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The survey on difference between simple cell phones and the smart phones in the specific absorption rate of electric waves on the human's head

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Abstract: *Today, exposure to electromagnetic waves emitted from cell phones, telecommunication antennas and other electrical devices is unavoidable. Many people around the world, in proportion to their income, use various types of basic and smart cell phones. Therefore, in this study, efforts have been made to compare the specific absorption rate of simple cell phones with the smart phones. Electric field in two models of basic cell phones and also in two models of smart cell phones was measured by a portable device for measuring electromagnetic waves, HI-3603-VDT/VLF model. Then, the specific absorption rate in the human head was calculated in these two cell phones by ICNIRP equation and in two frequencies of 900MHz and 1800MHz. Finally, with the use of statistical tests (Independent Sample T-Test), the comparison of specific absorption rate between smart cell phones and simple cell phones was conducted. The mean electric field created by simple cell phones in models 1 and 2 is 2.39±0.14 v/m and 2.16±0.24 v/m and in smart cell phones is 1.82±0.20 v/m and 1.96±0.186 v/m, respectively. In simple cell phones, the mean specific absorption rate in the human head, for two frequencies of 900MHz and 1800MHz is 0.0042±0.0008 W/Kg and 0.0062±0.0008 W/Kg, and in smart cell phones is 0.0027±0.0003 W/Kg and 0.0039±0.0005 W/Kg, respectively. The mean electric field and consequently the specific absorption rate in human's head, in simple cell phones and smart phones was less than the standard limits. In the frequency of 1800MHz, the specific absorption rate in the head emitted by simple cell phones is significantly (p value<0.05) more than smart cell phones (without Internet connection).*

Keywords: *Electric field, cell phone, smart and simple, specific absorption rate.*

I. Introduction

Today, exposure to electromagnetic fields that are emitted by mobile phones, telecommunication antennas, television, laptop, tablet, high voltage substations, electric cables and etcis inevitable [4-1]. 91% of people in the United States and 94% in Britain have used mobile phones [6 ,5].Also, mobile phone ownership in the world has reached from 12% in 1999 to 76% in 2009. This excessive use, especially in the last two decades, caused a lot of concern on the effects of electromagnetic waves emitted by mobile phones on the human health .[9-7] Although since the 1950s, numerous global and national guidelines have been developed in the field of dealing with electromagnetic field, but concerns in the field of unknown effects of this field, even lower than the guidelines, is still increasing [10]. The world health organization has classified the electromagnetic waves emitted by mobile phones in class 2B, in terms of carcinogenesis (possibly carcinogenic) [11]. Studies have shown that electromagnetic waves can cause undesirable effects on health [12], intervention in the performance of the cardiac battery (distance less than 15 cm), in people with heart disease [10], clinical disease [13]behavioral effects [14]headache, loss of concentration and memory, tiredness, drowsiness and anxiety in humans [16 ,15]. Studies have shown that at frequencies greater than 100 MHz, such as mobile frequency, assessing the human exposure by calculation of SAR (Specific Absorption Rate) is very important [18 ,17]. Institute of electrical and electronics engineers and the world health organization have recommended 2 W/kg meand over the 10 g of tissue [20 ,19]. In recent years, with technology advances and the growing entrance of smart phones into the market, their usage has become widespread. Therefore, in this study, efforts have been made to compare and assess the difference of specific absorption rate of electric waves the in the human's head in simple cell phones with smart phones.

II. Materials And Methods

1.2. The measurement of electric field

At first, two basic cell phones and two smart phones were selected from one of the world's most popular and widely used brands. 12 measurements from each cell phone were conducted. The electric field measurement was carried out by EMFs survey meter model HI 3603 (Figure 1). Before starting the

measurement, the electric field of the earth's surface was measured which can be caused by other equipment such as telecommunication antennas, power substations, television and etc. Then, the electromagnetic fields (EMFs) of the earth were deducted from the EMFs of the cell phones. Since in most cases, people hold the phone to their ear while talking, hence, the measurement of EMFs was carried out from a distance of 2 cm.

The measurements were done for all the phones without vibration and with no internet connection. Initially, the electric field and then the magnetic field were measured. Measuring was performed in the state of talking (ring mode). Finally, according to equation 1, the electric field was calculated by subtracting the earth's electric field from the measured electric field of the cell phones.

Equation 1 $EF_{(Mobile\ Phone)}\ (v/m) = EF_{(Measured)} - EF_{(Background)}$

Figure1. The portable device of electromagnetic field measurement, Model HI-3603 VDT/VLF

2.2. The calculatin specific absorption rate

Equation 2 was used by International Commission on Non-Ionizing Radiation Protection (ICNIRP) to calculate the specific absorption rate of the electric field [[22 ,21].

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

In which, SAR is the specific absorption rate of the electric field (W/kg), σ is the head tissues conductivity ($\Omega^{-1}m^{-1}$) which is respectively 0.7665 $\Omega^{-1}m^{-1}$ and 1.1531 $\Omega^{-1}m^{-1}$ in the frequencies of 900MHz and 1800MHz and ρ is the mass density of human's head (Kgm^{-3}), which is equal to 1030 Kgm^{-3} in both 900 and 1800 MHz frequencies [21].

2.3. Statistical analysis

After determining the normal distribution of data, T-Test was used for statistical analysis. For comparing the specific absorption rate of the electric field of simple cell phones with smart phones, at 900 and 1800 MHz frequency, Independent Sample T-Test was used, and One Sample T-Test was used to compare the specific absorption rate with the guidelines. P-value <0.05 was selected as the significance level (α = 5%).

III. Results

The earth's electric field, before starting the measurement, was 0.3v/m and the results were deducted by this number. The mean electric field emitted by simple cell phones in models 1 and 2 is respectively 2.39 ± 0.14v / m and 2.16 ± 0.24v / m. The specific absorption rate in the head for 900MHz, in model 1, 2 and the overall mean is respectively 0.0043 ± 0.0005 W/Kg, 0.0042 ± 0.0008 W/Kg and 0.0042 ± 0.0008 W/Kg (Table 1). The specific absorption rate in the human's head for 1800MHz, in model 1, 2 and the overall mean is 0.0062 ± 0.006 W/Kg, 0.0063 ± 0.0011 W/Kg and 0.0062 ± 0.0008 W/Kg , respectively (Table 2).

Table1. The electric field and the specific absorption rate in simple cell phones in 900 MHz

Number of detect	Simple mobile phone 1 (v/m)	Sar(W/Kg)	Simple mobile phone 2 (v/m)	SAR(W/Kg)	Total Mean SAR
1	2.4	0.0043	2.1	0.0033	0.0038
2	2.3	0.0039	2.2	0.0036	0.0038
3	2.4	0.0043	2.4	0.0043	0.0043
4	2.4	0.0043	1.8	0.0024	0.0033
5	2.6	0.0050	2.5	0.0046	0.0048
6	2.2	0.0036	2.4	0.0043	0.0039
7	2.2	0.0036	2.5	0.0046	0.0041
8	2.3	0.0039	2.5	0.0046	0.0043
9	2.3	0.0039	2.5	0.0046	0.0043
10	2.6	0.0050	2.5	0.0046	0.0048

11	2.5	0.0046	2.5	0.0046	0.0046
12	2.5	0.0046	2.4	0.0043	0.0045
mean	2.39	0.0043	2.16	0.0042	0.0042
SD	0.14	0.0005	0.24	0.0008	0.0008

Table2. The electric field and the specific absorption rate in simple cell phones in 1800 MHz

Number of detect	Simple mobile phone 1 (v/m)	SAR(W/Kg)	Simple mobile phone 2 (v/m)	SAR (W/Kg)	Total Mean SAR
1	2.4	0.0064	2.1	0.0049	0.0057
2	2.3	0.0059	2.2	0.0054	0.0057
3	2.4	0.0032	2.4	0.0064	0.0048
4	2.4	0.0064	1.8	0.0036	0.0050
5	2.6	0.0076	2.5	0.0070	0.0073
6	2.2	0.0054	2.4	0.0064	0.0059
7	2.2	0.0054	2.5	0.0070	0.0062
8	2.3	0.0059	2.5	0.0070	0.0065
9	2.3	0.0059	2.5	0.0070	0.0065
10	2.6	0.0076	2.5	0.0070	0.0073
11	2.5	0.0070	2.5	0.0070	0.0070
12	2.5	0.0070	2.4	0.0064	0.0067
Mean	2.392	0.0062	2.358	0.0063	0.0062
SD	0.1379	0.0012	0.2193	0.0011	0.0008

The mean electric field of smart phones in model 1 and 2 is 1.82 ± 0.20v / m and 1.96 ± 0.186v/m, respectively. The specific absorption rate in the head for 900MHz frequency in model 1, 2, and the overall mean is 0.0025 ± 0.0006 W/Kg, 0.0029 ± 0.0006 W/Kg and 0.0027 ± 0.0003 W/Kg, respectively (Table 3). The specific absorption rate in the head for 1800MHz frequency in model 1, 2, and the overall mean is 0.0035 ± 0.0008 W/Kg, 0.0043 ± 0.0008 W/Kg and 0.0039 ± 0.0005 W/Kg , respectively (Table 4).

Table3. The electric field and the specific absorption rate in human's head from smart phones at a frequency of 900 MHz

Number of detect	Smart mobile phone 1 (v/m)	SAR (W/Kg)	Smart mobile phone 1(v/m)	SAR (W/Kg)	total Mean SAR
1	1.75	0.0023	1.9	0.0027	0.0025
2	1.65	0.0020	1.9	0.0027	0.0024
3	2.1	0.0033	1.8	0.0024	0.0028
4	2.2	0.0036	1.9	0.0027	0.0031
5	1.95	0.0028	1.9	0.0027	0.0028
6	2	0.0030	1.8	0.0024	0.0027
7	1.8	0.0024	2.1	0.0033	0.0028
8	1.6	0.0019	1.8	0.0024	0.0022
9	1.8	0.0024	1.8	0.0024	0.0024
10	1.9	0.0027	2.2	0.0036	0.0031
11	1.6	0.0019	2.2	0.0036	0.0028
12	1.6	0.0019	2.3	0.0039	0.0029
Mean	1.82	0.0025	1.96	0.0029	0.0027
SD	0.20	0.0006	0.18	0.0006	0.0003

Table4. The electric field and the specific absorption rate in human's head from smart phones at a frequency of 1800 MHz

Number of detect	Smart mobile phone 2 (v/m)	SAR (W/Kg)	Smart mobile phone 2 (v/m)	SAR (W/Kg)	Total Mean SAR
1	1.75	0.0034	1.9	0.0040	0.0037
2	1.65	0.0030	1.9	0.0040	0.0035
3	2.1	0.0025	1.8	0.0036	0.0030
4	2.2	0.0054	1.9	0.0040	0.0047
5	1.95	0.0043	1.9	0.0040	0.0041
6	2	0.0045	1.8	0.0036	0.0041
7	1.8	0.0036	2.1	0.0049	0.0043
8	1.6	0.0029	1.8	0.0036	0.0032
9	1.8	0.0036	1.8	0.0036	0.0036
10	1.9	0.0040	2.2	0.0054	0.0047
11	1.6	0.0029	2.2	0.0054	0.0041
12	1.6	0.0029	2.3	0.0059	0.0044
Mean	1.82	0.0035	1.96	0.0043	0.0039
SD	0.20	0.0008	0.18	0.0008	0.0005

IV. Discussion

The frequency of communication networks in Iran is 900MHz and 1800 MHz, therefore, 41.25 m/v and 53.8 m/v are considered as the standard limitations of public exposures [19]. The ratio of the mean electric field of simple and smart mobile phones to the standard level is respectively 4.42% and 3.53% (P <0.05). As can be seen in Figure 2 and 3, the mean specific absorption rate in the head from simple and smart cell phones at frequencies 900 and 1800 is much less than the standard level (p value <0.05). As the study of Ghaffari and colleagues, there is a significant difference between the mean electric field and the magnetic field and the electric field is greater than the magnetic field [23]. In the study of Ghaffari et al, the electric and magnetic field of smart phones at a distance of 5 cm is respectively 1.78 m/v and 0.96 Mg, which in comparison with our study, the electric field is lower but the magnetic field is greater. Since, in our study, the measurement was done at a distance of 2 cm, the electric field was also higher (1.9v/m). But, as the electric field, the magnetic field was also expected to be greater, with a reduction in the distance, but it wasn't. The specific absorption rate in the head, at the frequency of 1800 MHz to 900 MHz is 1.33 (P value <0.05).

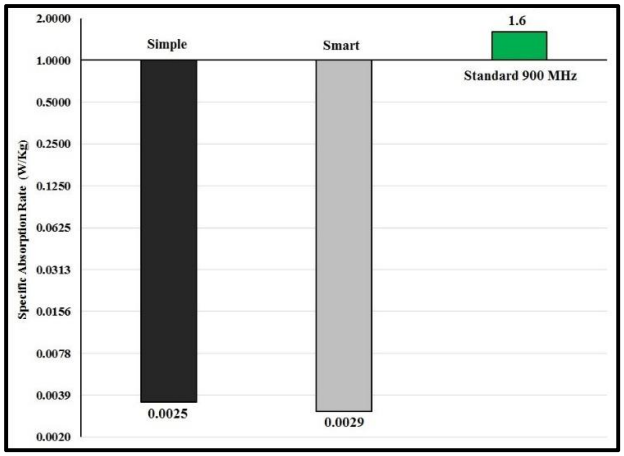

Figure 2. The comparison of specific absorption rate in the head at the frequency of 900MHz in simple and smart cell phones with standard level

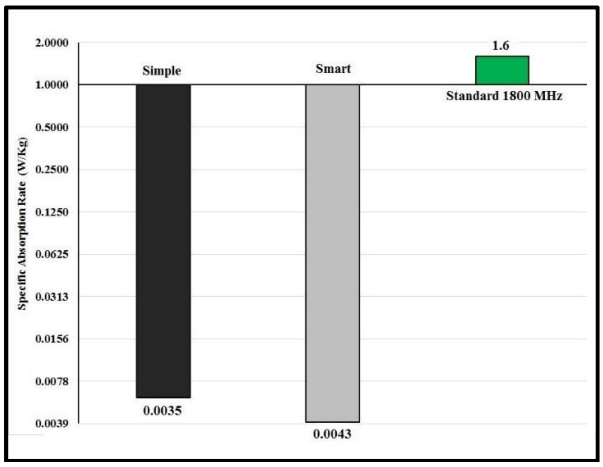

Figure 3. The comparison of specific absorption rate in the head at the frequency of 1800MHz in simple and smart cell phones with standard level

Statistical analysis of Independent Samples Test between the values of SAR in the head emitted by simple and smart cell phones, at frequencies 900 and 1800MHz is p-value = 0.1 and P-value = 0.039 , respectively. Statistical analysis showed that although the specific absorption rate in human's head from simple cell phones is more than smart phones at the frequency of 900MHz, there is no significant difference between them (p value> 0.05).But, in the frequency of 1800MHz, the specific absorption rate in the head from simple cell phones is more than smart phone (p value<0.05). This greater amount of specific absorption rate at a frequency of 1800 is due to the higher head tissue conductivity in this frequency. Since internet connection can increase the electromagnetic field, hence, in subsequent studies, the comparison of smart phones in the condition of internet connection can be studied [24]. In a study by Naif, the specific absorption rate in human's head at a distance of 0.01 mm is 1.57 W/kg. This specific absorption rate in the Naif's research is much more than this study [25]. In a study conducted by Burdalo et al, the specific absorption rate for adults at 900 MHz and 1800 MHz frequencies is respectively 0.02 W/Kg and 0.008 W/Kg which is close to our results [26].

V. Conclusion

The mean electric field and consequently the specific absorption rate in human's head from simple cell phones and smart phones are much lower than the standard limits (p value <0.05). The specific absorption rate at the frequency of 1800MHz is more than 900MHz. Since the specific absorption rate of electric field in human's head form simple cell phones is more than smart phones, especially at 1800MHz frequency (p value <0.05), hence, it can be said that the use of simple cell phones could be more harmful for human health than the use of smart phones(without internet connection).

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