Available online at www.sciencedirect.com
SCIENCE DIRECT®
Pathologie Biologie 53 (2005) 30–34
PATHOLOGIE BIOLOGIE
http://france.elsevier.com/direct/PATBIO/

Note brève

A survey study on some neurological symptoms and sensations experienced by long term users of mobile phones

Une recherche sur les troubles et les symptômes neurologiques à long terme liés à l'usage des téléphones mobiles

Kemal Balikci [a], I. Cem Ozcan [b], Dilek Turgut-Balik [c], Hasan H. Balik [d,*]

[a] *Department of Informatics, University of Firat, Elazig, Turkey*
[b] *University Health Centre, University of Firat, Elazig, Turkey*
[c] *Department of Biology, Faculty of Science and Arts, University of Firat, Elazig, Turkey*
[d] *Department of Electrical and Electronic Engineering, University of Firat, Elazig, Turkey*

Received 12 November 2003; accepted 10 December 2003

Available online 14 January 2004

Abstract

A survey study was conducted to investigate the possible effects of mobile phone on headache, dizziness, extreme irritation, shaking in the hands, speaking falteringly, forgetfulness, neuro-psychological discomfort, increase in the carelessness, decrease of the reflex and clicking sound in the ears. There is no effect on dizziness, shaking in hands, speaking falteringly and neuro-psychological discomfort, but some statistical evidences are found that mobile phone may cause headache, extreme irritation, increase in the carelessness, forgetfulness, decrease of the reflex and clicking sound in the ears.

Résumé

Une étude a été faite sur les relations entre l'usage du téléphone mobile et divers troubles neurosensoriels. Quelques données statistiques sont en faveur du rôle du téléphone mobile dans les maux de tête, la nervosité, les troubles de l'attention et de la mémoire, les bourdonnements d'oreille, l'état de certains réflexes.

Keywords: Neurological symptoms; Mobile phones; Long term usage; Biological effects; Microwave

Mots clés : Symptômes neurologiques ; Téléphones mobiles ; Usage à long terme ; Action biologique ; Micro-ondulation

1. Introduction

In the recent few years, the extensive use of mobile phones (MP) raises the question of possible health effects of the radio-frequency electromagnetic fields emitted by these phones, in particular on neural functions because of their use in close vicinity to the human brain.

MP operate on wireless technology, with communication typically occurring via a 900–1800 MHz signal that is pulsed at 217 Hz. This signal carries essentially no power when the user is not talking or receiving, but when the user communicates the power of this pulsed electromagnetic field reaches a maximum of 250 mW [1].

The effects of electromagnetic fields on biological systems have been extensively investigated over the last years [2–5]. Particular attention has been given to the effects of microwave exposure on the central nervous system [1,6–9].

In a survey study, some biological effects of MP on people living or not in vicinity of mobile phone base station were tested in 530 people [10]. In the study, non-specific health

* Corresponding author.
E-mail address: balik@firat.edu.tr (H.H. Balik).

doi:10.1016/j.patbio.2003.12.002

symptoms such as tiredness, headache, sleep disturbance, discomfort, dizziness, irritability, depression, lose of memory, etc. were detected depending on distance from base station and sex. It was suggested that minimal distance of people from mobile phone base stations should not be <300 m in view of radioprotection.

One another survey study was conducted in 161 students and workers in a French engineering school on symptoms experienced during use of digital cellular phones [11]. According to the results, concentration difficulties, sleep disturbance, discomfort, warmth, and pricking of the ear during phone conversation as a function of calling duration per day and number of calls per day were experienced.

The main goal of this study is to conduct a survey study, using questionnaire, in 695 people living in a city in Turkey, where these phones are extensively used, to detect the possible neural symptoms and sensations experienced by the long term users of MP in order to light the way of further studies.

2. Materials and methods

2.1. Questionnaire

Questionnaire used in this study was composed of two sections. In the first section, general questions were asked to individuals to learn about their general health, use of mobile phone and physical environment to prevent miss leading positives. In the second section questions were asked to directly detect the effects of long term use of mobile phone on each individual's health.

In the survey, questions were asked to investigate the following symptoms and sensations; headache, dizziness, extreme irritation, shaking in the hands, speaking falteringly, neuro-psychological discomfort, increase in the carelessness, forgetfulness, decrease of the reflex and clicking sound in the ears.

If an individual gave positive answer to the questions about any above symptoms and sensations, some extra questions were also asked to detect the beginning of the symptoms and sensations. Otherwise the statistical results yielded would be meaningless, unless person has not the symptoms and sensations after he has started to use mobile phone.

2.2. Study population

The study group consist of 193 females and 502 males randomly selected from different ages, educations, earnings, locations and occupations in Elazig, which is located in the east part of Turkey. Total number of attendant was 695. For simplicity, from now the person who has got a mobile phone and the person who has not got any mobile phone will be named as "mobile phone user" and "non-mobile phone user", respectively.

Table 1
Number of people attended to the survey

Usage	Females	Males	Total
Mobile phone users	157 (81.3%)	392 (78.1%)	549 (79.0%)
Non-mobile phone users	36 (18.7%)	110 (21.9%)	146 (21.0%)

Among female, 157 women were mobile phone users whereas 36 were non-mobile phone users. Five hundred and two male attendants were consist of 392 mobile phone users and 110 non-mobile phone users. These are summarised in Table 1.

As clearly seen in Table 1, although individuals were selected randomly around 80% of people were mobile phone users. This shows that mobile phone usage is very much common in the selected region and the results yielded from the survey could be valuable.

Since the aim of this survey is to investigate the possible neurological symptoms and sensations experienced by long term usage, attendants were grouped according to time of mobile phone possessions. Times of possessions were divided into four sub-groups. These are one, two, three, four and above years, respectively. Table 2 shows these intervals.

Table 2 showed that almost 60% of female have owned their mobile phone for the last 2 years whereas more than 30% of male have been carrying their MP for at least 4 years.

2.3. Statistical analysis

For this survey, an analysis of variance (ANOVA) were used and differences were considered significant at $P < 0.05$.

3. Results

As mentioned in Section 2.1, some extra questions were also asked to detect the starting time of the symptoms and sensations. The answers were sorted and given in Table 3. When Table 3 were analysed closely, apart from dizziness, vast majority of the mobile phone users reported that they had the symptoms and sensations after they had started using the cellular phone. In the dizziness symptom case 55.8% of

Table 2
The intervals of mobile phone possessions

Possession	Females	Males	Total
One year	44 (28.0%)	79 (20.2%)	123 (22.4%)
Two years	49 (31.2%)	97 (24.7%)	146 (26.6%)
Three years	35 (22.3%)	95 (24.2%)	130 (23.7%)
Four years and above	29 (18.5%)	121 (30.9%)	150 (27.3%)

Table 3
Starting time of the symptoms and sensations

Symptoms and sensations	Starting time	
	After mobile phone	Before mobile phone
Headache	313 (72.1%)	121 (27.9%)
Dizziness	29 (55.8%)	23 (44.2%)
Extreme irritation	140 (71.8%)	55 (28.25%)
Shaking in hands	25 (61.0%)	16 (39.0%)
Speaking falteringly	11 (73.3%)	4 (26.7%)
Forgetfulness	75 (67.6%)	36 (32.4%)
Neuro-psychological discomfort	53 (81.5%)	12 (18.5%)
Increase in the carelessness	186 (86.9%)	28 (13.1%)
Decrease of the reflex	71 (97.3%)	2 (2.7%)
Clicking sound in the ears	80 (72.1%)	31 (27.9%)

the users said that they had the symptom after the use of mobile phone whereas 44.23% of the users had the dizziness before they had the mobile phone of which there was no possible effect. With Table 3, statistical results found in this contribution should be taken into account.

Table 4
P-values for symptoms and sensations obtained by using analysis of variance

Symptoms and sensations	Mobile phone user and non-user	How long they have the phone
Headache	0.001*	0.001*
Dizziness	0.209	0.006*
Extreme irritation	0.005*	0.022*
Shaking in hands	0.151	0.22
Speaking falteringly	0.996	0.207
Forgetfulness	0.029*	0.138
Neuro-psychological discomfort	0.318	0.497
Increase in the carelessness	0.001*	0.01 *
Decrease of the reflex	0.001*	0.012*
Clicking sound in the ears	0.029*	0.044*

* $P < 005$.

Since analysis of variance (ANOVA) were used to analyse data, *P*-values of each symptom and sensation were given in Table 4. The first column of the table shows the considered symptoms and sensations. In the second column, *P*-values were calculated and written for mobile phone users and non-mobile phone users. For this column *P*-values of 6 out of 10 found to be meaningful. These symptoms and sensations are headache, extreme irritation, forgetfulness, increase in the carelessness, decrease of the reflex and clicking sound in the ears.

In the last column of Table 4, intervals of time that individuals had been using the mobile phone were taken into account. Again 6 out of 10 values of symptoms and sensations found to be meaningful. These are headache, dizziness, extreme irritation, increase in the carelessness, decrease of the reflex and clicking sound in the ears.

If both second and last column are considered, *P*-values of 5 out of 10 symptoms and sensations were found to be less then 0.05. These are headache, extreme irritation, increase in the carelessness, decrease of the reflex and clicking sound in the ears.

The main goal of this survey is to investigate the long term neurological effects of mobile phone usage. As seen in Table 4, there are 10 neurological symptoms and sensations, which were investigated. Results were summarised including number of people attended to each case in Table 5 and their percentages were given in Table 6. The statistical results found here as follows.

3.1. Headache

According to the results given in Tables 5 and 6, the use of mobile phone may cause headache, because the percentages of having headache were increased from 63.0% to 78.9%, but there were no statistical evidence that the percentages were increased for long term usage. This was because total num-

Table 5
Distribution of people attended to the survey for symptoms and sensations in percentages

Symptoms and sensations	Non-mobile phone users		Mobile phone users									
	Total		Intervals								Total	
			One year		Two years		Three years		Four years and above			
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Headache	92	54	98	25	115	31	98	32	123	28	434	116
Dizziness	9	137	10	113	24	122	10	120	8	142	52	497
Extreme irritation	34	112	42	81	44	102	52	78	57	93	195	354
Shaking in hands	6	140	11	112	13	133	5	125	12	138	41	508
Speaking falteringly	4	142	2	121	8	138	3	127	2	148	15	534
Forgetfulness	18	128	26	97	25	121	31	99	29	121	111	438
Neuro-psychological discomfort	13	133	11	112	16	130	16	114	22	128	65	484
Increase in the carelessness	34	112	53	71	57	89	50	80	55	95	215	335
Decrease of the reflex	5	141	19	104	19	127	14	116	21	129	73	476
Clicking sound in the ears	18	128	25	98	38	108	22	108	26	124	111	438

Table 6
Distribution of people attended to the survey for symptoms and sensations in percentages

Symptoms and sensations	Non-mobile phone users		Mobile phone users									
	Total		Intervals								Total	
			One year		Two years		Three years		Four years and above			
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Headache	63.0	37.0	79.7	20.3	78.8	21.2	75.4	24.6	81.5	18.5	78.9	21.1
Dizziness	6.2	93.8	8.1	91.9	16.4	83.6	7.7	92.3	5.3	94.7	9.5	90.5
Extreme irritation	23.3	76.7	34.1	65.9	30.1	69.9	40.0	60.0	38.0	62.0	35.5	64.5
Shaking in hands	4.1	95.9	8.9	91.1	8.9	91.1	3.8	96.2	8.0	92.0	7.5	92.5
Speaking falteringly	2.7	97.3	1.6	98.4	5.5	94.5	2.3	97.7	1.3	98.7	2.7	97.3
Forgetfulness	12.3	87.7	21.1	78.9	17.1	82.9	23.8	76.2	19.3	80.7	20.2	79.8
Neuro-psychological discomfort	8.9	91.1	8.9	91.1	11.0	89.0	12.3	87.7	14.7	85.3	11.8	88.2
Increase in the carelessness	23.3	76.7	42.7	57.3	39.0	61.0	38.5	61.5	36.7	63.3	39.1	60.9
Decrease of the reflex	3.4	96.6	15.4	84.6	13.0	87.0	10.8	89.2	14.0	86.0	13.3	86.7
Clicking sound in the ears	12.3	87.7	20.3	79.7	26.0	74.0	16.9	83.1	17.3	82.7	20.2	79.8

ber of people, who had mobile phone, were almost equal to people who had been using mobile phone for 1 year. These percentages were 79.7% and 78.9%, respectively.

3.2. Dizziness

As a result of Tables 3, 5 and 6, the use of mobile phones had no visible effects on dizziness. There were two reasons for reaching this assumption. First, as seen in Table 3 almost half of the people had got their dizziness before using mobile phone. Second, as seen in Table 6, the percentages of non-mobile users and mobile users were very close.

3.3. Extreme irritation

Our data showed an indication of causing extreme irritation; this is why the percentages of having extreme irritation were increased from 23.3% to 35.5%. Moreover, to keep on using mobile phone may slightly increase the possibility of having extreme irritation too. This was because the percentages increased from 34.1% to 40.0% after 3 years.

3.4. Shaking in hands

Although it could be said that the use of mobile phone may cause shaking in hands according to the results given in Tables 5 and 6, their *P*-values were not be meaningful. So this assumption could not statistically be proven.

3.5. Speaking falteringly

There were no possible effects of mobile phone on speaking falteringly. Since the percentages of non-mobile phone users were identical the percentages of mobile phone users. Both percentages were 2.7%.

3.6. Forgetfulness

The use of mobile phone may cause forgetfulness because the percentages were increased from 12.3% to 20.2%. But there were no statistical evidence for long term usage that the percentages were increased. This was because total number of mobile phone users who had forgetfulness were almost equal to people who had been using mobile phone for 1 year.

3.7. Neuro-psychological discomfort

According to Tables 5 and 6, the use of mobile phone may cause neuro-psychological discomfort after 2 years. Because the percentage of both non-mobile phone users and 1 year mobile phone users are the same, which was 8.9%. After 2 years the percentages increased to 12.3%. But, as seen in Table 4, both *P*-values were more then 0.05. So above conclusion could be discarded.

3.8. Increase in the carelessness

According to the results given in Tables 5 and 6, the use of mobile phone may cause increase in the carelessness because the percentages of having increase carelessness were increased from 23.3% to 39.1%, but there were no statistical evidence that for long term usage increases the possibility of having carelessness.

3.9. Decrease of the reflex

According to data, the use of mobile phone may cause decrease of the reflex because the percentages were dramatically increased from 3.4% to 13.3%, but there were no statistical for long term use of mobile phone.

3.10. Clicking sound in the ears

According to the results given in Tables 5 and 6, the use of mobile phone may cause clicking sound in the ears because the percentages of having clicking sound in the ears were increased from 12.3% to 20.2%, but there were no statistical evidence for long term usage that the percentages were increased. This was because total number of people who had

clicking sound in the ears were identical to people who have been using mobile phone for 1 year. These percentages were 20.3 and 20.2, respectively.

4. Discussion

As result of the survey, there were no evidence that the use of mobile phone may cause dizziness, shaking in hands, speaking falteringly and neuro-psychological discomfort. These results support [12,13] for dizziness and [5,12] for neuro-psychological discomfort. Unfortunately there are nothing available in the literature for the rest of the above symptoms and sensations.

The use of mobile phone may cause headache, forgetfulness, increase in the carelessness, decrease of the reflex and clicking sound in the ears as a result of our data. Above results contradicts to [12,13] for headache, forgetfulness, clicking sound in the ears, but support [14–17] for headache and [18] for increase in the carelessness.

Finally, the use of mobile phone could cause extreme irritation and long term usage could further increase it. This study has been supported by Santini et al. [15,19]. Since there are only a few publications dealing with long term usage of MP, further experimental studies will be off great value.

References

[1] Croft RJ, Chandler JS, Burgess AP, Barry RJ, Williams JD, Clark AR. Acute mobile phone operation affects neural function in humans. Clin Neurophysiol 2002;113:1623–32.

[2] Gos P, Eicher B, Kohli J, Heyer WD. No mutagenic or recombinogenic effects of mobile phone fields at 900 MHz detected in the yeast *Saccharomyces cerevisiae*. Bioelectromagnetics 2000;21:515–23.

[3] Jech R, Sonka K, Ruzicka E, Nebuzelsky A, Böhm J, Juklickova M, et al. Electromagnetic field of mobile phones affects visual event related potential in patients with nacrolepsy. Bioelectromagnetics 2001;22:519–28.

[4] Braune S, Schulte-Monting J, Raczek J. Influence of a radiofrequency electromagnetic field on cardiovascular and hormonal parameters of the autonomic nervous system in healthy individuals. Radiat Res 2002;158(3):352–6.

[5] Cook CM, Thomas AW, Prato FS. Human electrophysiological and cognitive effects of exposure to ELF magnetic and ELF modulated RF and microwave fields: a review of recent studies. Bioelectromagnetics 2002;23:144–57.

[6] Hermann DM, Hossmann KA. Neurological effects of microwave exposure related to mobile communication. J Neurol Sci 1997;152:1–14.

[7] Mausset AL, Seze R, Montpeyroux F, Privat A. Effects of radiofrequency exposure on the GABAergic system in the rat cerebellum: clues from semi-quantitative immunohistochemistry. Brain Res 2001; 912:33–46.

[8] Beason RC, Semm P. Response of neurons to an amplitude modulated microwave stimulus. Neurosci Lett 2002;333:175–8.

[9] Hossmann KA, Hermann DM. Effects of electromagnetic radiation of mobile phones on the central nervous system. Bioelectromagnetics 2003;24:49–62.

[10] Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. Symptoms experienced by people in vicinity of base stations: I/incidences of distance and sex. Pathol Biol 2002;50:369–73 (a).

[11] Santini R, Seigne M, Bonhomme-Faivre L, Bouffet S, Defrasne E, Sage M. Symptoms experienced by users of digital cellular phones: a study of a French engineering school. Electromag Biol Med 2002; 21(1):81–8 (b).

[12] Hietanen M, Hamalainen A, Husman T. Hypersensitivity symptoms associated with exposure to cellular telephones: no causal link. Bioelectromagnetics 2002;23:264–70.

[13] Koivisto M, Haarala C, Krause CM, Revonsuo A, Laine M, Hamalainen H. GSM phone signal does not produce subjective symptoms. Bioelectromagnetics 2001;22:212–5.

[14] Chia SE, Chia HP, Tan JS. Prevalence of headache among handheld cellular phone users in Singapore: a community study. Environ Health Perspect 2000;108(11):1059–62.

[15] Santini R, Santini P, Le Ruz P, Danze JM, Seigne M. Survey study of living in the vicinity of cellular phone base station. Electromag Biol Med 2003;22(1):41–9 (a).

[16] Wilen J, Sandstrom M, Mild KH. Subjective symptoms among mobile phone users—a consequence of absorption of radiofrequency fields? Bioelectromagnetics 2003;24(3):152–9.

[17] Sandstrom M, Wilen J, Oftedal G, Mild KH. Mobile phone use and subjective symptoms. Comparison of symptoms experienced by users of analogue and digital mobile phones. Occup Med Oxford 2001; 51(1):25–35.

[18] Santini R, Seigne M, Bonhomme-Faivre L, Bouffet S, Defrasne E, Sage M. Symptoms experienced by users of digital cellular phones. Pathol Biol 2001;49(3):222–6.

[19] Santini R, Santini P, Danze JM, Le Ruz P, Seigne M. Symptoms experienced by people in vicinity of base stations: II incidences of age, duration of exposure, location of subjects in relation to the antennas and other electromagnetic factors. Pathol Biol 2003;51(7): 412–5 (b).