

The Pattern of Mobile Phone Use and Prevalence of Self-Reported Symptoms in Elementary and Junior High School Students in Shiraz, Iran

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Abstract

Background: The use of mobile phone by children is increasing drastically. Children are likely to accumulate many years of exposure during their lives. Furthermore, as nervous systems in children are developing, children may be at a greater risk compared to adults. In this light, some scientists have suggested that the use of mobile phones should be restricted in high-risk groups such as children. This study is an attempt to explore the pattern of mobile phone use and its health effects among students from the city of Shiraz, Iran.

Methods: A total of 469 (235 males and 234 females; 250 elementary and 219 junior high school) healthy students participated in this study. The students were randomly selected from three different educational districts of the city. For each student, a questionnaire regarding the possible sources of exposure to electromagnetic fields or microwave radiation, specially the pattern of mobile phone use, medical history and life style was filled out by interviewers.

Results: Only 31.42% of the students used to use mobile phones. The average daily time of using mobile phones in talk mode was 7.08 ± 21.42 minutes. Not only the relative frequency of mobile phone ownership in boys was significantly more than the girls, but also the boys used their mobile phones more frequently. Statistically significant associations were found between the time mobile phones were used in talk mode and some symptoms. Furthermore, a statistically significant association was found between the time mobile phones were used in talk mode and the number of headaches per month, number of vertigo per month, or number of sleeping problem per month.

Conclusion: Results obtained in this study show that a large proportion of children in the city of Shiraz use mobile phones. A significant increase was found in some self-reported symptoms among users of mobile phones. These findings are in line with what is widely believed regarding the higher vulnerability of children to exhibit symptoms from using mobile phones. The findings and conclusion of the present study should be viewed in the light the nature of symptoms measurement (self-report) and the knowledge and understandings of the participants about the symptoms.

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Keywords • Mobile phone • Elementary school • junior high school • students • Iran

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Introduction

Electromagnetic radiation in radiofrequency (RF) region has long been used for different types of information exchange. Modern mobile phones support a wide variety of technical functions from enabling real time two-way communication to data processing. Furthermore, using Wi-Fi that is a protocol for fast data exchange over a wireless network, new mobile phones can access wireless data networks via the internet. In some countries such as the US the users of mobile phones consist about 80% of the population,¹ and in some European countries the effective penetration status is "one phone: one person."²

The first concerns about the exposure of humans to electromagnetic fields (EMF) were raised in the former Soviet Union, where an investigation in 1972 revealed that workers in extra-high-voltage transmission switchyards suffered from some specific diseases. Rapid increase in the use of wireless communication systems has caused a growing public concern about possible health effects of EMFs,³ particularly because the mobile phones operate in close proximity to brain.⁴ In spite of this, little is known about the patterns of mobile phone ownership and use, especially among children, either in developing or developed countries. A recent survey in Italy indicated that 96% of 14 to 18 teens in that country owned at least one mobile phone; while 22% of them had more than one mobile phone.⁵ Besides, in a study in Hungary it was revealed that 76% of the 989 students who had participated in the study owned a mobile phone.⁶ In another recent study that was conducted in Sweden it was shown that 79.1% of the 7-14-years old students had access to mobile phones, and 57.7% had reported possessing their own mobile phones.⁷ Also, Söderqvist et al recently reported that in Sweden girls use mobile phones more frequently. They also studied the self-reported symptoms and found that the most frequently-reported health complaints were fatigue, stress, headache, anxiety, concentration difficulties and sleep disturbances. Their findings also showed that generally girls reported higher scores than boys on all self-reported health symptoms.⁸

On the other hand, concerns about the potential vulnerability of children to electromagnetic fields have been raised. The rationale for these concerns are the potentially greater susceptibility of children's developing nervous systems; higher conductivity of their brain tissue, greater RF penetration due to their head size

and finally the point that the children have a longer life time exposure than adults.^{9,10}

The issue of possessing mobile phones on school grounds in elementary or high schools and especially using these communicational devices during instructional time is another great world-wide concern. In Islamic Republic of Iran, the use of mobile phone in schools is banned. However, similar to other countries in some schools the policies regarding mobile phone use are being somehow relaxed. At the same time new advances in mobile technology such as high resolution cameras, internet access and text or multimedia messaging may encourage children to cheat or even violate someone's privacy. On the other hand, working parents strongly depend on cell phones to keep track of their children. There are reports indicating that parents are encouraging their children to carry mobile phones. In this light, it seems that schools should only prohibit mobile phone use during instructional time to prevent the disruption of the school atmosphere. This realistic viewpoint, instead of banning mobile phone possession, makes some limitations for its use. In this light, in some American schools, only camera phones and the ones that can send text messages are banned. In these schools, mobile phones should not be visible or used (even as a clock) in instructional hours.

Regarding the safety of mobile phones, it should be noted that they are a relatively new technology. Therefore, scientists do not yet have long-term follow-up on their possible health effects.¹¹ As physiological functions of human body are regulated by electric currents, we can expect that placing human body within electromagnetic field, of sufficient strength, may affect physiological processes.¹² While the vast majority of the recently conducted research projects have focused on cancer, electromagnetic fields (EMFs) are also suspected as potential cause of such ailments as sleep disorders, headaches or allergy-like symptoms.¹³ Children tend to use these communication devices more frequently than the adults.^{14,15} The bioeffects of the use of mobile phones in children have yet to be investigated.¹⁶ Children start using mobile phones at an earlier age compared with adults. It is widely believed that there is a higher vulnerability of children to exhibit symptoms from using mobile phones. This higher susceptibility, as it was mentioned before, is reported to be due to deeper penetration of microwave radiation into children's brains. Furthermore, it has been reported that mobile phone use may alter the blood-brain barrier permeability.¹⁷ This may allow toxins in the

bloodstream to cross the blood brain barrier into brain cells are also caused by exposure to radiations emitted by mobile phones.

Students usually are among the frequent users of other common sources of electromagnetic fields such as Cathode Ray Tubes (CRTs) and cordless phones. Cordless phones operate at lower frequencies and power levels than mobile phones. People, especially children and teenagers, do tend to use cordless phones for extended periods of time while at home. We have previously found no association between the exposures to microwave radiation emitted by mobile phones or EMFs induced by some other major sources of electromagnetic fields and self-reported illness symptoms.¹⁸ We have also reported that microwave radiation emitted by mobile phones may increase the level of mercury; the most non-radioactive toxic element, released from dental amalgam restorations.¹⁹

Considering the popularity of mobile phones among Iranian students, the present study is investigating the extent of mobile phone use as well as other common sources of electromagnetic fields in this group and the potential self-reported health effects in this population.

Materials and Methods

Participants

Following applying medical ethics codes of Shiraz University of Medical Sciences regarding research on human subjects, and the informed consents of the subjects, a total of 469 (235 male and 234 female; 250 elementary and 219 junior high school) healthy students participated in this study. Samples were selected through cluster random sampling. Sample size determination was based on calculations using our previous study.¹⁴ The students were from schools located in three different educational districts of the city of Shiraz that covered a wide range of socio-economic variations, and could represent the whole city. The selection of the students in each school was based on random sampling (student registration numbers).

Data Collection

For each student, a questionnaire regarding his/her possible sources of exposure to electromagnetic fields or microwave radiation, specially the pattern of mobile phone use, medical history and life style was filled out. The reliability of the questionnaire was previously assessed by Cronbach's alpha test ($\alpha=0.88$) and test/re-test (P above 0.90). Content validity of the questionnaire was assessed by expert

consensus.¹⁴ Questions about subjective health symptoms due to mobile phone use were included in the questionnaire.

Score of Severity

All self-reported symptoms for each student were taken into account and a total score of severity (TSS) was calculated. The TSS was calculated as the sum of the self-reported symptoms \times severity of each symptom using the following equation:

$$\text{TSS}_{\text{for each individual}} = \sum (\text{Self-reported symptom} \times \text{Severity factor of that symptom})$$

To determine the severity of a factor in the above equation, occasionally reported symptoms were scored one, while those reported often and always were scored two and three, respectively. In the next step, according to their total score of severity, all participants were classified into four groups, namely no symptoms, moderate symptoms, strong symptoms and very strong symptoms.

Data Analysis

The Chi square test was used to compare the frequency and rate of the reported symptoms in mobile phone users and those who had not used mobile phones. Data analysis was performed using Statistical Package for Social Sciences (SPSS, version 17.0). A p value of <0.05 was considered as the level of statistical significance.

Results

The 469 students aged 6-16 years (Mean \pm SD; 11.00 \pm 2.33) participated in this study. Due to some problems in data recording, completed questionnaires of only 452 students were analyzed. Among these students, 50.1% were males and 49.9% were females. Considering the level of schools, 53.3% were from elementary school and 46.7% were from junior high schools. All participants were from public schools. In Islamic Republic of Iran there are some private schools that the students must pay different amounts of tuition.

Cathode Ray Tubes

Considering the status of working with cathode ray tubes (CRTs) as a common source of exposure to electromagnetic fields, 215 (45.8%) students did not have the history of CRT use, while 254 (54.2%) had used CRTs. Among these students, 73% had used CRTs for less than 1 hour per day, and 62.1% had used CRTs for less than 3 hours per week. Also 50% had used CRTs for duration of less than

0.2 year and 62.6% for between 0.2 to 1 year.

Cordless Phones

Regarding the status of using cordless phones as another common source of exposure to electromagnetic fields, 207 (44.1%) students did not have the history of using cordless phones, while 262 (55.9%) had used them. The average number of daily calls using cordless phones and the average duration of each call were 2.46±4.71 (ranged 0-17) and 9.27±25.77 minutes (ranged 0-180 minutes), respectively.

Mobile Phones

In regards to the status of using mobile phones, as the most important source of exposure to electromagnetic fields, 310 out of 452 (68.58%) students who answered the questions, did not have the history of using mobile phones, while 142 (31.42%) had used such phones. It was revealed that male students had owned mobile phones much more than the female students. The relative frequency of using mobile phones in male students was 34.7%, while in the case of female students it was only 28.6%. In this regard, Chi square test showed a statistically significant difference (P<0.05). It was also shown

that male students had used mobile phones more frequently than female students. The frequency of the male students using their mobile phones in talk mode for a period longer than 10 minutes/day was 16.7%, while it was 11.0% in the case of female students. Again, this difference was statistically significant (P<0.05).

Among the owners of mobile phones, 89.33% had only one receiver, 9.33% had two receivers and 1.33% had three receivers. The average daily time of using mobile phones in standby mode was 4.97±9.03 hours, while the average daily time of using mobile phones in talk mode was 7.08±21.42 minutes. In this regard, 86.1% and 91.4% had used mobile phones less than 10 and between 10 to 20 minutes per day, respectively. The places of mobile phones in standby mode were waist (23.4%), chest (6.5%), and bags or other locations (70.1%). The places of mobile phones in talk mode were ears (88.9%), waist using hands free (9.2%), and chest or pockets (2.0%).

After conducting a Chi square test, statistically significant higher prevalence of self-reported symptoms such as headache (P=0.009, table 1), myalgia (P=0.0002, table 2), palpitation (P=0.0001, table 2), fatigue (P=9×10⁻⁸, table 2),

Table 1: The frequency and rate of headache, as a self-reported symptom, in mobile phone users (three different levels of use) and those who did not use mobile phones.

Daily Average Talking Time	Headache		Total	P value
	No	Yes		
No Use	191 (61.62 %)	119 (38.38 %)	310	0.005
Less than 10 min	45 (56.25 %)	35 (43.75 %)	80	
11-30 min	15 (34.88 %)	28 (65.12 %)	43	
More than 30 min	8 (42.11 %)	11 (57.89 %)	19	
Total	259	193	452	

Table 2: The frequencies and (rate) of myalgia, palpitation and fatigue as self-reported symptoms in mobile phone users (two different levels of use) and those who did not use mobile phones.

Symptoms	Daily Average Talking Time	Never	Occasionally	Often and Always	Total	P value
Myalgia	No Use	200 (64.52 %)	98 (31.61 %)	12 (3.87 %)	310	0.0001
	Less than 10 min	40 (50 %)	30 (37.5 %)	10 (12.5 %)	80	
	More than 11 min	24 (38.71 %)	32 (51.61 %)	6 (9.68 %)	62	
	Total	264	160	28	452	
Palpitation	No Use	229 (73.87 %)	64 (20.65 %)	17 (5.48 %)	310	0.0002
	Less than 10 min	50 (63.29%)	19 (24.05 %)	10 (12.66 %)	79	
	More than 11 min	27 (44.26 %)	25 (40.98 %)	9 (14.75 %)	61	
	Total	306	108	36	450	
Fatigue	No Use	195 (62.90 %)	90 (29.03 %)	25 (8.07 %)	310	9×10 ⁻⁸
	Less than 10 min	39 (48.75 %)	25 (31.25 %)	16 (20 %)	80	
	More than 11 min	18 (29.03 %)	24 (38.71 %)	20 (32.26 %)	62	
	Total	252	139	61	452	

tinnitus (P=0.0005, table 3), concentration problems (P=0.0001, table 3), attention problems (P=0.0002, table 3) and nervousness (P=9×10⁻⁸, table 3) was found in students who had used mobile phones compared to those never used these phones.

Furthermore, a statistically significant association was found between the time mobile phones were used in talk mode and the number of headaches per month (P=0.035), number of vertigo per month (P=0.036), number of sleeping problem per month (P=0.002), or even the site of headache (P=0).

Among 158 students (33.7% of the participants) who had used mobile phones, 122 students (77.21%) answered to the question of whether the symptoms (if any) got worse when

they continued using mobile phones (table 4). Only 21 out of 122 students (17.21%) reported that the symptoms got worse when they continued using their phones.

On the other hand, among 158 students (33.7% of the participants) who had used mobile phones, 111 students (70.25%) did answer to the question of whether the symptoms (if any) got better (subsided) when they discontinued using mobile phones. Only 28 students (25.22%) reported that the symptoms subsided when they discontinued using their phones (table 4).

As indicated in materials and methods section, to have an overall score for all reported symptoms, the scores of different symptoms were added up to make a new variable; namely "total score of severity (TSS)". Table five pro-

Table 3: The frequency and rate of tinnitus, concentration problem, attention problem and nervousness, as self-reported symptoms, in mobile phone users (two different level of use) and those who had not used mobile phones.

Symptoms	Daily Average Talking Time	Never	Occasionally	Often and Always	Total	P value
Tinnitus	No Use	206 (66.45 %)	80 (25.81 %)	24 (7.74 %)	310	0.0005
	Less than10 min	49 (61.25 %)	27 (33.75 %)	4 (5 %)	80	
	More than 11 min	28 (45.16 %)	20 (32.26 %)	14 (22.58 %)	62	
	Total	283	127	42	452	
Concentration problems	No Use	175 (56.45 %)	108 (34.84 %)	27 (8.71 %)	310	0.0001
	Less than10 min	32 (40 %)	31 (38.75 %)	17 (21.25 %)	80	
	More than 11 min	24 (38.71 %)	21 (33.87 %)	17 (27.42 %)	62	
	Total	231	160	61	452	
Attention problems	No Use	201 (64.84 %)	87 (28.06 %)	22 (7.10 %)	310	0.0002
	Less than10 min	39 (48.75 %)	27 (33.75 %)	14 (17.50 %)	80	
	More than 11 min	24 (38.71 %)	28 (45.16 %)	10 (16.13 %)	62	
	Total	264	142	46	452	
Nervousness	No Use	134 (43.22 %)	126 (40.65 %)	50 (16.13 %)	310	9×10 ⁻⁸
	Less than10 min	26 (32.50 %)	31 (38.75 %)	23 (28.75 %)	80	
	More than 11 min	8 (12.90 %)	24 (38.71 %)	30 (48.39 %)	62	
	Total	168	181	103	452	

Table 4: The frequency and rate of students whose symptoms (if any) got worse when they continued using mobile phones, those who got better when they stopped using mobile phones stratified based on levels of use (three different levels) and those who did not use them.

Daily Average Talking Time	Getting worse on using			Getting better when stop using		
	No	Yes	P value	No	Yes	P value
Less than10 min	57 (+6.6 %)	7 (-31.9 %)	0.14	45 (+4.4 %)	12 (-13.1 %)	0.45
11-30 min	29 (-8.6 %)	10 (+41.5 %)		25 (-7.8 %)	12 (+23.2 %)	
More than 30 min	15 (-4.6 %)	4 (+22.3 %)		13 (+2.3 %)	4 (-6.7 %)	
Total	101	21		83	28	
Total	122			111		

Table 5: The frequencies and rates of participants who did not have any symptoms, and those who showed moderate, strong and very strong symptoms among users and non-users of mobile phones.

Severity of symptoms	Frequency of participants		Total	P value
	Non mobile phone users	Mobile phone Users		
No Symptoms	130 (27.90 %)	33 (7.08 %)	163	0.000
Moderate Symptoms	101 (21.67 %)	43 (9.23 %)	144	
Strong Symptoms	62 (13.30 %)	39 (8.37 %)	101	
Very Strong Symptoms	17 (3.65 %)	41 (8.80 %)	58	
Total	310	156	466	

vides the absolute and relative frequencies of participants who did not have any symptoms, and those who showed moderate, strong and very strong symptoms among users and non-users of mobile phones.

Discussion

Our findings clearly show that a large proportion of children in Shiraz, as the sixth most populous city in Iran, use mobile phones. Our findings showed that 310 out of 452 (68.58%) students who answered the questions about mobile phone use, did not have the history of using mobile phones, while 142 (31.42%) used these communication devices. Also, it was revealed that more male students had owned mobile phones than the female students. The rate of mobile phone use among students in our study is much less than what is reported by other investigators in some European countries. A study in Germany in 2004 showed that 34.7% of the 4th grade students owned cellular phones.²⁰ In 2005, Mezei et al. in Hungary reported that 76% of the 4th grade students owned mobile phone.⁶ According to a population-based study that was performed in Sweden in 2007, about 79% of the 7-14 year old students reported mobile phone access.²¹ However, when we consider the neighboring countries of Iran, the rate of mobile phone use among Iranian children is greater than those of these countries. A report by Turkish scientists that was published in 2004 indicated that only 16% of the 11 year old students used mobile phones.²²

The findings of the present study shows that the frequency of self-reported symptoms such as headache, myalgia, palpitation, fatigue, tinnitus, attention and concentration problems and nervousness in those students who used their mobile phones frequently was higher than what was expected. The number of headaches, vertigo and sleeping problems per month were significantly associated with the total time mobile phones were used in talk

mode. When all self-reported symptoms for each student were taken into account and a total severity score was calculated, all students were classified in four groups according to their total score. Again the frequency of students with strong or very strong symptoms among mobile phone users was significantly higher than what was expected. These findings are somehow in line with a recent report which concluded that mobile phone use was associated with changes in cognitive function in young adolescents.²³

Altogether, results obtained in our study are in line with those of some groups (sponsored by some European governments), which have advised that children should be discouraged from using mobile phones at all. For example, in December 2000, the Stewart group from the United Kingdom reported that the widespread use of mobile phones by children for non-essential calls should be discouraged.⁹ The group also recommended that the mobile phone industry should refrain from promoting the use of mobile phones by children. Stewart group believed that children were more vulnerable to health effects of radiofrequency because of their developing nervous system, the greater absorption of energy in the tissues of the head, and a longer life time of exposure.

Based on the results obtained in our study, children may be considered a relatively high risk proportion of the population. It should be noted that according to a recent report, although there is no clear evidence of adverse health effects associated with RF fields, continued research is recommended to address health effects of exposure to RF fields emitted by mobile phones among children.²⁴ Another report states that children, depending on their age, should be considered at a relatively higher potential risk compared to adults. They concluded that if adults are advised to minimize their exposure, such an advice is even more justified for children.^{15,25} Results obtained

in our study generally confirm the reports recommending a restriction in the use of mobile phones in high-risk groups such as elderly, children and ill people.²⁶

Conclusion

Lack of ionizing radiation and the low energy level emitted from mobile phones had initially led to the public perception that mobile phone was safe. However, the dramatic increase in the use of mobile phones, especially among children and adolescents, has caused great concerns about its potential adverse effects. An increasing number of people report subjective symptoms and hypersensitivity to a wide variety of electromagnetic sources including power lines, radio and TV broadcasting stations, mobile phones, and computer monitors. Approximately, one third of the elementary and senior high school students participated in this study had used mobile phones. Results obtained in this study show a significant increase in some self-reported symptoms among users of mobile phones. Further large-scale research is required to clarify the extent of health effects caused by long time regular use of mobile phones on children's health. Although we cannot urge children to stop using their mobile phones, there are a few simple steps they can take to protect their health for the future. The findings of the present study should be viewed in the light of a number of limitations. First, the reported symptoms are self-declared ones; therefore, the reported frequencies may not reflect their exact occurrence. Second, given the age and knowledge of the participants, their understandings about the exact definitions of the symptoms might have affected their answers to the questions asked. Both of these limitations might have affected the overall finding and conclusion of the study.

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