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ARTICLE

Exposure to electromagnetic field, cell phone use behaviors, SAR values, and changes in health following exposure in adolescent university students

Exposição ao campo eletromagnético, comportamentos de uso de telefones celulares, valores SAR mudanças na saúde após exposição em estudantes universitários adolescentes

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ABSTRACT

Background: The use of technological devices is growing rapidly, and the use of cell phones increases in parallel. Dependence on technological devices is a particular factor in this increased exposure. Many studies have been performed on this electromagnetic field, but no definite conclusions have been drawn. **Objective:** The purpose of this research was to investigate exposure to electromagnetic field, cell phone use behaviors, the specific absorption rate (SAR) values, and changes in health occurring after exposure in university students. **Methods:** A questionnaire was administered to 1,019 volunteer students aged 18–24 years at the Niğde Ömer Halisdemir and Recep Tayip Erdoğan Universities in 2018–2019. The questions were based on a survey of the literature. **Results:** The students spent an average 4–8 hours per day on their cell phones, and findings such as headache (p=0.002), concentration deficit (p=0.001), tiredness on waking in the morning (p=0.001), hyperactivity (p=0.001), general feeling of fatigue (p=0.001), and lethargy (p=0.001) increased in a statistically significant manner with length of use. **Conclusions:** Participants exhibited high levels of cell phone use and experienced biological, behavioral, and sleep problems. They also had very little knowledge about specific SAR values, an important criterion concerning cell phones.

Keywords: Adolescent; Surveys and Questionnaires; Cell Phone; Electromagnetic Field; Absorption.

RESUMO

Introdução: O uso de dispositivos tecnológicos está crescendo rapidamente e o uso de telefone celulares aumenta em paralelo. A dependência de dispositivos tecnológicos é um fator nesse aumento de exposição. Diversos estudos sobre o campo eletromagnético foram realizados, mas nenhuma conclusão definitiva foi alcançada. **Objetivo:** O objetivo desta pesquisa foi investigar a exposição ao campo eletromagnético, os comportamentos de uso do telefone celular, os valores de absorção específica (*specific absorption rate* — SAR) dos telefones celulares utilizados e as alterações na saúde ocorridas após a exposição em adolescentes universitários. **Métodos:** Um questionário foi aplicado a 1.019 alunos voluntários com idades entre 18–24 anos nas universidades Niğde Ömer Halisdemir e Recep Tayip Erdoğan em 2018–2019. As perguntas foram baseadas em um levantamento bibliográfico. **Resultados:** Os estudantes gastaram em média 4–8 horas por dia em seus celulares, e achados como cefaleia (p=0,002), dificuldade de concentração (p=0,001), cansaço ao acordar pela manhã (p=0,001), hiperatividade (p=0,001), sensação geral de fadiga (p=0,001) e letargia (p=0,001) aumentaram de forma estatisticamente significativa com o tempo de uso. **Conclusões:** Os participantes exibiram altos níveis de uso de telefone celular e problemas biológicos, comportamentais e de sono. Eles também tinham pouco conhecimento sobre valores específicos de SAR, um critério importante para telefones celulares.

Palavras-chave: Adolescente; Inquéritos e Questionários; Telefone Celular; Campos Eletromagnéticos; Absorção.

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Authors' contributions: AİK and CUŞ formulated the investigation and performed data collection. CUŞ: Recep Tayip Erdoğan University applied the questionnaire to the students. She entered the data collected as a result of the surveys. AİK: Niğde Ömer Halisdemir University applied the questionnaire to the students. She also performed data analysis and wrote the paper. All authors approved the final version of the manuscript.

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INTRODUCTION

Cell phone use is currently growing rapidly in all age groups, but particularly among adolescents. Predictions of this technology for 2019 were to reach 4.68 billion users[1]. A study with 2,000 individuals conducted in the US investigated cell phone use in the 18–24 age group, and reported that the rate of 85% reported back in 2015 had risen to 94% by 2018[2]. Adolescence is an important time in life, one when physical, sexual, and psychosexual development happen. The fact that individuals are in development in this period causes the effects of cell phone use to become a subject of interest to researchers. The period of adolescence used to be defined as the age range of 10–19 years, but recently was changed to 10–24 years[3,4]. The present study was planned for university students aged 18–24 years, when a better awareness of the advantages and disadvantages of cell phone use is expected.

Experimental animal studies have been performed in the search of information about the effects of electromagnetic fields (EMFs). Studies have investigated the effects of 1-hour exposure to 900 MHz EMF on the central nervous system in the prenatal, adolescent and adult periods. EMF applied in the prenatal period has been found to cause histological changes in the hippocampus and in the spinal cord of 21-day-old rat pups[5], as well as to adversely affect motor behaviors[6] and to cause a decrease in the number of neurons in the hippocampus[7] and cerebellum[8] by the time pups reach 32 days of age. Studies involving adults have shown a decrease in neurons in the hippocampus and histological changes[9]. In terms of adolescent rats, decrease in neurons and histological changes in the cerebellum[10], biochemical and histopathological changes in the spinal cord[5,11], no changes in learning behaviors[12], and even increase in hippocampus neurons[13] have been reported.

The specific absorption rate (SAR) is a measurement of the speed at which energy is absorbed by the human body when exposed to EMF. It is defined as the power absorbed by the tissue mass and is generally expressed as watts per kilogram (W/kg) or milliwatts per gram. The US Federal Communications Commission (FCC) sets the limit for public exposure from cell phones at 1.6 watts per kg (1.6 W/kg)[14].

In the light of all these studies, the present research was planned to assess the effects of EMF on adolescent students. We chose to select adolescence because this is a period of life when cell phone use is particularly high, in an attempt to produce distinct results from previous studies. The purpose of this research was to investigate cell phone use behaviors among adolescents, changes in health occurring after exposure, the importance of cell phones in participants' lives, and their awareness concerning the use of this technology.

METHODS

Ethical issues and procedures

Approval for the research was granted by the Niğde Ömer Halisdemir University ethical committee. The study was conducted in accordance with ethical standards set out in the Declaration of Helsinki. Questionnaires were applied in two universities in two different Turkish cities: Niğde Ömer Halisdemir University, in the city of Niğde (population: 364,707), and Recep Tayip Erdoğan University, in the city of Rize (population: 348,608).

We aimed to contact the entire population using the known sampling method. Data were collected at face-to-face interviews by means of a form (questionnaire) created after a literature review, based on the principle of voluntary participation. The questionnaire consisted of seven sections. The first contained 11 questions on the sociodemographic characteristics of adolescent students. The second had 25 questions related to adolescent students' cell phone use. The third section contained nine questions about general health problems in the previous six months after cell phone use. The fourth section consisted of six questions on participants' sleep problems in the previous six months. The fifth section had 12 questions related to behavioral problems in the previous six months, while the sixth section had 17 questions about any health problems arising after cell phone use in the previous six months. The seventh and final section consisted of ten questions on conditions other than cell phone use in the previous six months. The questionnaires were completed in 20–25 minutes by students, who gave their consent, before the start of classes, and were collected by the administrator.

Participants

The questionnaires were applied to 1,019 volunteer university students (700 females, 310 males) who agreed to participate, aged 18–24 years, and were attending the Niğde Ömer Halisdemir or Recep Tayip Erdoğan Universities in 2019. These students were attending 21 different departments — Turkish Language and Literature (131 students), Mechatronics (28), Biotechnology (24), Midwifery (40), Child Development (33), Medical Secretariat (14), Justice (1), History Teaching (41), Criminal Execution and Security Services (26), Social Service (29), Finance (31), International Relations (89), Operating (45), Economy (61), Physiotherapy (26), First and Emergency Aid (51), Nursing (119), Medical Laboratory (43), Medical School (156), Elderly Care (30) and Classroom Teaching (1). The departments were selected at random. The study's objectives and procedures were explained to all participants.

Statistical analysis

All data obtained from the participants were analyzed in the software IBM SPSS Statistics version 20.0. The chi-square

test for trend was used in statistical comparisons. The value of p<0.05 was set as significant for all analyses.

RESULTS

Respondent profile

One thousand eight (98.9%) students used cell phones, while 11 (1.1%) did not (n=1,019). As to sex, 700 (68.7%) of the sample was composed of female students and 319 (31.3%) were males, with mean age of 21.0±2.2 years. Analysis showed that 78.6% of students had low-income levels. Only 13 (1.3%) of them were married, the other 1,006 (98.7%) being all single. In addition, 124 (12.2%) students were alcohol consumers, 220 (21.6%) were smokers, 93 (9.1%) had chronic disease, 134 (13.2%) were using medications of any kind, and 734 (72.0%) took part in social activities.

Findings concerning SAR values

Although 44 (4.3%) reported knowing their phones' SAR values, only 17 identified them correctly. When asked about the meaning of the term, five students defined it as 'emitted radiation', 19 wrote down numerical values, and 24 gave no answer. This shows that, despite having reached a certain level of knowledge, students are still unfamiliar with the devices they use and do not know how these may affect their health. Identifying duration of exposure, the tissue exposed, and the level of exposure is very important in assessing the effects of SAR on biological tissues, as well as their response to EMF. We therefore also ascertained the makes of cell phones used by the students. We found that students used 13 different trademarks, and we established the SAR values of the cell phones in the head and trunk. Cell phone brands were numbered in order to avoid any possible publicity (Table 1). The mean±standard deviation (SD) values were 1.04±0.45 in the head and 1.10±0.59 in the trunk.

General cell phone use findings

In total, 502 students reported using cell phones for 1–4 hours a day, 322 for 4–8 hours, 119 for 8–12 hours, and 76 for 12 hours a day or more. The highest level of use across all the departments was 4–8 hours (45.3%). However, it is worrying that some students (7.85%) used their cell phones for 12 hours or more (Figure 1). In addition, 1,008 (98.9%) students stated that they used cell phones to access the internet, 519 (50.9%) to access social media, 14 (1.4) to do research for classes, 123 (12.1) to access information, 846 (83.0%) to study class notes, and 363 (35.6) for all the options. These activities all suggest that cell phone use may be higher in departments with more intensive academic curricula. We therefore examined the relation between cell phone use in different departments and daily use, but determined no significant variation across them

Table 1. Specific absorption rate values of cell phones used by the students (n=1,019).

Phone identification	Cell phone SAR values (W/kg)		n	%
	Head	Body		
1	0.6	0.3	390	38.2
2	1.4	1.4	292	28.7
3	1.5	1.3	120	11.7
4	1.4	1.4	60	5.9
5	0.8	0.1	41	4.0
6	1.5	1.6	31	3.0
7	1.2	1.2	21	2.1
8	0.9	1.6	19	1.9
9	1.7	1.9	17	1.7
10	0.9	1.5	11	1.1
11	0.3	0.3	8	0.8
12	0.9	0.5	5	0.5
13	0.4	1.2	4	0.4
	mean± standard deviation 1.04±0. 45	mean± standard deviation 1.10±0.59	1,010	100%

SAR: specific absorption rate.

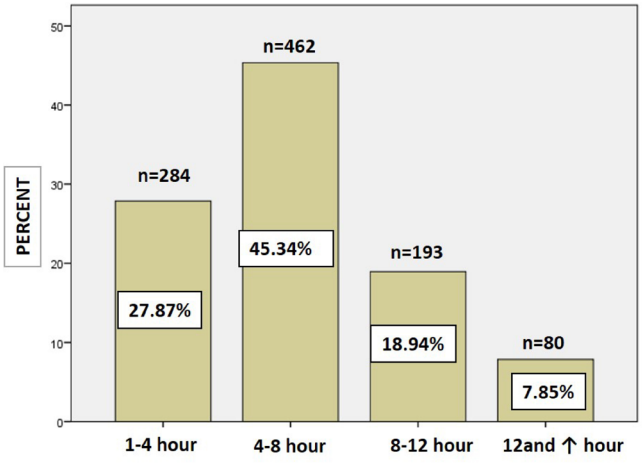

Figure 1. Number of times cell phones were used per day: percentage and number of individuals (n).

(Figure 2). Cell phone use characteristics by participants are shown in Table 2.

Clinical findings

The questionnaire inquired whether students experienced any health problems during cell phone use. Responses included reddening and warming of the ear, reddening and warming in the face, voice restriction, nausea, altered heart rhythm, fainting, short-term hearing loss, inability to focus,

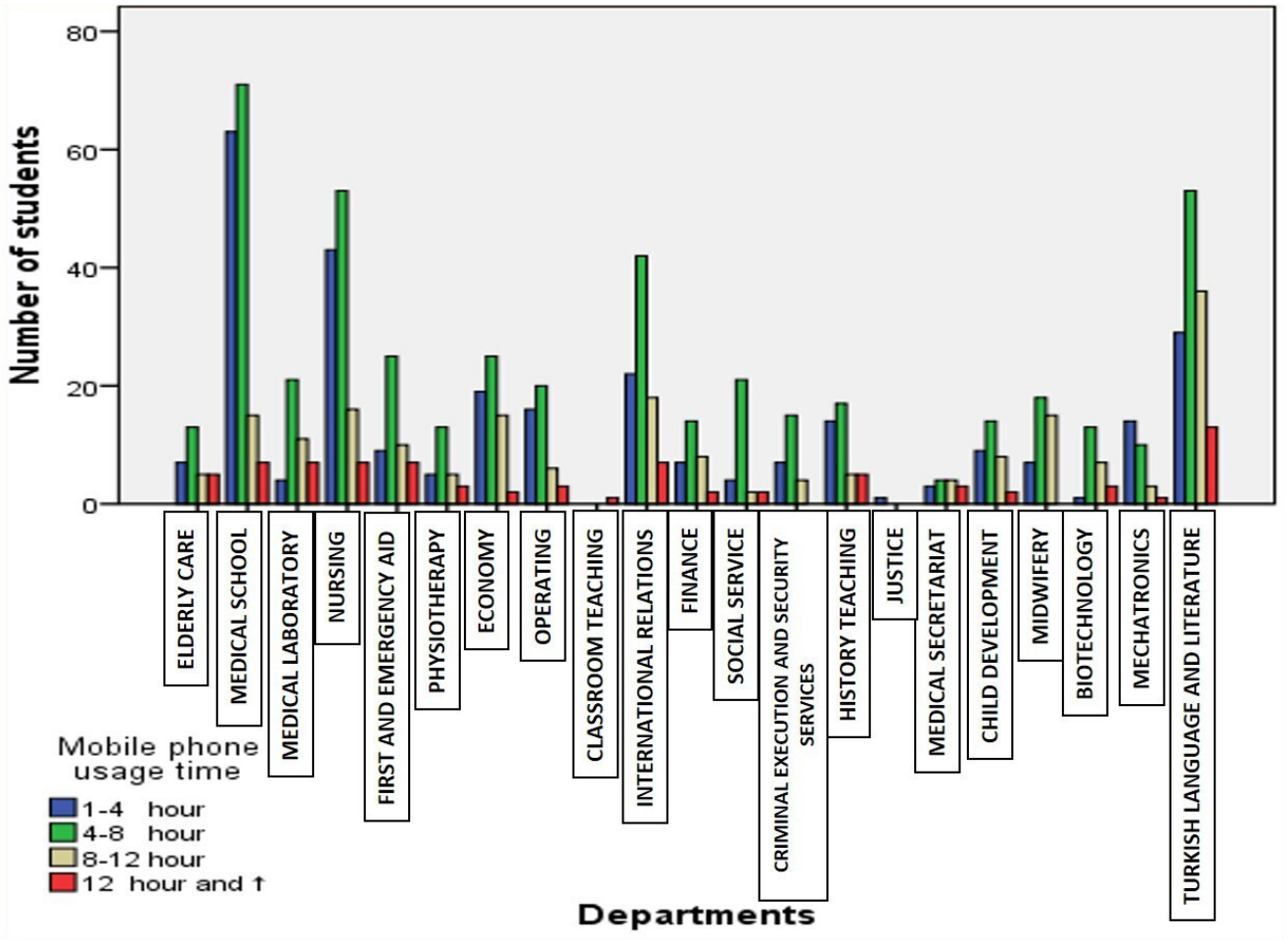

Figure 2. Cell phone use per department.

Table 2. Cell phone use behaviors (n=1,019).

Cell phone use behaviors		n	%
Where the phone is kept during daytime	In a bag	440	43.2
	In a shirt pocket	57	5.6
	In a pants pocket	519	50.9
	All of the above	3	0.3
Number of hours of use per day	1–4	502	49.3
	4–8	322	31.6
	8–12	119	11.7
	12 or more	76	7.5
Use of headphones/ ear buds along with the phone	Yes	744	73.0
	No	275	27.0
Checking the phone for no reason	Yes	814	79.9
	No	205	20.1
Where do you put the phone when you go to sleep?	Beside my head	431	42.3
	Under the pillow	159	15.6
	On a table in my room	419	41.1
	Different rooms	10	1.0

Continue...

Table 2. Continuation.

Cell phone use behaviors		n	%
Is the phone turned off when you are sleeping?	Yes	68	6.7
	No	951	93.3
Do you play with the phone in bed?	Yes	976	95.8
	No	43	4.2
Turning the phone on immediately upon waking	Yes	855	83.9
	No	164	16.1
Using the phone while it is charging	Yes	859	84.3
	No	160	15.7
Using the phone as a wake-up tool	Yes	967	94.9
	No	52	5.1
Deferring to going to the toilet when using the phone	Yes	180	17.7
	No	839	82.3
Deferring eating when using the phone	Yes	151	14.8
	No	868	85.2
Postponing studying while using the phone	Yes	552	54.2
	No	467	45.8

short-term inability to move, and burning, redness, pain, and tears in the eyes (Figure 3).

In addition, students were asked about general symptoms that could affect their performance in studies such as headache, dizziness, lack of concentration, learning difficulty or increased learning, forgetfulness, and Carelessness (Table 3).The duration of device use was significantly associated with headache (p=0.002) and carelessness (p=0.001), but

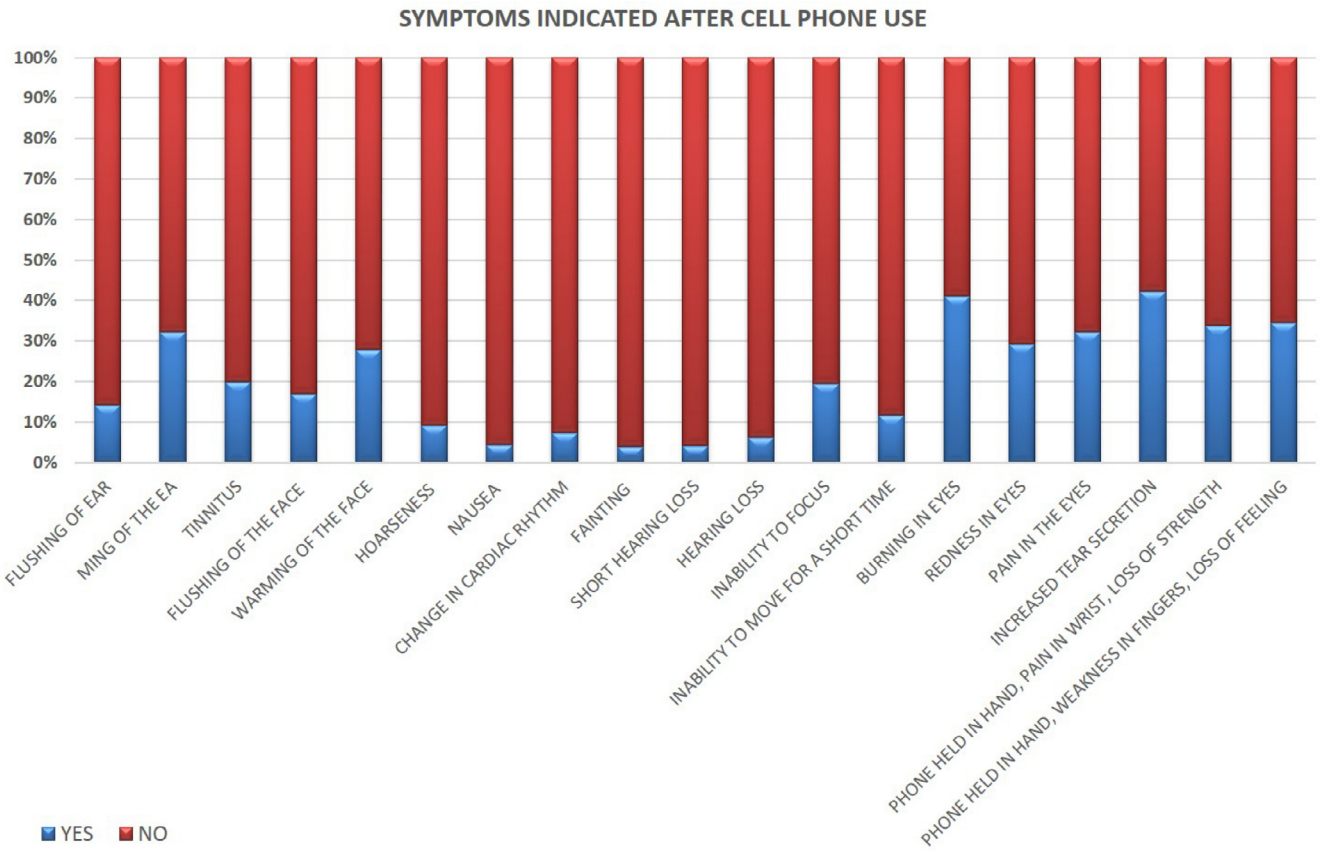

Figure 3. Symptoms experienced after cell phone use.

Table 3. General health and sleep symptoms in cell phone users in the previous six months (n=1,019).

General symptoms		n	%
Headache	Yes	612	60.1
	No	407	39.9
Dizziness	Yes	276	27.1
	No	743	72.9
Lack of concentration	Yes	597	58.6
	No	422	41.4
Learning difficulties	Yes	288	28.3
	No	731	71.7
Improved learning	Yes	391	38.4
	No	628	61.6
Forgetfulness	Yes	661	64.9
	No	358	35.1
Carelessness	Yes	610	59.9
	No	409	40.1
Sleep symptoms		**n**	**%**
Total sleep time	1–4 hour	36	3.5
	4–7 hour	463	45.4
	7–10 hour	485	47.6
	10–13 hour	29	2.8
	13 hour and ↑	6	0.6
Sleep onset latency	Yes	490	48.1
	No	529	51.9
Feeling tired upon waking	Yes	608	59.7
	No	411	40.3
Frequent nocturnal waking	Yes	272	26.7
	No	747	73.3
Falling asleep quickly	Yes	353	34.6
	No	666	65.4

Continue...

Table 3. Continuation.

not with dizziness (p=0.151), lack of concentration (p=0.038), learning difficulty (p=0.336), improved learning (p=0.543) or forgetfulness (p=0.010) (Table 4).

We also aimed to identify sleep status in the six months prior to the study, and 456 students (44.7%) reported experiencing sleep problems. Total sleep time, early or late sleep latency, frequent nocturnal awakening, and feeling tired upon waking were the variables investigated (Table 3). The analysis of length of cell phone use and sleep characteristics was not related to waking up tired in the morning (p=0.001), late sleep latency (p=0.024), falling asleep instantly when going to bed (p=0.693), and frequent nocturnal awakening (p=0.010).

Another problem with the use of communication devices such as cell phones is that young people may become isolated, their communication skills can be impaired, and they become separated from society. Adolescent behavior was therefore also investigated among cell phone users (Figure 4). The results showed statistically significant increases in

Table 4. Relations between duration of cell phone use and general health and sleep problems among cell phone users.

	General health							Sleep symptoms			
Hours of use per day	Headache (%)	Dizziness (%)	Lack of concentration (%)	Learning difficulties (%)	Improved learning (%)	Forgetfulness (%)	Carelessness (%)	Sleep onset latency (%)	Feeling tired on awakening (%)	Frequent nocturnal waking (%)	Falling asleep quickly (%)
1–4	50.7	24.3	53.5	25.4	34.9	57.4	51.4	45.4	46.5	21.5	35.9
4–8	62.8	26.2	58.2	28.6	39.6	66.5	60.2	45.5	61.0	26.2	35.5
8–12	65.8	29.5	66.8	32.6	39.4	71.5	69.4	52.8	69.9	30.6	32.6
11 and ↑	63.8	27.1	58.8	26.3	41.3	66.3	65.0	61.3	73.8	38.8	30.0
χ^2	14.886**	5.294*	8.447*	3.194*	2.144*	11.263*	16.698**	9.397*	35.957**	11.431*	1.455*

**p<0.005, statistically significant; *p>0.005, statistically insignificant; χ^2: Pearson's chi-square test.

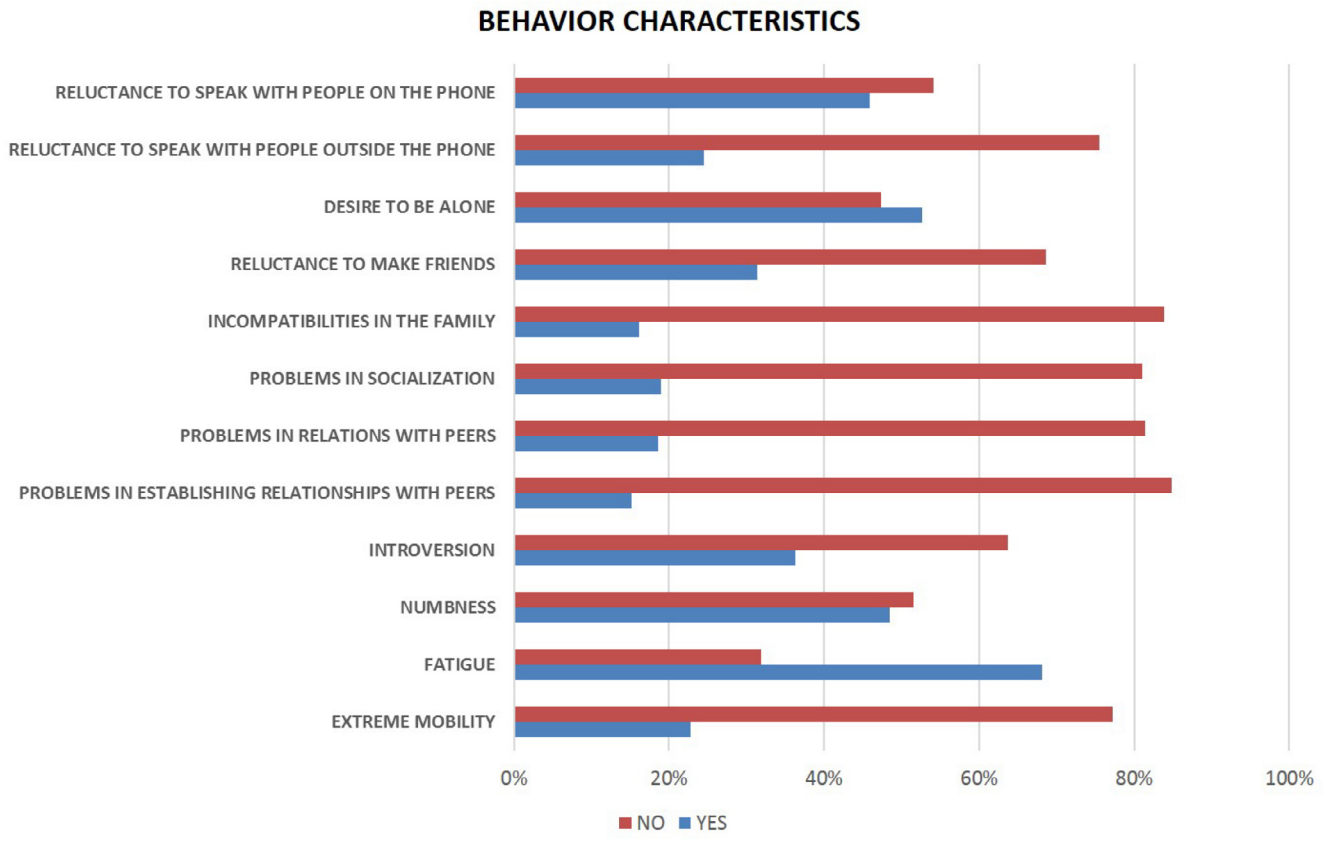

Figure 4. Behavioral characteristics of cell phone users.

hyperactivity (p=0.001), fatigue (p=0.001) and feelings of lethargy (p=0.001), but no significant difference in introversion (p=0.467), frequent wish of being alone (p=0.402), problems in establishing relationships with peers (p=0.182), problems in relationships with peers (p=0.587), socialization problems (p=0.924), isolation from family problems (p=0.121), reluctance to establish friendships (p=0.780), reluctance to speak to other people out of the cell phone (p=0.531), or reluctance to speak to other people on the cell phone itself (p=0.608) (Table 5).

Findings concerning other devices with effects of electromagnetic fields

EMFs are not solely limited to cell phones. The students in our study were therefore also asked about other devices to which they might be exposed. We found that Wi-Fi was used by 748 students (73.4%), home phone with wireless use by 468 (45.9%), computers by 580 (56.9%), and microwaves by 370 (36.3%), while 322 (%31.6) played video games and 636 (62.4%) watched television. Time spent on these devices was lower than the time reported for cell phone use (Figure 5).

Table 5. Relations between duration of cell phone use and behavioral characteristics among cell phone users.

	Behavioral characteristic											
Hours of use per day	Hyperactivity (%)	Fatigue (%)	Numbness (%)	Introversion (%)	Desire to be alone (%)	Problems in establishing relationships with peers (%)	Problems in relations with peers (%)	Problems in socialization (%)	Incompatibilities in the family (%)	Reluctance to establish friendships (%)	Reluctance to speak with people outside the phone (%)	Reluctance to speak with people on the phone (%)
1–4	17.3	58.8	39.4	33.1	49.6	17.3	22.2	19.0	13.4	30.3	23.6	44.4
4–8	22.7	70.1	48.5	36.4	53.5	14.5	16.7	19.5	15.2	32.7	26.6	46.1
8–12	43.9	75.6	56.5	39.9	51.8	13.0	16.6	18.7	20.7	31.6	21.8	49.2
11 and ↑	45.0	71.3	48.5	38.8	60.0	16.3	22.5	16.3	20.0	27.5	22.5	41.3
χ^2	27.510**	17.605**	19.464**	2.546*	2.936*	1.931*	4.862*	0.476*	5.822*	1.087*	2.206*	1.830*

**p<0.005, statistically significant; *p>0.005, statistically insignificant; χ^2: Pearson's chi-square test.

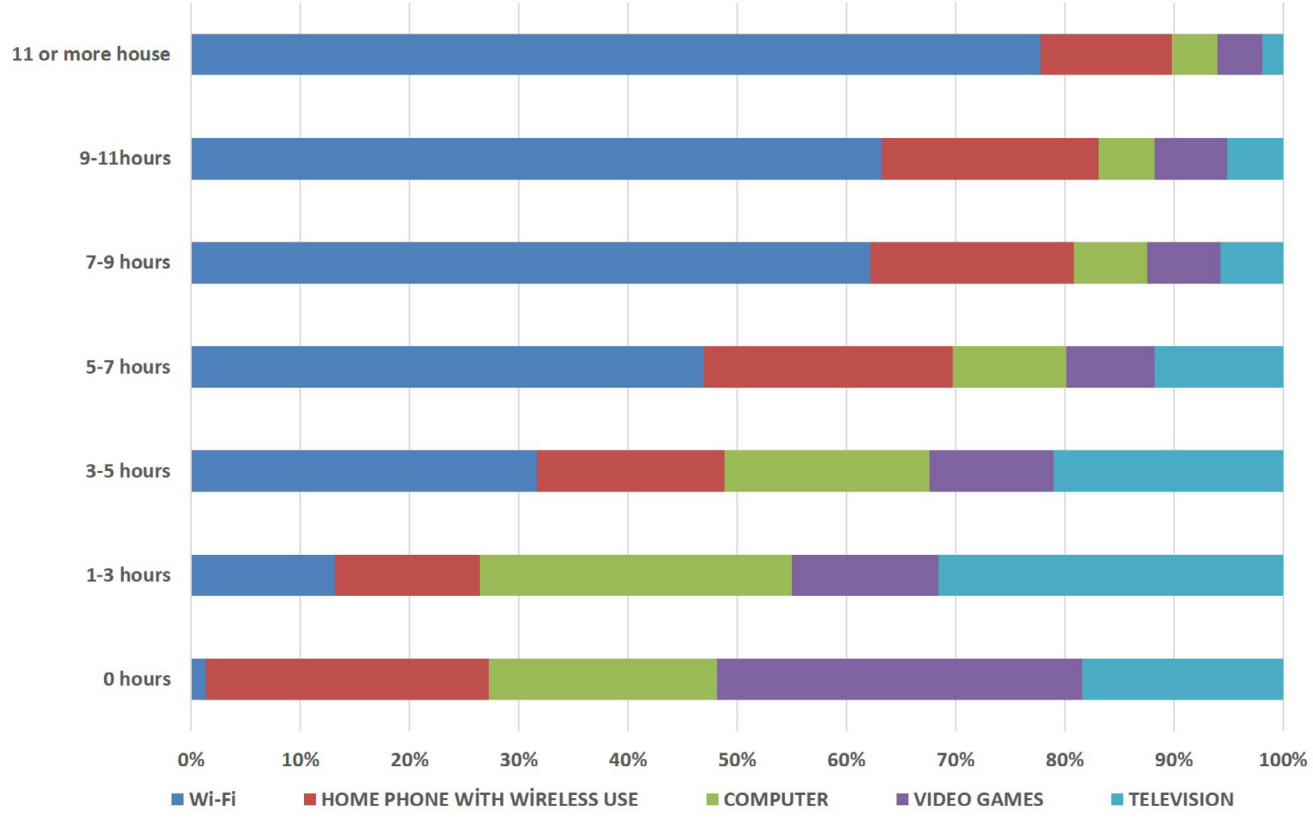

Figure 5. Length of use of devices emitting electromagnetic fields other than cell phones (n=number of individuals).

DISCUSSION

Studies have shown that students, who have achieved some level of life experience, lack sufficient awareness on the matter of cell phone use. In particular, they are largely unaware of the meaning of "SAR values", which have a great impact on health and should be considered at the time of acquisition of cell phones; they heard about this concept for the first time, in general, when completing our questionnaire. The fact that even students from the health department and who are taught about this in their first years are unfamiliar with "SAR" requires particular investigation. We also think that SAR values should be specified by cell phone sellers and brands. We identified the SAR values of our participants' cell phones. In terms of head and body SAR values, these did not exceed the exposure thresholds recommended by the US FCC. In addition to responses suggesting a lack of awareness on the part of cell phone users, other responses suggested that students were in fact aware of the advantages and disadvantages of these phones. This knowledge was particularly reflected in the fact that 854 (83.8%) students described cell phones as beneficial, while 795 (78.0%) described them as harmful.

The time spent on cell phones increases in line with the rise in possibilities of their use. Although the mean 4–8 h/day in all departments may appear to be a low figure, it actually represents a significant proportion of the day. However, 12 hours a day or more is definitely alarming. Previous animal studies have shown that exposure to 900 MHz EMF for even one hour causes problems in some tissues[6,7,8,9,10,14]. In addition, Wi-Fi, televisions, computers, video games, home phone with wireless use and microwaves are also used by adolescents, and one must not forget that these will also be affected by the EMF in such devices.

In terms of cell phone use habits, more than 70% of students were never apart from their phones, and some even delayed various important activities such as using the toilet (17.7%), eating (14.8%), and studying (54.2%). Muscle fatigue and pain have been reported in adult smartphone users[15]. In addition, the number of students keeping their cell phones beside them even when sleeping was quite high (42.3%). This will have a greater impact on the brain and could lead to diseases. One survey conducted with cell phone users identified symptoms such as headache, fatigue, and sleep disorders[16]. Similarly, in the present study, symptoms such as headache, concentration disorder, and fatigue were reported.

Symptoms such as hoarseness, nausea, altered cardiac rhythm, fainting, inability to focus, short-term paralysis, reddening and warming in the ear, loss of hearing, stinging in the eyes, rash, pain, and epiphora have been detected following cell phone use. One study reported visual problems among individuals using cell phones for prolonged periods, including eye strain, double vision, eye damage, conjunctivitis, and blurred vision[17], all consistent with the symptoms identified in our study.

One previous study involving adolescents (aged 16–19) reported an adverse relationship between technological devices and sleep[18]. Another survey reported that the use of electronic devices, particularly close to bedtime, resulted in impaired quality of sleep, decrease in duration of sleep, and excessive daytime sleepiness[19]. A different survey study of adolescent individuals reported a partial relationship with sleep disorders[20]. Although our study involved university students aged 18–24, a group with greater expected awareness of such problems, 44.7% nevertheless experienced sleep-related problems (long sleep onset latency, insufficient sleep, feelings of fatigue upon waking, and frequent nocturnal awakenings). This was particularly prominent among individuals using their cell phones in bed. Our analysis revealed a statistically significant association between waking up tired in the morning and prolonged cell phone use.

High levels of symptoms capable of affecting students' academic lives were determined in the present study, including headache (60.1%), dizziness (27.1%), attention deficit (58.6%), learning difficulty (38.4%), forgetfulness (64.9%), and concentration disorder (59.9%). Analysis of these symptoms in terms of length of cell phone use revealed that headache and attention deficit increased with duration of use. Previous studies show that headache can have a relationship with smartphone use[21] Another study reported that adolescent students who used cell phones experienced more problems such as headache and concentration difficulties[16]. In our previous animal study, we observed learning problems in newborn rat pups exposed to prenatal 900 MHz EMF[5]. However, another animal study reported that exposure to cell phones in the adolescent period had no impact on learning[11]. The inconsistent findings in two different studies are confusing in terms of the significantly increased symptoms such as learning difficulty, concentration disorder, forgetfulness, and attention deficit investigated in the students in this study. This raises the question of whether these problems are the result of prenatal parental cell phone use, or whether they derive from individuals' own cell phone use. Since this study involved adolescents aged 18–24 years, their prenatal periods would correspond to the years 1995–2001. According to the Turkish Statistical Institute (TSI), 81,276 cell phone user subscriptions were recorded in 1994, the first year when records were kept, rising to 19,502,897 in 2001 (the population of Turkey in 2000 was 64,729,501). By 2019, the number of registered cell phones had risen to 80,926,481 (the population of Turkey in 2018 was 82,003,882). Since cell phone use was not as common in 1995–2001, it is less likely that our participants were exposed to prenatal EMF[22].

Another criterion addressed in our questionnaire was behavioral characteristics. Our questionnaire, therefore, inquired about various behavioral characteristics. Higher

levels of affirmative responses were given to questions concerning the presence of fatigue (68.1%), lethargy (48.5%), introversion (36.3%), and wish of being alone (52.6%). However, only hyperactivity, lethargy, and fatigue were significantly associated with duration of cell phone use. In contrast, no significant positive or negative association was determined between length of cell phone use and problems such as introversion, frequent wishes of being alone, difficulties in establishing relations with peers, socialization problems, distance from or problems with the family, reluctance to establish friendships, reluctance to speak to others out of the cell phone, or reluctance to speak to others on the cell phone. Whether this stems from cell phones or some other cause, technology has been implicated as one of the factors involved. Lemola et al. reported that cell phone use in adolescence can result in depressive symptoms[20]. This is also compatible with our study findings.

There may be various reasons for the emergence of the symptoms described above. We therefore put various questions addressing it in order to eliminate some possibilities. Substance use is one factor that causes numerous symptoms. However, the number of smokers (21.6%) and individuals consuming alcohol (12.2%) were not sufficiently high to affect the present study's results. Another factor we investigated was the presence of chronic diseases. However, we also think that the number of participants with chronic diseases (9.1%) was not high enough to affect our findings. In addition, 13.2% of our participants stated that they used medications of some kind. However, one pleasing finding is the high level of individuals taking part in social activities (72%).

Our study findings show increased effects on the biological and psychological domains following cell phone use, insufficient knowledge concerning SAR values, which are particularly important in terms of health, and high rates of use of other technological devices besides cell phones. It all suggests that adolescents need to be given more information about the use of devices and the exposure to EMF, the precautions that should be taken, and the biological effects that may arise from it.

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