Experimental Study of Digital Enhanced Cordless Telecommunication Devices Electromagnetic Field Possible Hazard Health Effects

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Abstract— Radiofrequency electromagnetic field (RF EMF) wireless personal telecommunication devices may be the reason of increased adverse human health effects. The most of recent studies analyze the possible health hazards of cellular phone EMF only. The goal of research was to investigate the Digital Enhanced Cordless Telecommunication (DECT) EMF biological effects to animal behavior and reproduction function. EMF exposure parameters: frequency 1890 MHz, continuous wave (CW), power density 250 μW/cm^2 (exposure time 2 hours/day; 5 days/week; 4 weeks) and 500 μW/cm^2 (3 hours/day; 5 days/week; 4 weeks). The objects: white rats male (330–350 and 200–220 g). Each exposed group had sham exposure. The evaluated parameters: weight (body, spleen, adrenal glands, testis), behavioral parameters (open filed test), the function of reproduction system (epididymis sperm count, sperm osmotic resistance). Exposure value 500 μW/cm^2: significant decrease of rats' behavioral parameters after 5 days; decrease of behavioral parameters, sperm osmotic resistance, spleen and testis weights after 10 days; decrease of sperm osmotic resistance and body weight after 20 days. Exposure value 250 μW/cm^2: significant decrease of rats' sperm osmotic resistance after 20 days of exposure and 2 weeks after exposure, as well as significant decrease of adrenal glands weight and epididymis sperm count 2 weeks after exposure. There were carried out the simulation EMF exposure experiment. The simulation helps to find the dependency interrelation between power density, power exposure and specific absorption rates. The results showed that exposure to CW EMF at 1890 MHz with 500 and 250 μW/cm^2 may lead to adverse health effects on reproductive system of male rats; and using of DECT devices may be evaluated as possible human health risk factor.

1. INTRODUCTION

Wireless personal telecommunications use a wide range of personal devices, which operate by transmitting and receiving the radiofrequency electromagnetic fields (RF EMF). The cordless telephones operate in 1880–1900 MHz frequency range according to the Digital Enhanced Cordless Telecommunication (DECT) standard. Such phones are popular personal portable devices used at workplace and home. There is increased number of recent studies analyzing the possible health hazards of wireless personal telecommunications EMF. The significant part of them focuses on potential EMF effects of cellular phones on nervous and reproductive systems to assess the adverse health effects on present and future generation. There are some scientific publications of experimental evidence DECT RF EMF biological effects [1, 2]. The goal of the research was to investigate DECT RF EMF (1890 MHz) acute and subacute exposure biological effects to animal behavior and reproduction function.

2. METHODS

There were carried out two series of experiment. Object of study: white rat males with body weight 330–350 g and 200–220 g (in different series of experiment respectively). The experiment groups of 12 animals were formed. Each exposed group had sham exposure group.

The animals were exposed to 1890 MHz EMF continuous wave (CW) with different power exposure parameters. In first series 24 exposed and 24 sham exposed rats were used. The animals were exposed to EMF with power density (PD) 500 μW/cm^2 (exposure time 3 hours/day; 5 days/week; 4 weeks; power exposition, calculated as PD multiplication at the time result, was 1500 (μW/cm^2) $\cdot$ h. In second series 36 exposed and 36 sham exposed rats were used. The animals were exposed to EMF of power density 250 μW/cm^2 (2 hours/day; 5 days/week; 4 weeks; the power exposition was 500 (μW/cm^2) $\cdot$ h.

The exposure system included sector antenna 739196 (KATHREIN WERKE KG, Germany), signal generator N5181A MXG (Agilent Technologies, USA) and amplifier HL-42W (Mini-Circuits, USA). The animals were placed into individual radio transparent containers with holes during experiment (exposure and sham exposure groups). Animal exposure area selection and exposure

parameters control were implemented by means of EMF measurement system DASY 52 NEO (SPEAG AG, Switzerland) and broadband EMF meter NARDA NBM-550 (Narda Safety Test Solutions, USA).

The behavioral parameters of animals were evaluated in open field test with hole reflex "entropy" parameter assessment after 1, 5, 10 and 20 days of exposure as well as 2 weeks after exposure.

The weight (body, spleen, adrenal glands, and testis) and the reproduction system parameters (epididymis sperm count, sperm osmotic resistance) were evaluated after 10 and 20 days of exposure as well as 2 weeks after exposure.

The statistical data processing was performed in STATISTICA 7.0 (StatSoft, USA) with U-test (Mann-Whitney).

Simulation of experiment was made by means of full wave 3D electromagnetic simulation software SEMCAD X14.8 (SPEAG AG, Switzerland) to specific absorption rate (SAR) parameters evaluation in each experiment series. The models calculated by the Finite-Difference Time-Domain method corresponded to the experimental EMF exposure conditions.

3. RESULTS

The data show significant decrease ($p < 0.01$) for 37% and 35% (relative to sham exposure group) behavioral parameter (hole reflex "entropy") of animals in group exposed to EMF with 1500 ($\mu W/cm^2$) · h power exposition (PD 500 $\mu W/cm^2$, 3 h/day) after 5 and 10 days correspondingly. Subacute EMF exposure with 500 ($\mu W/cm^2$) · h power exposition (PD 250 $\mu W/cm^2$, 2 h/day) did not lead to any significant changes in animal behavior.

Different evaluated weight parameters of exposed and sham exposed animal groups data are presented in Table 1.

Table 1: Weight parameters data.

Power exposition	1500 ($\mu W/cm^2$) · h		500 ($\mu W/cm^2$) · h		
Days / **Group**	10 days	20 days	10 days	20 days	2 weeks after exposure
Body weight, g					
Exposed	339.58 ± 7.16	$349.00 \pm 3.93^{*}$	227.73 ± 4.28	257.08 ± 5.52	274.17 ± 8.14
Sham	366.25 ± 9.60	377.27 ± 12.07	240.00 ± 6.60	274.17 ± 7.41	296.82 ± 8.10
Spleen weight, g					
Exposed	$0.72 \pm 0.033^{**}$	0.84 ± 0.04	0.81 ± 0.04	0.82 ± 0.03	0.67 ± 0.04
Sham	0.94 ± 0.04	0.86 ± 0.05	0.79 ± 0.04	0.89 ± 0.06	0.74 ± 0.04
Adrenal glands weight, g					
Exposed	42.50 ± 3.05	47.27 ± 3.59	36.67 ± 2.25	39.17 ± 2.29	$35.00 \pm 1.95^{*}$
Sham	41.67 ± 3.22	47.27 ± 3.59	39.17 ± 1.93	42.50 ± 3.29	41.82 ± 1.82
Testis weight, g					
Exposed	$2.49 \pm 0.17^{**}$	2.44 ± 0.09	2.39 ± 0.14	2.79 ± 0.07	2.66 ± 0.08
Sham	3.14 ± 0.13	2.73 ± 0.17	2.64 ± 0.09	2.64 ± 0.12	2.83 ± 0.11
$^{*}p < 0.05$; $^{**}p < 0.01$.					

The Table 1 shows:

- Significant decrease ($p < 0.05$) for 7% relative to sham exposed animals in body weight parameters of rats exposed by EMF with 1500 ($\mu W/cm^2$) · h power exposition after 20 days.
- No significant changes in body weight in group exposed by EMF with 500 ($\mu W/cm^2$) · h power exposition.
- Significant decrease ($p < 0.01$) for 23% relative to sham exposed group in spleen weight in group exposed by EMF with 1500 ($\mu W/cm^2$) · h power exposure after 10 days.
- No significant changes in adrenal glands weight with exception of decrease ($p < 0.05$) for 16% relative to sham in group exposed by EMF with 500 ($\mu W/cm^2$) · h power exposition after 2 weeks.

- Significant decrease ($p < 0.01$) for 21% relative to sham in testis weight in group exposed by EMF with 1500 ($\mu W/cm^2$) · h power exposure after 10 days.
- No significant changes in testis weight in group exposed by EMF with 500 ($\mu W/cm^2$) · h power exposition.

The study of reproductive function parameters shows: significant decrease ($p < 0.01$) for 16% (relative to sham exposure group) was observed in sperm osmotic resistance in group exposed by EMF with 1500 ($\mu W/cm^2$) · h power exposition after 10 and 20 days of exposure. Also there were found sperm osmotic resistance significant decreases ($p < 0.05$) for 5% and 7% in group exposed by EMF with 500 ($\mu W/cm^2$) · h power exposition after 20 days and 2 weeks after exposure respectively.

The epididymis sperm count decrease ($p < 0.05$) for 24% in group exposed by EMF with 500 ($\mu W/cm^2$) · h power exposition 2 weeks after exposure.

Numerical simulation of experiment shows the small different mean SAR for both exposure series: 0.041 W/kg and 0.039 W/kg for first and second series respectively.

4. CONCLUSION

The data of experimental study show the effects of acute and subacute 1890 MHz EMF exposure to rat male behavioral parameters and reproductive system. Sperm osmotic resistance as a rat reproduction function estimated parameter was evident sensitive to EMF exposure. Significant decreases of this parameter were observed in groups exposed by EMF with 1500 ($\mu W/cm^2$) · h power exposition as well as in groups exposed by EMF with 500 ($\mu W/cm^2$) · h power exposition. The decrease of sperm osmotic resistance was more expressed under 1500 ($\mu W/cm^2$) · h EMF power exposition than under 500 ($\mu W/cm^2$) · h power exposition (the sperm osmotic resistance decreased during less period of high exposure (500 $\mu W/cm^2$) than lower (250 $\mu W/cm^2$). These data support the concept of RF EMF cumulative efficiency.

The results showed that exposure to CW EMF at 1890 MHz with 500 and 250 $\mu W/cm^2$ may lead to adverse health effects on reproductive system of male rats; and using of DECT devices may be evaluated as possible human health risk factor.

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