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SYMPTOMS EXPERIENCED BY USERS OF DIGITAL CELLULAR PHONES: A STUDY OF A FRENCH ENGINEERING SCHOOL

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ABSTRACT

A survey study, using a questionnaire, was conducted in 161 students and workers in a French engineering school on symptoms experienced during use of digital cellular phones. A significant increase in concentration difficulties ($p < .05$) was reported by users of 1800-MHz (DCS) cellular phones compared to users of 900-MHz (GSM) cellular phones. In users of cellular phones, women significantly ($p<.05$) complained more often of sleep disturbance than men. The use of both cellular phones and VDT significantly ($p<.05$) increased concentration difficulties. Digital cellular phone users also significantly ($p < .05$) more often complained of discomfort, warmth, and pricking of the ear during phone conversations as a function of calling duration per day and number of calls per day.

Key Words: Digital cellular phone; Microwave; Bioeffects; Human

It has been reported that occupational exposures to microwaves produce subjective disorders such as headache, tiredness, sleep disorders, and memory impairment in humans.[1,2] Those symptoms, associated with others (dermographism, tumors, hematological alterations, reproductive, and cardiovascular abnormalities) are known as microwave or radiofrequency sickness[3] and were described first by soviet scientists.[4]

Digital cellular phones emit microwaves pulsed at extremely low frequency.[5] In France, two microwave frequencies are used: 900-MHz for Global System for Mobile Communication (GSM) and 1800-MHz for Digital Cellular System (DCS). [6,7]

Some studies have reported biological effects of electromagnetic fields emitted by cellular phones on working memory: a speeding of response times[8,9] or on events related to brain activity, such as an effect on preparatory slow brain potentials in visual monitoring, or an effect on rapid eye movement during sleep.[11]

Some other studies have reported nonspecific health symptoms (NSHS) during cellular phone use, including headache, dizziness, concentration difficulties, and warmth around the ear[12-15]

In this paper, we present a study involving 161 human subjects, students, and workers at a French engineering school. This study, using a questionnaire given to users and nonusers of cellular phones, aims to determine the influence of digital cellular phone use on nonspecific health symptoms (NSHS).

MATERIALS AND METHODS

Questionnaire Used

A questionnaire was distributed to 161 people at the school. General questions were about: age, sex, model of digital cellular phone used (GSM or DCS), and type of antenna (short, long, incorporated). .

Other questions were about use of the cellular phone:

1) *Number of calls per day:* <2 calls, 2 to 5 calls, 5 to 10 calls, > 10 calls.
2) *Calling duration per day. <2 mm, 2* to 15 min, 15 to 60 min, >60 min.
3) *How long the phone had been owned:* < 3 months, 3 to 9 months, 9 months to 2 years, 2 to 5 years, > 5 years.

A question was asked about the use or nonuse of a video display terminal (VDT). For subjective disorders, questions asked were about:

1) ***General*** *symptoms experienced by users and nonusers of cellular phone:* headache, concentration difficulties, loss of memory, tiredness, or sleep disturbance.
2) *Symptoms experienced during cellular phone use:* discomfort, burning sensation of the face, pricking sensation on the ear, or warmth of the ear.

Informations About Respondents

About 83% of respondents were under 40 years old, 55% were men and 45% were women, 51.5% of respondents had no cellular phone and 48.5% owned a cellular phone.

For users of cellular phones, 70% had a GSM (900 MHz) and 30% had a DCS (1800 MHz) phone. For 95% of users, the number of calls per day was < 5 and for 85% of users, the calling time per day was < 15 min (only 3% of calls were longer than 60 min per day). Eighty-four percent of users owned a cellular phone for <2 years (1% for more than 5 years).

Data Analysis

Results obtained were analyzed by the Chi-Square test with Yates correction[16] by the way of a VDT program (STATITCF, 1987—France). A $p<.05$ was considered statistically significant.

RESULTS

Comparison of Users vs. Non-users of Cellular Phones

For general symptoms studied (headache, concentration difficulties, loss of memory, tiredness, sleep disturbances), no significant difference was observed in complaint frequencies between users and nonusers of digital cellular phones (Table 1).

Results for Digital Cellular Phones Users

1) *Kind of antenna:* two questionnaires had no response about the antenna. For the 76 responses obtained, 64.4% of cellular phones used had a short antenna, 18.4% a long one, and 17.1% an incorporated antenna. There was no significant difference in general symptoms or in symptoms occurring during communication in relation to the type of antenna (results not shown).
2) *Comparison of GSM (900 MHz) vs. DCS (1800 MHz) users:* a significant difference was observed between users of DCS and GSM: more complaints ($p<.05$) were reported for concentration difficulties by DCS users (45.8%) than GSM users (16.6%). No significant difference appeared for other complaints, though headache and tiredness were more often reported by DCS phone users.
3) *Incidence of telephone time possession',* for general symptoms and for symptoms experienced during communication, no significant difference was observed between users with cellular phone possession >9 months as compared to users with cellular phone possession < 9 months (results not shown).
4) *Sex difference:* women reported significantly more sleep disturbance symptoms *($p<.05$[1])* than men. This sex difference for sleep disturbances was not

Table 1. Percentages of Complaints Frequency for Studied Symptoms and for Different Comparisons

Symptoms	Nonusers (83)	Users (78)	900 MHz (54)	1800 MHz V (24)	wom (27)	Men (51)	Cellular Phone Users (28)	Cellular Phone+VDT Users (50)	Calling Duration <2 min (22)	Calling Duration >2 min (56)	Number of Calls <2(50)	Number of Calls >2 (28)
Headache	7.2	12.8	9.2	20.8	14.8	11.7	3.5	18	18.1	10.7	12	14.2
Concentration difficulties	24	25.6	16.6	45.8*	27.9	25.4	10.7	34*	22.7	26.7	28	21.4
Loss of memory	14.4	6.4	3.7	12.5	7.4	3	0	10	9	5.3	8	3.5
Tiredness	54.2	53.8	46.2	70.8	66.6	49	46.4	60	54.5	55.3	56	53.5
Sleep disturbances	18	12.8	12.9	12.5	25.9	5.8*	7.1	16	9	14.2	12	14.2
Discomfort			24	'20.8	22.2	21.6	14.2	26	0	30.3*	10	46.4*
Burning sensation to the face			7.4	8.3	3.7	9.8	7.1	8	0	9	8	7.1
Pricking of the ear			16.7	16.7	22.2	15.7	14.2	20	13.6	19.6	8	35.7*
Warmth of the ear			53.7	58.3	59.2	54.9	46.4	62	36.3	64.3*	42	78.6*

In parenthesis: number of subjects. Results of chi-square test: *=$p<.05$.

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observed in the group of cellular phone nonusers. Complaint frequencies for other general symptoms and for symptoms expressed during communication were not significantly different between men and women. The sex difference for sleep disturbances was not related to the model of cellular phone used (GSM or DCS—results not shown).

5) *Incidence of VDT use:* among digital cellular phones users (900 +1800 MHz), one general symptom, concentration difficulties, was significantly increased ***(p*** < .05) for users of both cellular phone and VDT as compared to users **of** cellular phone only. Other general symptoms and symptoms expressed during communication were not significantly different.
6) *Incidence of calling duration per day:* complaint frequencies for discomfort and for warmth of the ear experienced during communication were significantly *(p<.05)* more often reported when the calling duration per day was >2 min, as compared to a calling time per day of < 2 min.
7) *Incidence of number of calls per day:* complaints of discomfort, pricking sensation of the ear, and warmth of the ear reported during communication were significantly increased *(p<.05)* when the number of calls per day was >2 as compared to < 2 calls per day.

DISCUSSION

In our study, we did not observe a significant difference for general symptoms (headache, concentration difficulties, loss of memory, tiredness, sleep disturbances) between nonusers and users of cellular phones, even when we observed, as in the Chia et al.[15] study, an increased incidence of headache (+77%) is nonsignificant in our case. This result has to be put in perspective on considering the fact that nonusers of cellular phones were in fact, exposed to other electromagnetic sources they knew about (for example, in our study: 70% of them are exposed to VDT) or did not know about (microwaves from base station transmitters, radiofrequencies from radio and television transmitters, extremely low frequencies from electrical wiring, transformers, electric appliances, etc.). This situation may have affected results when we compared nonusers and users of cellular phones because people unexposed to electromagnetic fields are non-existant (at least in France). The lack of any difference between users and nonusers of cellular phones in general symptoms has also to be considered with the fact that, in our study, use of cellular phones by the subjects was not heavy, in mean, less than five calls per day and less than 15 min per day for call duration. In their study, Chia et al.[15] observed a significant increase of headache in users when call duration per day was > 60 min.

Some of our results are in agreement with those obtained by Mild et al.[14] For example, we observed that two exposure factors, calling duration per day and number of calls per day, significantly increased complaints reported during communication, as warmth of the ear, pricking of the ear and general discomfort. For the other exposure factors we studied (duration of telephone ownership), no significant difference was observed for general symptoms or symptoms experienced during cellular phone use. As in the Mild et al.[14] study, we observed a significant difference in complaints about concentration difficulties in users of both cellular phones and VDT as compared to users of cellular phones only. We did not observe, for VDT and cellular phone users, the

significant increase in skin symptoms like the burning sensation of the face, as reported by Sandstrom et al.[17] for VDT users.

Some results obtained in our study are new. We observed a significant difference between women and men cellular phone users in complaints about sleep disturbances. This result, not observed in women and men nonusers of cellular phones, may be related to women's heightened sensibility to electromagnetic fields.[18,19] Our study shows also that 1800-MHz users reported a significant increase of concentration difficulties more often than 900-MHz users. This result has to be put in relation to factors like power density, microwave frequencies emitted by digital cellular phones, and factors which affect electromagnetic absorption by the human head.[20] Concentration difficulties observed here for 1800-MHz users may have been correlated with a short-term memory bioeffect of radiofrequency radiation.[21]

In a report of the UK independent expert group on mobile phones,[22] in line with precautionary approach, the expert group notes that individuals may choose to "use phones for as short a time as possible." Our results agree with this safe approach of the independent expert group, because nonspecific health symptoms (NSHS) are observed here, when calling duration per day is >2 min.

Our study showed, for three of the four symptoms experienced during cellular phone use (discomfort, pricking sensation on the ear, warmth of the ear), a significant increase in relation with the number of calls per day. This result has to be seen in relation to the fact that maximum electromagnetic energy is generated by a cellular phone at the begining of the call.[23]

Electromagnetic fields emitted by digital cellular phones affect working memory in humans[18] and this effect may be related to cerebral vessel dilatation, attributed to brain heating. [24] It is well known also that microwaves increase the temperature of material from inside to outside. [25] Thus, we can say that the warmth sensation of the ear reported by digital cellular phone users during communication is the result, at the skin level, of mild cerebral hyperthermia. Thus, the warmth sensation of the ear might be a signal for users indicating that it is time to stop the call.

CONCLUSION

This study has shown that digital cellular phone users more often complained of discomfort, warmth, and pricking on the ear during communication, as a function of the calling duration per day and the number of calls per day. The type of antenna of the cellular phone and the duration of telephone ownership had no significant effect on the incidence of complaints reported by digital cellular phone users.

Users of 1800-MHz (DCS) cellular phones complained significantly more often of concentration difficulties than 900-MHz (GSM) users. The combined use of cellular phones and VDTs significantly increased concentration difficulties in users of digital cellular phones.

In users of digital cellular phones, women complained significantly more often of sleep disturbances than men. This sex difference in sleep disturbance is not observed between women and men nonusers of cellular phones.

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