the electric and magnetic fields resulting from liquid crystaldisplays may cause adverse effects on users.
Objectives: This study aimed to assess the electromagnetic field intensities of liquid crystal displays and their impacts on the users' general health.
Materials and Methods: Electric and magnetic field intensities were measured at 30, 50, and 60 cm around the screens using anHI-3603 device. Also, to investigate the probable relationship between exposure to electromagnetic fields and the users' general health, the General Health Questionnaire (GHQ) was used. The questionnaires were completed by 69 employees, both in the study and control groups. Data from the questionnaires were analyzed using SPSS software.
Results: The magnetic field intensities were less than commonly accepted standards such as The Swedish confederation of professional employers (TCO) for both laptop and desktop displays. Also, the electric field intensities in laptop displays were all within the allowable range in this study. However, values in the desktop displays were higher than 1 v/m (based on TCO standard) in 15% ,4% and 2% of the cases involving the distances of 30, 50, and 60 cm in one or more directions, respectively. There is a significant relationship between the general health of the people exposed to electromagnetic radiation and that of the control group (P = 0.0001).
Conclusions: The study results are indicative of the impact of electromagnetic fields on computer users' health, and it is thus advisable to avoid leaving computers switched on unnecessarily in addition to observing the minimum distance of 60 cm from computer monitors to control the adverse effects of electromagnetic fields.

Keywords: Electromagnetic fields, Video Displays, Health

1. Background

The invention of the computer and the video display terminal (VDT), together with their widespread use in various activities, has caused this device to be an integral part of human life. In addition, convenience and ease of use of computers are additional factors that have led to their increasing numbers of users. However, with the increasing number of users, some concerns about their health effects appear, since users spend a long time working with computers in the workplace and are, therefore, continuously exposed to the electric and magnetic fields generated from the devices (1-3). The electromagnetic fields around the displays are of an extremely low frequency (ELF) and very low frequency (VLF), within the range of 3 - 3000 Hz and 3 - 30 kHz, respectively (4). The effects of low and high frequency electromagnetic fields are different, while a higher voltage is associated with the former. This is while human beings are exposed to it freely and without protection.

The international agency for research on cancer (IARC), affiliated with the world health organization (WHO), has recently declared in a report that exposure to such fields are possibly carcinogenic to humans (5). The results of a study entitled "Assessment of the effects of exposure to ELF electromagnetic fields on the incidence of mental disorders in Mexican elderly", which was conducted by Davanipour et al. in America in 2014, showed that exposure to these fields increased the risk of mental disorders (6). In another study performed by Monazzam et al. in the petrochemical industry in 2014 to evaluate general health and sleep quality in workers who were exposed to ELF electromagnetic fields, it was found that 28% and 61% of the people exposed to electromagnetic fields lacked general health and had sleep disorders, respectively. The control group had good general health and only 4.5% of the subjects were facing a substandard quality of sleep (7). In 2014, Koeman et al. studied the effects of exposure to ELF electromagnetic fields on the incidence of cancer in the Netherlands. Although their results demonstrated no association between lung, breast, and brain cancers, and the mentioned magnetic field waves was studied in

both men and women, the relationship was significant : between male patients with leukemia (8).

In 2013, Felix et al. carried out a study on the evaluation of ELF magnetic field strength in computers and its health problems in Nigeria. They measured the magnetic field intensity around 10 personal computers (PCs) with an LCD display, including five laptops and five desktop computers within a distance of 5 - 40 cm and showed the intensity is lower around a desktop monitor compared to a laptop screen. However, the values were less than the allowable amounts in both computers and no evidence was found of the ill health effects caused by working with LCD displays (3). In their study carried out on the employees of the social security organization in the eastern region of Tehran in 2009, Ranjbarian et al. measured the electric and magnetic field intensities around 237 computer monitors within the distances of 30, 50, and 60 cm and found the intensities were higher at a distance of 30 cm compared to 50 cm and 60 cm. The prevalence of symptoms, such as runny tears, eye irritation, and fatigue, was observed in the study group as well as the control group (9).

In the beginning, computer monitors were made of cathode ray tubes (CRTs). Yet, they are made less this way today due to the development of new technologies, while being replaced by the displays commonly known as liquid crystal displays (LCDs). Their specific characteristics, such as lower power consumption, less space occupation, and lighter weight have differentiated them from CRTs, thus causing them to be more welcomed by users (2, 10). Due to the rise of electronic and software systems, and the necessity to use them in administrative correspondence, the computer is one of the most used tools in the workplace and in offices, and users regularly deal with a computer during working hours. Nevertheless, exposure to the electric and magnetic fields resulting from the displays may cause adverse effects on users.

2. Objectives

This study aimed to assess the electromagnetic field intensities of liquid crystal displays and their impacts on the users' general health.

3. Materials and Methods

In this descriptive-analytic study performed on all the male employees of a governmental office, according to the available population, seven people from a total of 53 subjects working as computer users were excluded from the research, since they had a history of non-occupational disease and could cause distortion of the results. In addition, 23 employees in the same office, with the same situation as the favored group in terms of age and gender, were selected as the control group. Their only difference was a lack of working with computers and dealing with their electromagnetic fields. To examine the exposure levels of the staff to the electric and magnetic fields, the field strengths were measured at 30, 50, and 60 cm in the four front, back, and side directions around the screens using a calibrated gauss meter, the HI-3603 model manufactured by HoladayCo. The mentioned device was able to separately measure the electric and magnetic fields on different scales and units, as well as store the measurement results. Since the direction of an electric field emission is perpendicular to that of a magnetic field, the device sensors were set parallel and perpendicular to the screen displays to measure the electric and magnetic fields, respectively (Figures 1 and 2). The results were ultimately compared with The Swedish confederation of professional employers (TCO) and the Swedish national board for measurement and testing MPRII standards (11).

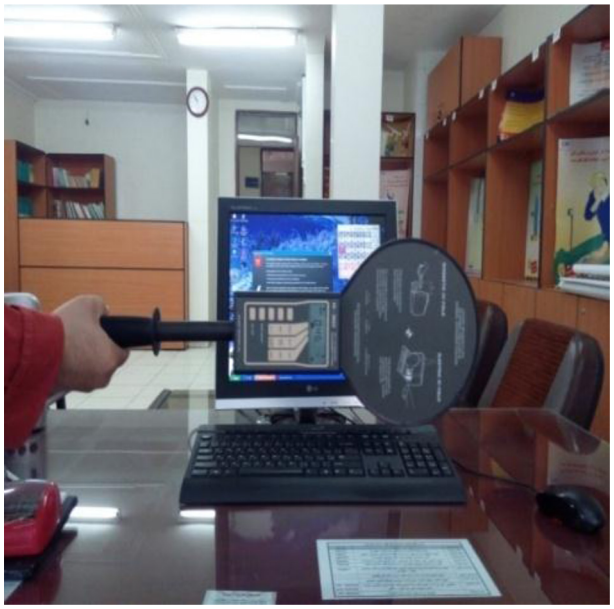

Figure 1. Gauss Meter Direction for Measuring the Electric Field

Figure 2. Gauss Meter Direction for Measuring the Magnetic Field

Also in this study, to investigate the probable relationship between exposure to electromagnetic fields and the users' general health, a two-part questionnaire was used. The first part included demographic questions such as age, occupation, daily duration of working with a computer, working background, and medical history, and the second part consisted of a general health questionnaire (GHQ). The GHQ was created by Goldberg and Hiller with 28 questions and includes four subscales of seven questions assessing somatic symptoms, anxiety, social disorder, and severe depression. The questionnaire has a cut-off point of 23. Accordingly, if an individual's total score is between 0 and 22, his or her general health is regarded as suitable, while a score of 23 or higher is considered as undesirable. After adequate training of both the case and control groups, the questionnaires were completed and the required data were collected. Then, descriptive statistics, t-test, independent t-test, and X^2 (Chi-square) test were utilized with the help of SPSS software to provide indices, such as mean, standard deviation, and a frequency table, compare the average electric and magnetic fields with the allowable limits, compare the average general health, and assess the relationship between general health symptoms and electric and magnetic fields, in the study and control groups.

4. Results

The intensities of electric and magnetic fields were measured on 46 screen displays including 20 laptop and 26 desktop displays in 4 directions at the distances of 30, 50, and 60 cm and compared with TCO and MPRII standards. The allowable limit of the magnetic field strength is 20 mA/m for both the MPRII and TCO standards, while the limits of the electric field intensity have been suggested to be equivalent to 2.5 v/m and 1 v/m, based on MPRII and TCO standards, respectively (11). Table 1 shows the means and standard deviations of the electric and magnetic fields measured at different distances and directions for laptop and desktop displays.

The general health investigations of the study and control groups demonstrated that 39% of the participants had a score higher than the cut-off point, indicating a lack of general health, while this value was about 4% in the control group. Furthermore, the results of the data analysis using the t-test showed a significant difference between the two groups based on general health (Table 2). The results of some general health symptoms analyzed for the study and control groups using the Chi-square test are shown in Table 3.

Table 1. The Means and Standard Deviations of the Electric and Magnetic Fields for Laptop and Desktop

Direction/Distance, cm	Laptop		Desktop	
	Magnetic Fields (STD) [a]	Electric Field (STD) [b]	Magnetic Fields (STD) [a]	Electric Field (STD) [b]
Front				
30	1.10 (0.49)	0.73 (0.14)	0.53 (0.41)	0.78 (0.29)
50	0.65 (0.21)	0.57 (0.1)	0.42 (0.26)	0.62 (0.2)
60	0.47 (0.14)	0.45 (0.08)	0.41 (0.26)	0.53 (0.16)
Back				
30	0.64 (0.2)	0.67 (0.14)	0.75 (0.75)	0.88 (0.35)
50	0.47 (0.13)	0.51 (0.11)	0.54 (0.37)	0.74 (0.27)
60	0.37 (0.09)	0.40 (0.07)	0.46 (0.28)	0.64 (0.24)
Right				
30	0.58 (0.16)	0.37 (0.21)	0.84 (0.89)	0.63 (0.46)
50	0.46 (0.13)	0.34 (0.24)	0.63 (0.57)	0.49 (0.44)
60	0.40 (0.12)	0.28 (0.22)	0.45 (0.23)	0.41 (0.35)
Left				
30	0.58 (0.13)	0.38 (0.16)	0.46 (0.17)	0.45 (0.3)
50	0.47 (0.10)	0.34 (0.2)	0.36 (0.08)	0.33 (0.23)
60	0.37 (0.06)	0.31 (0.22)	0.31 (0.06)	0.26 (0.2)

[a] mA/m.
[b] v/m.

Table 2. Comparison of the Case and Control Groups in Terms of General Health

Groups	N	Mean	Variance	P-Value
Case	46	19.46 ± 9.62	93.94	.0001
Control	23	12.61 ± 5.59	31.24	.0001

Table 3. The Results of Some General Health Symptoms Analyzed for the Case and Control Groups

Symptoms	Group		P Value
	Case	Control	
Headache			0.002
Have	32	7	
Have not	14	16	
Lack of sleep			0.601
Have	29	13	
Have not	17	10	
Insomnia			1
Have	30	15	
Have not	16	8	
Anger			0.723
Have	30	14	
Have not	16	9	
Hot flash			0.38
Have	19	7	
Have not	27	16	
Fatigue			0.0001
Have	35	14	
Have not	1	9	

5. Discussion

The findings showed that the magnetic field intensities were less than the standard levels in all the different distances and directions for both laptop and desktop displays, which are consistent with the results obtained by Felix et al. and Ranjbarian et al. (3, 9), yet incongruent with the study of Ghorbani et al. The reason for this discrepancy could be the simultaneous use of CRT-type monitors in their research (12). The results of this investigation are contradictory to those obtained by the study of Bellieni et al. conducted on five laptop devices, for which the magnetic field strength was measured in the range of 1.8 - 6 microtesla, representing an amount higher than the levels recommended by the committee on non-ionizing radiation protection (13). The reason for this discrepancy could be the use of screens of different sizes and different models. The electric field intensities in laptop displays were all within the allowable range in this study, however, their values for the desktop displays were higher than 1 v/m (based on TCO standard) in 15% ,4% and 2% of the cases involving the distances of 30, 50, and 60 cm in one or more directions , respectively. In the research conducted by Ranjbarian et al. the amount of electric field intensity at a distance of 30 cm from LCD desktop screens was higher than the standard level. Yet, this amount was reported to be in accordance with TCO and MPRII standards at a distance of 50 cm (9). Additionally, in another study performed on 40 laptop displays by Golmohammadi et al., the values of electric field strength measured at 30, 60, and 90 cm in different directions were reported to fall within a range of 10.86 - 58.14 v/m (14).

The present study showed that electric and magnetic field intensities vary in different directions such that they are higher in the front position of a laptop screen (where the keyboard and processor are situated) compared to the back position, while the opposite is true for a desktop display. Our obtained results are different from Charron's, which claimed the values are the same in all directions (11). Nevertheless, it is in line with the investigations done by Fehresti at the University of Medical Sciences of Zanjan, Ranjbarian et al. and Golmohammadi et al. (9, 14). In this research, the mentioned amounts were almost identical on the left and right sides in laptop displays, but the values on the right side of a desktop computer were found to be slightly larger than those of the left side, which could be due to the computer case being positioned generally on the right side of the display. Therefore, it is recommended that the desk layout be set in a way that the computer case is placed on the bottom of the desk if possible, so as to prevent the cumulative effects of such fields.

This investigation revealed that there is a significant relationship between the general health of the people exposed to electromagnetic radiation caused by the computer and that of the control group ($P = 0.0001$). In a case/control study conducted by Zahiroddin et al. 17% and 32.7% of the control and sample groups, respectively, who were exposed to electromagnetic waves were lacking in general health ($P < 0.01$) (15). In another study carried out by Shrivastava and Bobhate, 68%, 63%, and 44% of eye complications, musculoskeletal disorders, and social-psychosocial disorders, respectively, were reported as the most common health problems of computer users (16). Furthermore, in a study by Labbafinejad et al. performed on Iran's Statistics Center staff, sleep disorders, poor quality of sleep, and disorders in sleep duration were found as evident among the employees who were working with VDTs for a long time every day (17). In an investigation conducted by Monazzam et al. 72% of the subjects who were exposed to electromagnetic waves of an extremely low frequency were found to lack general health, while those of the control group were all in good health (7). Also, Zamanian et al. showed that the health levels of the people exposed to the above-mentioned radiations were less than those of the control group, and there was a significant relationship between their health and level of education (18). Moreover, Beale et al. discovered some signs of a tendency for suicide among the people who were exposed to electromagnetic fields, and this could be a result of depression and lack of general health among those individuals (19). These symptoms were also completely evident in another study conducted by van Wijngaarden et al. (20).

The results of general health symptoms examination in this research suggested that the prevalence of head-

ache and fatigue symptoms were significantly different between the two groups (higher prevalence in the study groupcompared to the control group). This is consistent with the Ghorbani and Ranjbarian's studies (9, 12). The Swedish Institute of Standards announced these symptoms could have many causes, including lack of observing ergonomic issues in the workplace, as well as getting involved in work stresses, intellectual work, numerous movements of the eyeball, and poor light. The results of five investigations conducted in various European countries in 1985 showed that headache and dizziness prevalence in VDT users who sat in front of the terminals more than four hours was higher than other people due to ergonomic problems (12).

5.1. Conclusions

The studies presented and the findings of the current study are indicative of the impact of electromagnetic fields on computer users' health, and it is thus advisable to avoid leaving computers switched on unnecessarily, in addition to observing the minimum distance of 60 cm from computer monitors to control the adverse effects of electromagnetic fields.

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Footnotes

Authors' Contribution: Concepts, design, manuscript editing, manuscript review: Behzad Fouladi Dehaghi; literature search, experimental studies, data analysis, manuscript preparation: Alireza Ghamar; statistical analysis: Seyed Mahmood Latifi.

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