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ORIGINAL ARTICLE

The excretion of 6-hydroxymelatonin sulfate in healthy young men exposed to electromagnetic fields emitted by cellular phone – an experimental study

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Abstract

OBJECTIVES: It is quite likely that non-visible electromagnetic fields (EMF) may affect melatonin production. Some studies confirmed this hypothesis and showed that extremely low EMF altered pineal function in animals and humans. Thus, it is reasonable to suppose that EMF emitted by cellular phones may also influence secretion of melatonin. The present study sought to evaluate possible effect of the exposure to EMF emitted by cellular phone on 6-hydroxymelatonin sulfate (6-OHMS) excretion, which reflects melatonin levels in blood.

MATERIAL AND METHODS: The examined group consisted of 9 healthy males aged 19-29 years. The experiment was performed under controlled conditions (the light intensity-50 lx till midnight and 0 lx during night). Each person was examined twice: on a day without exposure (control day, C-day) and on a day with continuous exposure (60 min. exposure from cellular phone, frequency 900 MHz, pulsed with 217 Hz, pulse with 576 μs, SAR 1.23 W/kg, E-day). From 7 p.m. to 8 p.m. they used a cellular phone. The subjects did not know which day was E-day, and which was C-day. From 8 p.m. till midnight the subjects listened to music and than they slept till 7 a.m. next day. Urine samples were collected at 7 p.m., at midnight, and at 7 a.m. in the same way in C-day as in E-day. Sample were frozen for later ELISA analysis of 6-OHMS. The 6-OHMS ELISA kit from Immuno-Biological Laboratories (Hamburg) was used for measurement of 6-OHMS. The data were analysed using Wilcoxon matched-pairs signed-ranks test for each subject and for the whole group. We compared 6-OHMS level on the E-day and on the C-day separately for 3 time-points – 7 p.m., midnight, 7 a.m.

RESULTS: Mean 6-OHMS level in both experiments did not differ significantly for any of the respective time points. Circadian variations of 6-OHMS level were detected in all subjects.

CONCLUSIONS: The results of our investigation has demonstrated that EMF emitted by cellular phones has no distinct influence on the melatonin level.

Introduction

The increasing use of mobile phones has caused growing interest in possible health effects of electromagnetic fields which they produce. Although exposure caused by cellular phones does not exceed the admissible levels, it is worth noting that the standards were developed on the basis of expected thermal effects and do not consider possible effects of chronic, non-thermal exposures. Studies on this subject are still sparse and incomplete, some of them report disturbances in various physiological functions associated with such exposure; non-specific neurovegetative disorders, headaches, muscle pains, sleep disturbances, and increased arterial blood pressure have been observed in the exposed subjects [1-5]. A lot of physiological and biochemical functions are influenced by melatonin. Considering the significance of the effects of visible light on the pineal function, theoretically it is quite likely that non-visible electromagnetic fields may affect melatonin production. Some studies confirmed this hypothesis and showed that extremely low electromagnetic fields altered pineal function in animals and humans [6]. Thus, it is reasonable to suppose that radio frequency electromagnetic fields emitted by cellular phones may also influence pineal production and secretion of melatonin. However, either the experimental investigations on animals nor on humans have brought a conclusive answer to this question. The objective of this study was to determine whether 1-hour exposure to electromagnetic fields emitted by cellular phone suppressed nocturnal melatonin production. The present study sought to evaluate possible effects of the exposure on 6-hydroxymelatonin sulfate (6-OHMS) excretion, which reflects melatonin levels in blood.

Material and methods

Our studies were conducted according to the same protocol as that employed by the Nara Women's University in Japan and by the Nofer Institute of Occupational Medicine Lodz, Poland. In this paper we report some of the results of experiments performed at the Institute of Occupational Medicine.

Our experiment was carried out on volunteers, and all participants were qualified for the experiment on their prior agreement. Before the start of the experiment, all procedures were fully explained to each subject. The protocol was approved by the Regional Research Ethics Committee prior to commencement of the trial. The examined group consisted of 9 young male, healthy students aged 19–29 years.

The subjects had not used a cellular phone for at least one week before the experiment. They consented to the following study requirements: (1) maintain a consistent and normal daily activity rhythm before experiment; (2) refrain from alcohol intake and many dietary supplements of proteins and amino acids; (3) avoid intensive physical activity and sauna. The experiment was performed under controlled conditions The ambient temperature and relative humidity were maintained at 24ºC and 70%. The light intensity was controlled at 50 lx till midnight and 0 lx during night (midnight to 7 a.m.).

Each person was examined twice: on a day without exposure (control day – C-day) and on a day with continuous exposure (60 min. exposure from cellular phone, frequency 900 MHz, pulsed with 217 Hz, pulse width of 576 μs, output power 5 mW/cm^2 – E-day). There was at least one week's interval between the tests. Both experiments (non-exposed and exposed) were performed according to the same procedure. The protocol of experiment is shown in Figure 1. The subjects entered the laboratory at 6 p.m. From 7 p.m. to 8 p.m. the subjects used a cellular phone (on one day it emitted electromagnetic fields and on the second day it did not). Since it was necessary to eliminate the influence of possible stress caused by a conversation on the physiological parameters, the use of the phone involved only keeping the subject's head close to the receiver mounted on a stand. On E-day, the receiver emitted electromagnetic field, while on C-day there was no emission. The subjects did not know which day was exposure E-day, and which day was control C-day (blind experiment).

Starting from 8 p.m. till midnight the subjects listened to the music and then they slept till 7 a.m. next day.

During the experiment (6 p.m-7 a.m.) the heart rate (HR) was monitored continuously and the systolic and diastolic blood pressure (BPS, BPD) was recorded every 10 minutes. Tympanic temperature (6 p.m.-11 p.m.) was measured every minute by the thermistor probe (ST-21S, Tecnica Co. sensor). Urine samples were collected at 7 pm, at midnight and at 7 am in the same way on control day as on exposure day. Samples were transferred to labeled bottles and frozen for later ELISA analysis of 6-OHMS. The concentration of 6-OHMS was measured using ELISA kit (Immuno-Biological Laboratories, Hamburg). The intraassay coefficient of variation was 5.4% at 7.5 ng/ml; within-assay variability ranged from 4% to 10% (mean 6%) and the limit of detection was 0.1 ng/ml in the undiluted sample. The concentrations were normalized to creatinine (6-OHMS/cr). Both on control and exposure (C and E) day, at 8 p.m., then at midnight and at 7 a.m. next day, all subjects were interviewed for possible disorders attributable to mobile phone use (headache, dizziness, fatigue, itching or tingling of skin, redness on skin sensations of warmth on the skin behind the ear, difficulties with falling asleep, wake-ups during sleep hours and sleep quality).

The data were analyzed using Wilcoxon matched-pairs signed-ranks test for each subject and for the whole group. We compared 6 OHMS level on the day with exposure and on the control day separately for 3 time-points: (1) 7 p.m., (2) midnight, (3) 7 a.m.

Results

Table 1 presents the concentration of 6-OHMS in individual subjects and average level for the whole group on the day with exposure and on the day without exposure, separately for 3 time-points.

Our analysis of the 6-OHMS concentrations in the individual subjects during the exposed and non-exposed days revealed considerable differences between the individuals (Table 1). The differences were greater on the exposed days. The greatest differences were recorded at

Table 1. 6-hydroxymelatonin sulfate (6-OHMS) concentrations during the experiment

Subjects		6-OHMS (ng/mg cr.)					
		I (C)	I (E)	II (C)	II (E)	III (C)	III (E)
Subject 1		2.95	2.54	20.13	17.26	57.72	61.06
Subject 2		3.00	4.21	26.79	27.14	68.17	62.96
Subject 3		5.81	1.73	3.87	2.48	78.15	66.82
Subject 4		2.48	2.52	9.81	7.31	58.27	42.64
Subject 5		4.86	3.35	8.66	2.51	70.43	37.20
Subject 6		3.16	11.52	2.30	52.66	37.38	56.13
Subject 7		3.58	5.58	32.39	55.76	69.18	78.40
Subject 8		3.88	14.55	14.15	32.45	70.09	113.79
Subject 9		3.33	12.96	17.31	18.39	94.61	60.46
Group total	Mean	3.67	6.55	15.05	23.99	67.11	64.39
	SD	1.05	5.03	10.16	19.97	15.63	22.23

C – day without exposure; E – day with exposure; I – urine collected at 7 p.m.; II – urine collected at midnight; III – urine collected at 7 a.m.

Figure 1.

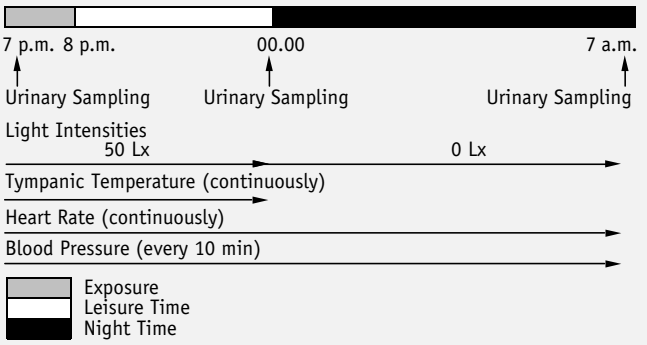

Fig. 1. Experiment schedule.

Figure 2.

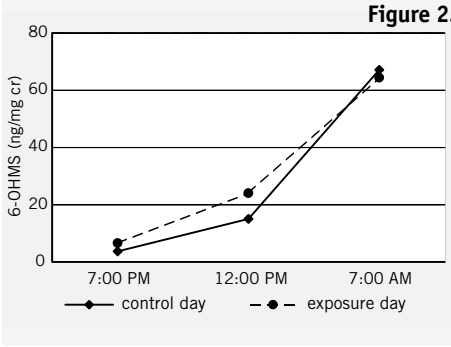

Fig. 2. 6-hydroxymelatonin sulfate (6-OHMS) levels during the experiment.

midnight on the exposed day. The characteristic daily variations of 6-OHMS concentration were detected in all subjects. However, no significant changes in the 6-OHMS excretion curve were recorded on the exposed day in studied subjects (Fig. 2). In our experiment, maximum 6-OHMS concentrations were recorded at 7 a.m., because there is a 2- to 4-h lag between the maximum blood serum and urine 6-OHMS concentrations (the maximum for blood occurs between midnight and 3 a.m.).

Mean 6-OHMS level in examined group did not differ significantly in both experiments for any of the respective time points (Fig. 3).

Our analysis of the reported symptoms shows that on the non-exposed day 2 patients had a headache and 6 had sleep disorders, while the corresponding numbers for the exposed day were 3 and 6, respectively.

Discussion

It is difficult to compare our results with those obtained by other authors because of differences in experimental conditions and melatonin assessment methods. In the de Seze et al. [7] 4-week (2h/day, 5d/week) experiment, melatonin circadian profile was not disrupted. Mann et al.[8] in an experiment involving people exposed to low-intensity (0.2 W/m^2) 900 MHz EMFs similar to those emitted by the mobile phones did not record changed melatonin levels. Animal experiments during which rats and mice were exposed for 6 h to weak 900 MHz EMF (SAR 0.06–0.6 W/kg) did not show any effect on melatonin secretion either [9]. Likewise, a 17-month exposure of rats and mice to 900 MHz constant (SAR 1.5 W/kg) and modulated (SAR 0.33 W/kg) EMF for 1.5 h/day, 5 days/week did not result in changed urine 6-OHMS levels [10]. The results of our investigation has demonstrated that EMF emitted by cellular phones has no distinct influence on the melatonin level. The reaction to the exposure varied considerably from individual to individual and it was difficult to assess it statistically.

The physiological significance of nocturnal melatonin secretion is well established. The effects of melatonin secretion during the afternoon or evening hours are less clear, but there are several reasons why reductions in melatonin at these times may be important. Mean daytime blood melatonin levels are approximately 10 pg/ml [11]. These levels coincide with those required for activation of the melatonin receptor (approximately 5 to 14 pg/ml) [12, 13]. Thus modest (~30 percent) decreases in evening melatonin levels may reduce melatonin receptor activation, thereby altering functional melatonin responses. In humans, ambient light or electromagnetic field exposures that influence afternoon/evening melatonin levels also suppress or delay the onset of nocturnal melatonin production [14-18]. The combined reduction of both daytime and nocturnal melatonin secretion could alter immunological [19, 20], oncostatic [21, 22], or antioxidant [23, 24] processes influenced by melatonin.

Sleep disturbances reported in a questionnaire survey by the users of mobile phones in the USA, Australia, Norway and Sweden could be also attributable to reduced melatonin secretion [6, 25, 26]. In our experiment, the exposure was short-lasting (1 h), and the subjects did not use mobile phones during the week preceding the test. This seems to be the reason why the changes of melatonin levels observed in our experiment were slight and were not accompanied by sleep disturbances. It is likely that more intense use of the mobile phone may be associated with more evident changes. Further research is required to confirm or repeal this hypothesis.

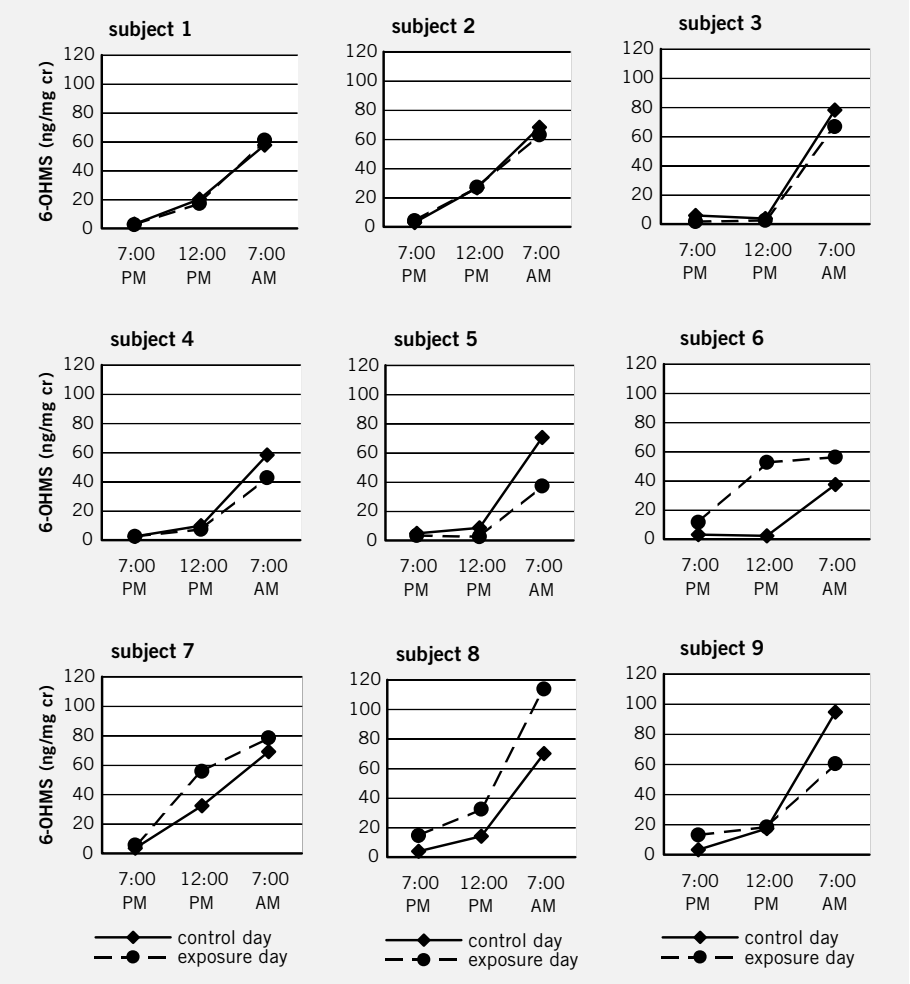

Fig. 3. Mean values of 6-hydroxymelatonin sulfate (6-OHMS) during the experiment.

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