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SURVEY ON ELECTRIC AND MAGNETIC FIELDS HP AND LENOVO LAPTOPS IN THE VICINITY OF INTERNET-CONNECTED SMART PHONES

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Received on 12-05-2016

Accepted on 02-06-2016

Abstract

Nowadays exposure to electromagnetic fields, emitted from electronic devices, especially laptops and mobile phones is inevitable due to their portability. Exposure to electromagnetic fields causes harmful effects on human health. Today, most people are exposed to these fields while using their mobiles or laptops. In this cross-sectional study, the electric and magnetic fields of HP and Lenovo laptops are measured in the vicinity of 3G internet-connected Samsung smart phones at a distance of 30 and 45 cm in front of laptops. The mean electric field in the vicinity of the smartphone at a distance of 30 cm for HP and Lenovo laptops was 0.11v/m and 0.06 v/m and the mean magnetic field was 1.69 mG and 1.43 mG, respectively. The domain of electric and magnetic fields were ND-0.17 v/m and 0.3-2.4 mG, respectively. The mean electric field for HP and Lenovo laptops in the vicinity of the smartphone, at a distance of 45 cm, was 0.10 v/m and 0.06 v/m, respectively and the mean magnetic field was 1.32 mG and 1.16 mG. The mean of SAR, for HP and Lenovo laptops, in the vicinity of mobile phones, at a distance of 30 cm was 19×10^{-6} w/kg and 5×10^{-6} w/kg and at a distance of 45 cm, was 17×10^{-6} w/kg and 5×10^{-6} w/kg. The Electric and magnetic field as well as SAR were less than standard. HP laptops magnetic field was significantly more than the Lenovo laptops.

Unlike Lenovo laptops, electric and magnetic fields of HP laptops, in the vicinity of mobile phones, was significantly higher than the absence of mobile phones. Putting the internet-connected smart phones in the vicinity of HP laptops (significantly) and Lenovo laptops (insignificantly) increases the of electric and magnetic fields.

Keywords: Electric fields, Magnetic fields, HP laptops, Lenovo laptops and Smart phones

1. Introduction

Electro-magnetic fields caused by the movement of electric charges in the space generate electric and magnetic fields [1]. Nowadays, exposure to electromagnetic fields, emitted by mobile phones, telecommunication towers, TVs, laptops, Tablets, high voltage power cables, electrical cables, etc. is inevitable [2,3]. Using laptop computers and mobile phones is increasing in many countries [4]. Besides, its use in sensitive groups such as children, has increased significantly [5]. 91% of people In the United States of America and 94% in Britain use mobile phones [6,7]. The ownership of mobile phones has reached from 12% in 1999 to 76% in 2009 [9, 8]. Portability and lightweight of laptops and cell phones have caused more concerns about the damaging impacts of their emitted electro-magnetic fields on human health because in this case, the contact surface of the body (skin, bone, blood and Genitals) increases [9-12]. In fact, the physical interaction of the body and electro-magnetic field cause the electric current, pass through the tissues of the body and it can be biologically harmful [13]. Biological effects of electromagnetic fields depends strongly on the frequency and strength of fields [14-15]. Electromagnetic fields can penetrate into the deep parts of the body and generate electric currents. If the electrical currents' exceed the limit, they will stimulate the muscles and brain, causing membrane depolarization [16]. Studies have shown that electromagnetic fields interfere in the performance of heart batteries (at a distance of less than 15 cm) in people with heart disease [17], clinical disease [18] behavioral effects [19] headaches, poor concentration and memory, fatigue and sleepiness [20,21]. Kinyemi et al (2010) in an evaluation of the ELE¹ fields emitted by a variety of laptops showed that the of 4-200 mA/m fields for Laptops was variable and the highest belonged to HP laptop Model DV6000. In addition, it was indicated in this study, that the of fields depends on the type of laptop [22]. According to the Swedish Board for Technical Accreditation the standard limit of the of the magnetic field is 25 nT which is in accordance with the Tjänstemännens central organization (TCO). But according to MPRII, the standard limit of electric field's is supposed to be 2.5 m/v, and the standard of TCO is supposed to be 1 m/v [23]. Studies have shown that the assessment of human exposure by calculating the SAR (Specific Absorption Rate) is very important at frequencies greater than 100 MHz [24]. The International commission on non-ionizing radiation protection have suggested 2 w/kg in 10 grams of tissue for

specific absorption rate and Institute of electrical and electronics engineers of the World Health Organization has suggested 1.6 w/kg in 10 grams of tissue [13,25]. In recent years the concomitant use of laptops and smart phones connected to 3G internet has increased dramatically. In most cases people put their smartphones next to their laptops while working with them. Therefore, we attempted to compare the of the electric and magnetic fields of two famous brands of HP and Lenovo of laptops in the vicinity of smart phone connected to the 3G Internet. Also we calculated the specific absorption rate of electromagnetic fields to the head and compared it with the standards.

2. Materials and Methods

1.2. Measurement of electric and magnetic fields

The electric field was measured by EMF survey meter model HI 3603 Manufactured by Holaday Co. of America (Figure 1). It is portable of measuring electric and magnetic fields separately at different scales and units and also is portable of storing measurement results [26]. Before starting the measurement, the background electric and magnetic fields that from other equipment such as telecommunication towers, electric substations, and the TVs were measured. Since the background electric and magnetic fields were lower than the electric and magnetic fields of mobile phones and laptops, the background field was not considered in the calculation. The electric and magnetic fields of the two famous brands of HP laptop (ProBook 650 G1 i7, Pavilion 15-p215nia, ProBook 450 G3) and Lenovo laptop (Z4170 i7, Yoga 500 i3, Essential G5045) were measured while the office application was running and the laptops were connected to the internet, in the vicinity of Samsung GT-i9070 smartphone connected to the 3G internet. The distance between the phone and the laptops was 10 cm and the distance of measuring device from laptop was 30 and 45 cm, in front of the laptops' screen.



Figure-1. Portable device measuring electromagnetic field, Model HI-3603-VDT/VLF.

2.2. Calculation the specific absorption rate

To calculate the specific absorption rate of the electric field, we used the equation 1, by ICNIRP [28 ,27].

Equation 1

$$SAR = \sigma \frac{E^2}{\rho}$$

In this equation SAR; is the electric field’s specific absorption rate (w/kg), σ is the conductivity of the tissues of the head ($\Omega^{-1}m^{-1}$) which is $0.7665 \Omega^{-1}m^{-1}$ and $1.1531 \Omega^{-1}m^{-1}$ in 900 and 1800 MHz, respectively; p is the mass density of the head which is $1030 Kgm^{-3}$ both in 900 MHz and 1800MHz [27].

3.2. Statistical analysis

For statistical analysis, software, Spss 16 inc, Chicago, IL was used. After determining the normal distribution of data by using One-Sample Kolmogorov-Smirnov, T-Test was used for statistical analysis. Specific absorption rate and electric field with the standard limits were compared by one sample T Test. Also Independent Sample T-Test was conducted to compare the specific absorption rate of two brands of laptops with each other in the presence or absence of mobile phones. P value <0.05 was chosen as the significance level.

3. Results

In this cross-sectional study, the electric and magnetic fields of HP and Lenovo laptops were measured in the vicinity of samsung mobile phones connected to 3G internet from a distance of 30 and 45 cm in front of laptops. The background electric and magnetic fields were 0.02 v/m and 0.16 mG, respectively. The mean electric field in the vicinity of the smartphone at a distance of 30 cm for HP and Lenovo laptops was 0.11 and 0.06 v/m, in the absence of mobile phones was 0.05 and 0.04 v/m, respectively. The mean magnetic field, in the vicinity of mobile phones was 1.69 and 1.43 mG for HP and Lenovo laptops and absence of mobile phones was 1.36 and 0.97 mG. The domain of electric and magnetic fields was ND-0.17 v/m and 0.3-2.4 mG, respectively (Table 1).

Table-1. Electric and magnetic fields of HP and Lenovo laptops in the vicinity or absence smart phones internet-connected at a distance of 30 cm.

Number detect	Along with mobile phone		Without mobile phone		Along with mobile phone		Without mobile phone	
	Electric				Magnetic			
	HP ¹	Lenovo ²	HP	Lenovo	HP	Lenovo	HP	Lenovo
1	0.09	0.10	0.03	0.02	1.9	1.51	1.6	1.1
2	0.12	0.08	0.06	0.06	1.5	1.3	1.2	0.9
3	0.13	0.09	0.07	0.07	1.6	1.2	1.4	0.6
4	0.08	0.04	0.05	0.04	1.8	1.4	1.5	0.9
5	0.08	0.04	0.02	0.01	1.7	1.3	1.4	0.7
6	0.17	0.06	ND	0.00	1.6	1.8	1.3	1.5
7	0.14	0.05	0.09	0.08	1.6	1.6	1.1	1
8	0.12	0.08	0.07	0.04	1.8	1.6	1.5	1
9	0.09	0.05	0.03	0.02	1.3	1	1.1	0.6

10	0.05	0.02	ND	0.00	2.4	2.3	2.1	1.8
11	0.05	0.05	ND	0.00	2.3	1.9	1.9	1.5
12	0.14	0.08	0.08	0.07	1.5	1.3	0.9	0.9
13	0.15	0.10	0.1	0.10	1.5	1.2	1.2	0.8
14	0.15	0.03	0.05	0.08	1.7	1.4	1.25	1
15	0.15	0.04	0.05	0.08	1.2	0.7	0.9	0.3
Mean	0.11	0.06	0.05	0.04	1.69	1.43	1.36	0.97
SD	0.04	0.03	0.03	0.03	0.32	0.38	0.33	0.39

The mean electric field in the vicinity of the smartphone at a distance of 45 cm for HP and Lenovo laptops was 0.10 and 0.06 v/m and the mean electric field in the absence of the smartphones was 0.03 and 0.04 v/m respectively. Mean magnetic field in the vicinity of smartphones for HP and Lenovo laptops was 1.32 and 1.16 mG and the mean magnetic field in the absence of the smartphones was 1.26 and 0.94 v/m (Table 2).

Table-2. Electric and magnetic fields of HP and Lenovo laptops in the vicinity or absence of internet-connected smart phones at a distance of 45 cm.

	Along with mobile phone		Without mobile phone		Along with mobile phone		Without mobile phone	
	HP	Lenovo	HP	Lenovo	HP	Lenovo	HP	Lenovo
	Electric (v/m)				Magnetic (mG)			
Number detect	HP	Lenovo	HP	Lenovo	HP	Lenovo	HP	Lenovo
1	0.08	0.08	0.02	0.01	1.54	1.22	1.50	1.03
2	0.11	0.07	0.04	0.04	1.22	1.00	1.13	1.06
3	0.12	0.08	0.05	0.05	1.30	0.97	1.60	0.90
4	0.07	0.03	0.04	0.03	1.46	1.13	1.41	1.20
5	0.07	0.03	0.01	ND	1.38	1.05	1.32	0.80
6	0.16	0.08	ND	0.02	1.30	1.46	1.22	1.00
7	0.13	0.05	0.08	0.03	1.30	1.30	1.03	0.94
8	0.11	0.09	0.05	0.03	0.60	1.30	1.41	0.94
9	0.08	0.04	0.02	0.05	1.05	0.81	1.03	0.60
10	0.05	0.03	ND	0.03	1.94	1.86	1.50	1.30
11	0.08	0.05	ND	0.04	1.86	1.54	1.79	1.10
12	0.13	0.05	0.06	0.05	1.22	1.05	0.85	0.85
13	0.14	0.09	0.07	0.07	1.22	0.97	1.13	0.90
14	0.14	0.03	0.04	0.06	1.38	1.13	1.18	0.94
15	0.14	0.04	0.04	0.06	0.97	0.57	0.85	0.60
Mean	0.10	0.06	0.03	0.04	1.32	1.16	1.26	0.94
SD	0.03	0.02	0.03	0.02	0.33	0.31	0.27	0.19

The mean of SAR, for HP and Lenovo laptops, in the vicinity of mobile phones, at a distance of 30 cm was 19×10^{-6} and 5×10^{-6} w/kg and at a distance of 45 cm, the was 17×10^{-6} w/kg and 5×10^{-6} w/kg. The mean of SAR, for HP and Lenovo laptops, in the absence of mobile phones, at a distance of 30 cm was 3×10^{-6} and 3×10^{-6} and the distance of 45 cm was 2×10^{-6} and 2×10^{-6} w/kg.

Table-3. Specific absorption rate of electromagnetic fields with and without the presence of mobile phones.

	Along with mobile phone		Without mobile phone	
	HP	Lenovo	HP	Lenovo
30 cm	19×10^{-6}	5×10^{-6}	3×10^{-6}	3×10^{-6}
45 cm	17×10^{-6}	5×10^{-6}	2×10^{-6}	2×10^{-6}

Since the One-Sample Kolmogorov-Smirnov test showed that P value = 0.82 (p value > 0.05); therefore, t test was used for statistical analysis. Magnetic field from HP and Lenovo laptops' in the vicinity of mobile phones (30 cm) was greater than 45 cm, significantly. In other circumstances, a significant difference was not observed (Table 4).

Table-4. The comparison of the electric and magnetic fields at the distance of 30 cm and 45 cm.

			p value	95%CI	
Alone	HP	Electric	0.61	-0.02	0.03
		Magnetic	0.004¹	0.13	0.62
	Lenovo	Electric	0.6	-0.01	0.02
		Magnetic	0.03	0.01	0.53
Without	HP	Electric	0.2	-0.009	0.03
		Magnetic	0.4	-0.13	0.32
	Lenovo	Electric	0.5	-0.01	0.02
		Magnetic	0.79	-0.19	0.25

In the vicinity of HP mobile phones, the electric field of HP laptops was higher than the Lenovo laptops, significantly. In addition, the magnetic field of HP laptops was higher than Lenovo laptops significantly (Table 5). Electric and magnetic fields of HP laptops, in the vicinity of mobile phones, are significantly higher than the conditions without the presence of the mobile phones [p value < 0.001 (Electric field) and p-value = 0.009 (magnetic field)]. Electric and magnetic fields of Lenovo laptops was not significant in the presence or absence of laptops [p-value = 0.16 (Electric field) and p-value = 0.7 (Magnetic field)]

Table-5. The comparison of the electric and magnetic fields HP with Lenovo laptops.

		P value	95%CI	
Alone	Electric	<0.001	0.02	0.07
	Magnetic	0.055	-0.006	0.52
Without	Electric	0.87	-0.02	0.027
	Magnetic	0.007	0.11	0.65

4. Discussion

The results of this study showed that unlike Lenovo laptops, the smart phones internet- connected increase the of electric and magnetic field of HP laptops, significantly. All electrical appliances produce electro-magnetic field and all the people are constantly exposed to electromagnetic fields. Several studies indicate the harmful effects of electromagnetic fields on human's health, including an increased risk of cancer and non-malignant diseases (Nonmalignant) [29]. Some studies also showed a significant positive relationship between exposure to electromagnetic fields and heart and nervous diseases [30-32]. Since laptop users, depending on their conditions of employment and work, spend long hours working with laptops during the day, the mean of magnetic and electric fields was measured. At a distance of 30 cm, the mean of electric field for HP laptops, in the vicinity or absence of mobile phones was 1.83 and 1.25 times more than that of Lenovo laptops, respectively. The mean of magnetic field for HP laptops at the same distance was 1.8 and 1.4 times more than that of Lenovo laptops, respectively. At a distance of 45 cm, the electric and magnetic fields of HP laptops were higher than that of Lenovo laptops. However, the statistical analysis showed that the magnetic field of HP laptops is more than Lenovo laptops only when the mobile phones are in the vicinity (Table 4). This increase in electric and magnetic fields in HP laptops may be resulted from higher amperage or different parts used in the device [33]. Besides, the results of Table 5 show that the placing mobile phones in the vicinity of the laptops may increase the of electric field compared to the magnetic field. Since in the vicinity of mobile phones the electric field of HP laptops was higher than that of Lenovo laptops significantly. But when there were no mobile phones in the vicinity of laptops, the magnetic field of HP laptops was significantly higher. In the study of Golmohammadi et al, the mean electric (153.7 ± 259.28 v/m) and magnetic fields (106.14 ± 58.4 mA/m) in HP laptops, when running office program, were much more than that of our study[34]. In the studies of Akinyemi et al and Ranjbarian et al, like ours, the of electric and magnetic fields decreased with an increase in the distance [22,35]. The domain of magnetic field was more than ours in the study of Akinyemi et al (4-

200 m/mA). Results of the study of Abadi et al showed that, at a distance of 30 cm, HP laptops have a more sever electric field 0.56 ± 0.32 v/m compared to the mean of our study (0.11 ± 0.04 v/m) [36].

Unlike Ranjbarian et al, the electric and magnetic fields of our study was much less than standard in both HP and Lenovo models of laptops [37].

Placing the mobile phones internet-connected at a distance of 30 cm from HP and Lenovo laptops increased SAR. Increase in the SAR for HP laptops was (6.3 times more) and for Lenovo laptops was (1.6 times) (Figure 2). Also at a distance of 45 cm, the placing of mobile phonesinternet-connected increased the SAR for HP and Lenovo laptops. The Increase in the SAR for HP laptop (8.5 times more) and for Lenovo laptops was (2.5 times) (Figure 3). With an increase in the distance, from 30 cm to 45 cm, the of electric and magnetic fields of HP and Lenovo laptops decreased (Figure 4).

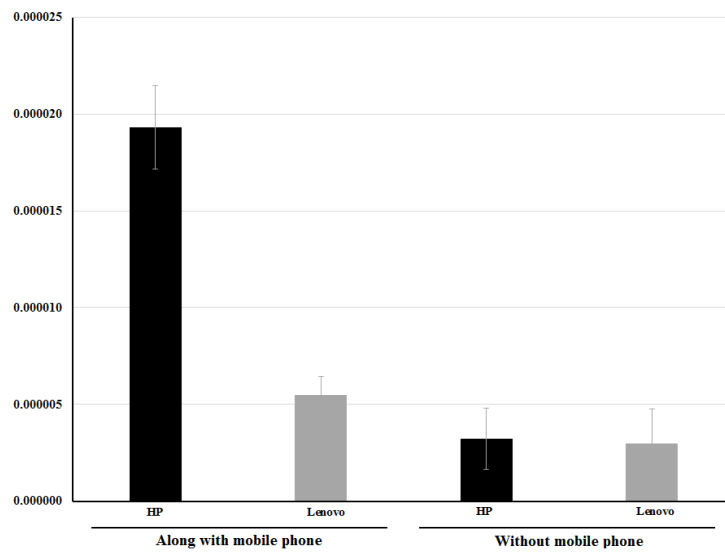


Figure 2 Comparison of specific absorption rate of the head in HP and Lenovo laptops at a distance of 30 cm.

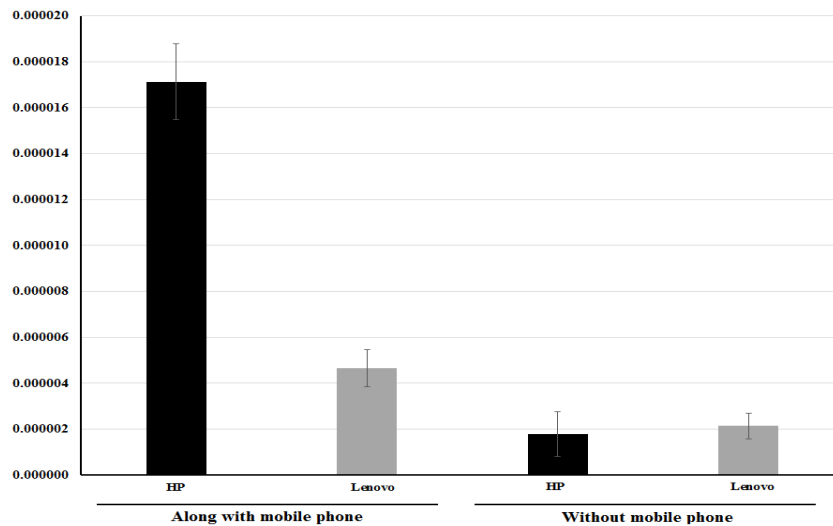


Figure 3. Comparison of specific absorption rate of the head in HP and Lenovo laptops at a distance of 45 cm.

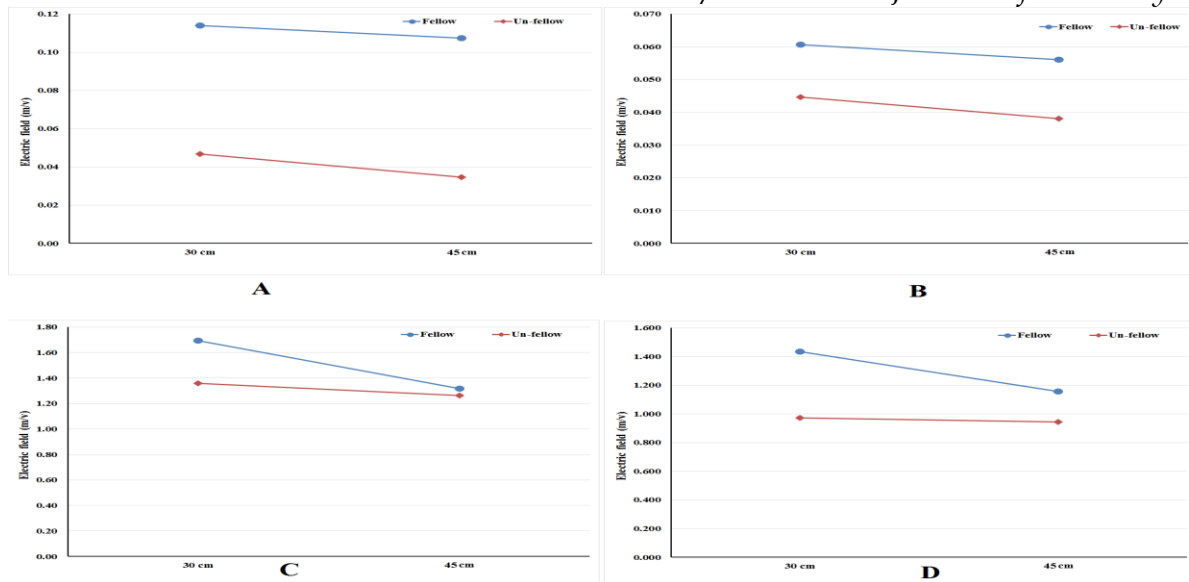


Figure-4. Comparison of electric and magnetic fields of HP and Lenovo laptops at the distances of 30 and 45 cm, A: HP- electric field, B: Lenovo-electric field, C: HP-magnetic field, D: Lenovo-Magnetic field.

Since laptops are usually close to the body and according to the inverse-square law in the of electric and magnetic fields, it is concluded that if laptops are too close to body or in some cases are used in a sitting position and placed on the thigh muscles, the of exposure to these fields will increase[38].

Different researches have demonstrated that exposure to electromagnetic fields with a low frequency cause changes in testosterone [39-41]. Also it causes an Increase in prolactin and estrogen and hence breast cancer risks in people who are prone to breast cancer [42, 43].

5. Conclusions

The SAR of the electro-magnetic fields to the head was less than the standard limits in the HP and Lenovo laptops at a distance of 30 and 45 cm, significantly. The increase in the distance, decreases the electric and magnetic field's . Putting the smart phones internet-connected in the vicinity of HP laptops (significantly) and Lenovo laptops (insignificantly) increases the of electric and magnetic fields. It is therefore recommended that people avoid using the smart phones internet-connected in the vicinity of HP and Lenovo laptops.

6. Acknowledgment

Students research office of shahid beheshti university of medical sciences was supports the financial of this research (Code:2650, Date:2016/02/29).

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