The Relation Between Exposure to Electromagnetic Field and Daily Life Cycle: Affects on Learning in Students

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Abstract

Circadian rhythm includes approximately 24-hour physiological changes and is synchronized by environmental stimulus. Supra chiasmatic nucleus regulating this rhythm is in charge of regulating variants related to the sleep. Sleep serves a number of functions such as growing up, learning, memory strengthening. A person can feel himself ready for a new day, fit and alive following high-quality and efficient sleep. Socio-demographic factors, biological, psychological and environmental factors affect sleep. Electromagnetic waves transmitted from electronic devices have adverse effects on circadian system.

The objectives of this study are to determine factors affecting sleep quality and sleep status of university students and evaluate exposure to the electromagnetic field and to analyze their relation.

Volunteer students, selected randomly among students at Izmir University of Economics participated in the descriptive study. Data were collected with a questionnaire including personal and behavioural characteristics, sleep, state of wakefulness, time of sleep, use of

electronic devices, attention and concentration states, complaints, and ESSorth sleepiness scale and Pittsburg sleep quality scale.

It was found out that students being exposed to electronic field highly because of long-term mobile phone and computer use had sleep problems and poor sleep quality and were sleepy excessively during day time. General health condition, preferred studying period, physical activity, period of sleeping, sleeping in illuminated area, state of dozing off, distance from the mobile phone while sleeping affect sleep quality significantly. Habits, state of waking up as rested, sleeping while studying/falling asleep and sleep interrupting at night affect both state of sleepiness in the daytime and sleep quality significantly.

Key words: Circadian rhythm, sleep quality, electromagnetic field

Introduction

A number of physiological phenomena occur in compliance with a certain rhythm in living organisms. Sleep-wakefulness cycle, body temperature, hormone level, affection and some cognitive functions have a daily rhythm called as Circadian rhythm *(Selvi et al., 2011)*. Circadian rhythm involves approximately 24-hour behavioural and physiological changes formed by endogenous biological clocks and synchronized by environmental stimulus. The center in charge of this rhythm is the supra chiasmatic nucleus in anterior hypothalamus known as the circadian or biological clock and this center is also responsible for regulating variants related to the sleep *(Selvi et al., 2011)*.

Sleep is a repeated and reversible behaviour serving a number of different functions such as repair and growing up in the brain and body, learning or memory strengthening *(Benington, 2000; Krueger and Obal, 2003)*. It is one of the significant variables of the health and affects the state of wellbeing *(Ertekin and Doğan, 1999; Engin and Özgür, 2004)*. While it varies by the person, life style and age, it is stated that ideal sleep time for the young adults between the ages of 18-25 corresponding to the university study period is average 7-9 hours *(Hernandez et al., 2012; Hirshkowitz et al., 2015)*. High-quality and efficient sleep should be in time, for sufficient time and uninterrupted *(Kline, 2013)*. By this means, the person can feel himself ready for the new day, fit and alive after waking up *(Bingol, 2006)*.

As the environmental stimulus increases with the technological advances, life is lived faster and sleep disorder occurring as a result of physiological or psychological reactions of the human body during adaptation to this rate becomes a widespread and significant health problem *(Van Cauter et al., 2005)*. Factors affecting sleep quality include psychological factors such as stress and unsolved daily life problems, tendency of insomnia, psychiatric disorders, senility, chronic diseases, alcohol, smoking, tea, coffee consumption, stimulants, sleeping pills, life style with long working hours, environmental conditions such as noise, light, temperature *(Stepanski, 2005; Gargaro et al., 2012)*. Sleeplessness is one of the most striking problems of the modern societies *(Bonnet, 2000)* and especially university students experience sleep problems and tiredness frequently *(Yi-Chin Lee et al., 2007)*. An accepted opinion is in question for insufficient sleeping of the said group and it was reported that they are substantially sleepy *(Orzech et al., 2011)*. Most of young people have problems such as tiredness, anxiety, irritation, depression and difficulty in concentration as a result of sleeplessness frequently *(Fernandez et al., 2009)*. Sleep deprivation has a number of results such as being sleepy, neurocognitive and psychomotor performance disorders *(Harrison and Horne, 2000)*. Moreover, sleep quality and deficiency of sleep can result in metabolic disorders and cardiovascular disorders *(Chang et al., 2015)*.

Exposure to electromagnetic field result in fast aging, rise of blood glucose and lipid levels, increase of neuro regulator disorders, decrease of testosterone levels in men. At the same time, it affects immune functions, blood pressure, pulse rate and other dynamics of cardiovascular system *(Zahiroddin et al., 2006; Ahmadi et al., 2010)*.

In addition to these, results of a number of epidemiological and experimental studies show that exposure to electromagnetic fields have adverse effects on circadian system and create risks to endanger the health *(Barsam et al., 2012; Nakatani-Enomoto et al., 2013; Lewczuk et al., 2014; Reza Monazzam et al., 2014)*.

Learning requires attention and motivation of the person. Sleep withdrawal, attention and concentration impairment are the factors affecting learning negatively. Moreover, usual biorhythm of the persons will result in choosing different hours of the day for learning by their biological structure as the day or night student. (Kimençe, 2002; Cardinali, 2008).

In this study, it is aimed to evaluate exposure of students to electromagnetic field and to determine its effect on their daily lives and biorhythm involving sleeping pattern and the relation of state of learning with the biorhythm. The accuracy of the hypothesis that there is a relation between the state of being exposed to the electromagnetic field and biorhythm of the student was tested.

Method

The whole students studying at Izmir University of Economics in 2014-2015 academic year constituted the population of the descriptive study. Sample was not selected and 357 students above the age of 18 and accepting to participate were involved in the study.

Data were collected by use of personal information form prepared by the researchers; ESSorth Sleepiness scale (ESS) and Pittsburg sleep quality scale (PSQS). There are questions about gender, age, BMI, state of working, general health perception, continuous consumption of smoking/alcohol/medicine, consumption of energy drink/tea/coffee and frequency, habit of having a breakfast/ physical activity, frequency of using computer/mobile phone, environmental order of the bedroom, state of attention and concentration, sleeping habits, time period preferred for studying, complaints of health in the personal information form.

ESSorth Sleepiness Scale (ESS)

It is one of the self-notification scales for measuring sleep qualitatively and quantitatively to determine the excessive daytime sleepiness, developed at ESSorth Hospital in Melbourne by Murray W. Johns (1991) in 1990. The scale evaluates sleepiness in daily special conditions (8 different conditions) and special time period. The scale's Turkish validity and reliability study was performed by Agargun, Cilli, Kara et al. in 1999. In the original scale, while Cronbach's alpha value is 0.88 it was found as 0.80 in Turkish version. ESS is a quarter point likert type scale. Scoring system of 8-question scale is like 0, 1, 2, 3 and the highest score indicates the sleepiness.

Pittsburgh Sleep Quality Scale (PSQS)

It was developed by Buysse, Reynolds, Monk et al. in 1989. Studies of validity and reliability in Turkish were carried out by Agargun, Kara and Anlar in 1996. By means of PSQS, reliable, valid and standard measurement is possible for the sleep quality and a reliable distinction between the ones "Sleeping well" and "sleeping bad" can be made. In the original scale, Cronbach's alpha value is 0.83 while it was found as 0.80 in Turkish version. PSQS comprises of total 24 questions and question 19 and the next questions are answered by the partner or roommate. Since it is not possible to contact partner or roommate for our data collection method, 18-question form of the scale recommended by Turkish Thoracic Society was used (Türk Toraks Derneği, 2012). Components of the scale include subjective sleep quality, sleep latency, sleeping time, accustomed sleep efficiency, sleep disorders, using sleeping pill and daytime dysfunction. Global Pittsburg sleep quality index is found by adding scores of all components. Each component is scored between the points of 0-3. The scale total score is 0-21. Total score of 5 and above of PSQS shows the bad sleep quality. Cronbach's alpha value of the scale was found as 0,77 in this study.

Analysis and evaluation of data

Data were analyzed with SPSS 21,0 package program. For socio-demographic characteristics number and percentage values, normal distribution and constant variance concordance were tested, and parametric or non-parametric analysis methods were used. Frequency and percentage distributions, t test and One Way Anova statistic analysis were performed for independent groups to analyze data. Post-Hoc test was carried out to find the parameters of statistically significant differences by complying with the normal distribution and not complying and Tukey, Lsd, Bonferroni, Dunnet T3, Games Howell analyses were reviewed. The study was evaluated by $p < 0.05$ statistical significance.

Results

30.4% of 357 students participating in the study attend to preparation class, 27.1% of them are in class 1, 20.9% of them are in class 2, 11.5% of them are in class three and 9.8% of them are in class 4.

Information about students' demographic data are presented in Table 1.

Table 1. *Socio-demographic Data of the Students*

		Number	Percent (%)
Gender	Male	201	56,1
	Female	156	43,6
Age groups	17-24	337	94,2
	25-33	20	5,6
Body Mass Index (BMI kg/m^2)	≤18.5 (underweight)	47	13,9
	18.6-24.9 (normal)	242	65,5
	25-29.9 (overweight)	57	17
	≥30 (obese)	9	2,7
Settlement Type	Metropolis	224	62,6
	Large City	76	21,2
	Town	52	14,5
	Village	5	1,4
Educational Level	Associate	51	14,2
	Undergraduate	301	84,1
	Postgraduate	5	1,4

20.7% of participants expressed that they perceived their health condition as very well, 59.8% of them as well, 17.9% of them as moderate and 1.4% of them as bad. While 86.3% of students express that they don't use medicine continuously, 12.8% of them use medicine continuously. Data related to daily living habits of the students are shown in Table 2.

Table 2. *Daily Living Habits and Sleep Scores of the Students*

Factors	Number	Percent (%)
Settlement type		
Metropolis	224	62,6
Large City	76	21,2
Town	52	14,5
Village	5	1,4
Health status		
Very Well	74	20,7
Well	214	59,9

Moderate	64	17,9
Bad	5	1,4
Frequently consumed items		
Cigarette	114	31,8
Energy drink	16	4,5
Tea/Coffee	150	41,9
Antidepressant	10	2,8
Doing Physical Activity		
Regular exercise	277	1,7
Irregular exercise	6	77,4
None	74	20,7
Study preference for morning or evening hours		
Morningness	134	37,4
Eveningness	217	60,6
Sleep Time		
3-4 hours	35	9,8
5-8 hours	264	73,7
> 8 hours	57	15,9
Sleep fragmentation		
Yes	45	12,6
No	125	34,9
Sometimes	173	48,3
Wake up as rested		
Yes	88	24,6
No	100	27,9
Sometimes	169	47,2
Need wake up stimulants		
No	48	13,4

Yes (someone)	26	7,3
Yes (alarm clock)	282	78,8
Wake up when the alarm clock begins to ring		
immediately after alarm	153	42,7
press snooze to delay 1 time	106	29,6
press snooze to delay 2-3 times	97	27,1
fall asleep		
sleeping instantly	154	43
sleeping difficulty	203	56,7
time preferences for study		
Morning	34	9,5
Night	166	46,4
No matter	157	43,9
Attention and concentration problem		
Yes	231	64,5
No	123	34,4
Sleep or drowse while studying		
Yes	129	36
No	228	63,7
PSQS total score		
$\leq$ 5 good sleep quality	111	30,9
> 5 bad sleep quality	246	68,8
ESS total score		
< 10 normal	258	72.2
≥ 10 excessive daytime sleepiness	97	27

73.7% of participants indicated that they slept for 5-8 hours at night. 48.3% of participants answered the experience of sleep interruption as "varying". 47.2% of them answered the question of "waking as rested" as sometimes. 78.8% of them expressed that they wound a clock to wake up and 42.7% of them indicated that they woke up immediately when the clock went off. It is seen that 56.7% of

participants don't fall asleep immediately when they go to bed. While 46.4% of participants expressed that they studied at night, 43.9% of them answered the question as "It doesn't make any difference". It was found out that 64.5% of them had attention and concentration problem while studying. 36% of them said that they slept or drowsed while studying.

Point average of ESS (p=0.020) and PSQS (p=0.007) of participants growing in a city was found significantly higher than metropolitan.

PSQS point average (0.011) of the ones describing the health condition as "moderate" is significantly higher than the ones expressing as "very well".

PSQS (p=0.000) point score of the ones smoking by the ones consuming tea/coffee and using sleeping pill and more than one stimulants simultaneously (grouped as other) is significantly higher.

PSQS (p=0.007) point scores of the ones not doing exercise are significantly higher than the ones doing exercise regularly or irregularly.

PSQS (p=0.001) point average of the persons feeling themselves more alive in the evening is significantly higher. 60.6% of the participants expressed in this way and indicated that they preferred completing what should be done at night.

PSQS (p=0.000) point averages of the students sleeping for 3-4 hours at night are significantly higher than the ones sleeping for 5-8 hours and more than 8 hours.

Both PSQS (p=0.000) point averages and ESS are significantly higher in the persons expressing that their sleep was interrupted at nights than the ones not having interrupted sleep (p=0.022) and having sometimes (p=0,006).

Both ESS (p=0.019) and PSQS (p=0,000) point averages of the ones expressing that "I don't wake up as rested" are significantly higher than the students expressing that "I wake up as rested"

PSQS (p=0,012) point averages of the students saying that "I wake up after delaying the clock for 2-3 times" are significantly higher than the ones saying that "I wake up after delaying the clock for once" and "I wake up immediately".

PSQS (p=0.000) point averages of the ones saying "I don't wake up immediately" are significantly higher.

ESS (p=0,004) and PSQS (p=0.000) point averages of the students having the problem of attention and concentration are significantly higher.

ESS (p=0.000) and PSQS (p=0.014) point averages of the students saying that "I sleep/drowse while studying" are significantly higher.

It was found out that 68.8% (246 persons) of the participants had poor quality sleep and 27% (97 persons) had excessive daytime sleepiness. Moreover, total time of waking within the day was determined as 16 hours in the rate of 20.1%. 21.2% of participants expressed that they went to bed at 01:00 and 20.4% of them said that they woke up at 08:00 in the morning. 58.4% of the participants expressed the main complaint as "weakness".

Conditions associated with exposure to electromagnetic fields of the students are given in Table 3.

Table 3. *Sleep Scores and Electromagnetic Field Exposure Status of the Students*

		Number	**Percent (%)**
Daily computer usage	0-4 hours	266	74,3
	5-8 hours	70	19,6
	>5-8 hours	21	5,9
Mobile phone usage on average in a day (calls only)	0-30 minutes	163	45,5
	30 minutes-2 hours	108	30,2

	2-4 hours	36	10,1
	4-8 hours	22	6,1
	> 8 hours	28	7,8
Mobile phone usage on average in a day (apart from making phone calls)	0-30 minutes	34	9,5
	30 minutes-2 hours	78	21,8
	2-4 hours	81	22,6
	4-8 hours	90	25,1
	8-16 hours	60	16,8
	>16 hours	14	3,9
Usage of headphones	Yes	33	9,2
	No	217	60,6
	Sometimes	105	29,3
Having a TV in the bedroom	Yes	70	19,6
	No	285	79,6
Having a cordless phone in the bedroom	Yes	37	10,3
	No	320	89,4
Having a computer in the bedroom	Yes	280	78,2
	No	77	21,5
Fall asleep with the lights on	No	273	76,3
	Yes	51	14,2
	Sometimes	33	9,2
Distance from mobile phone while sleeping	< 0,5 meter	136	38
	0,5 - 1 meter	142	39,7
	1 - 3 meter	65	18,2
	> 3 meter	13	3,6

74.3% of participants reported daily computer use as 0-4 hour, 45.5% of them reported daily time of speaking on the mobile phone as 0-30 minutes, 60.6% of them said that they did not wear headphone while speaking on the mobile phone. It is seen that 21.8% of participants use mobile phone other than daily speaking for 30 minutes-2 hours, 22.6% of them use for 2-4 hours and 25.1% of them use for 4-8 hours. While 79.6% of them don't have TV in the bedroom and 89.4% of them don't have wireless home phone, 78.2% of them have computers in the bedroom. About the distance from mobile phone

while sleeping, 39.7% of them answered as 0.5-1 meter. 76.3% of students reported that they slept in the dark.

ESS (p=0,024) point averages of the participants using computer for 5-8 hours a day are significantly higher.

ESS (p=0.000) and PSQS (p=0.000) point averages of the participants speaking on the mobile phone for 4-8 hours and more than 8 hours a day are significantly higher than the ones using for 0-30 minutes.

PSQS (p=0.019) point average of the ones leaving any light or bedside lamp on while sleeping are significantly higher than the ones sleeping in the dark.

PSQS (p=0.000) point averages of the participants keeping the distance from the mobile phone while sleeping as 0-0,5 m and 0,5-1 m are significantly higher compared to "1-3 meters".

Discussion

Exposure to electromagnetic field is inevitable because of the electronic devices we use in increasing variety and time in our daily lives and education in parallel with fast increasing technological advances. Negative effects of being exposed to electromagnetic field affecting health and study order of the students are observed with especially sleep problems and biorhythm defined as physical, emotional and mental disharmony.

Sleep quality point averages of the students was found as 68.8% as bad in our study. In studies carried out Altintas et al. (2006), Saygili et al. (2011), rate of university students with poor quality of sleep were found as 54.4% and 59% respectively. In the international studies, it is seen that rate of poor quality of sleep is between 53% -57.5% (Cheng et al., 2012; Lemma et al., 2012; Suen et al., 2008). One of the most distinct reasons of it is the long-term computer use and in this study, it is seen that persons using computer for 5-8 hours a day have poor quality of sleep. Similarly in the study performed by Kocoglu and Arslan (2011) with high school students that it is noted that computer use for playing a game is 2 hours and above a day and it is among risk factors determined for daytime sleepiness state. In another study conducted by Joo et al. (2005) in Kore with college students that students being excessively sleepy in day time use computer 25 minutes more than the students not being sleepy.

When the sleep quality is poor, excessive daytime sleepiness and dozing off while studying are expected cases and it was determined as 27% and 36% respectively in this study. Tran et al. (2014) reported daytime sleepiness prevalence as 27.9% in university students. In another study carried out by Lovato et al. (2014) with university students, 53.6% of students had a nap during the day and were more sleepy than the others.

Sleeping being very significant in the daily life cycle is affected by biological rhythms of the individuals directly. Biological rhythm of every person is different; persons being able to wake up early in the morning prefer early time of the day for working and studying because they are tired and sleepy later in the day. Individuals feeling themselves active and fit in late hours at night prefer sleeping in the morning. If these preferences do not match with the business and education life of the person, biorhythm will be affected and compliance problem will occur. In this study, the rate of students feeling more alive at the evening hours and preferring completing things to be done at night was found as 60.6%. Night chronotype rate is 13% in the study performed by Tran et al. (2014). The rate we found in this study is close to the rate of students with poor quality of sleep and it makes us think that students have difficulty in receiving education in the daytime.

Weakness and tiredness in the rate of 58.4%, headache in the rate of 45.8% and stinging, itching and hydration in eye in the rate of 22.9% were detected. In the study conducted by Ozen et al. (2002) about exposure of university students to electromagnetic field and use of mobile phone, headache depending on mobile phone use was determined as 24.3% and sleep problem as 8.3% and sensitivity to noise and difficulty of hearing was determined as 7.2% and tiredness was determined as 15.7%. Similarly, in the study carried out by Noland et al. (2009) with adolescents, rate of tiredness of the ones having sleep problem was reported as 93.7%. Results show that computer-mobile phone use of students and habit of sleeping in illuminated environment at night increases exposure to electromagnetic field and leads to above-mentioned complaints in addition to sleep problems.

Excessive use of mobile phone can lead to nervous system complaints and complaints related to cognitive abilities such as sleep-wakefulness, attention and memory. It was determined that

radiofrequency waves transmitted from the mobile phones may affect cognitive functions negatively because of the exposure of some regions of the brain (Eliyahu et al., 2006). It was found out in this study that long-term mobile phone use affected daytime sleepiness and sleep quality negatively. Similarly, in a study carried out by Murdock et al. (2016) with the young people between the age of 18-29, a significant relation between following notifications in the mobile phone at night and forcing himself to control them and poor quality of sleep was found. Following the messages at night leads to more interruptions of sleep.

In this study, 60.6% of the students stated that they did not wear headphone while using mobile phone. Similarly, in the study carried out Ergin et al. (2014) with high school students it was found out that 76.1% of participants did not wear headphone.

Some students tend to sleep so close to their mobile phones on the nightstand or under the pillow. And mobile phones radiate electromagnetic radiation when they are on. In the study found out that the persons keeping the distance between the mobile phone shorter than one meter had poor quality of sleep. No study supporting this information was seen. However, in a study of Loughran et al. in 2005, it was seen that electromagnetic field exposure was related to REM sleep latency.

It was determined in this study that students smoking, consuming coffee/tea, using sleeping pills and students having more than one of these habits had poor quality of sleep. It is reported that caffeine drinks make sleeping difficult and interrupt sleep (Shcao et al., 2010) and deteriorates the sleep quality (Walsh et al., 1990).

It was determined in this study that sleep quality of the ones not doing exercise was worse than the ones doing exercise. Similarly in the study carried out by Aktas et al. (2015) with the individuals between the ages of 20-65, it was determined that level of sufficient physical activity of the participants was very low and approximately half of them had poor quality of sleep. In another study conducted by Nojomi et al. (2009) with students of school of medicine in Tehran, it was concluded that sleepiness was more widespread in students doing less exercise.

Conclusion

In the study, it was found that exposure to electromagnetic field has bad effects on cyrcadien rhythm and sleep quality that can lead problems with attention and concentration. It will be good to inform the students for reducing the complaints and increasing the awareness about this issue. For this purpose, it is recommended that training programs on healthy living behaviours and conscious use of devices propagating electromagnetic wave should be planned.

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