Conference Paper

Technique and Instrumental Complex for Research of Encoded Microwave on Metabolism of Experimental Animals

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Abstract

New instrumental techniques for research of the metabolism' reactions of the bio-objects under the microwave electromagnetic radiation, modulated by interval patterns of neural activity in the brain registered under different biological motivations, are suggested. The preliminary results of these new tool tests in real psycho physiological experiments on rats are presented.

Keywords: encoded microwave, bio-parameters registration, metabolism, experimental rats

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1. Introduction

World Health Organization introduced a new term – "global electromagnetic contamination of the environment" in 1995 and included this problem in the list of most important problems for humanity. The problem of the action of electromagnetic fields on bio-objects engaged in all the technically advanced countries: hundreds of laboratories, thousands of studies, publications, standards, guidelines, etc. At present, a huge amount of data on the effect of electromagnetic radiation on practically all physiological systems and psycho-physiological parameters of any bio-object, including a human, has been collected and systematized [1–3]. Despite the 'omnipotence' of existing standards for electromagnetic safety based on the thermal effects of microwave radiation, there are more evidence about the essential effects on biological objects by the low-intensity (week) electromagnetic fields. The methods and instruments for research of weak microwave field influence on human psycho-physiological parameters are presented in the recent work of the author [4–6]. There is another important aspect of the experimental researches of the influence of physical fields on the cognitive functions of the brain, so these are fundamental advanced investigations of the basic mechanisms of the brain. Techniques and instrumental complex for research of influence of microwaves encoded by brain neural signals on biological objects' psycho physiological state are shown in [7]. Analysis of literature nowadays shows that there are practically no data that illustrate changes in the parameters of metabolic processes. While the fluctuations in metabolic rate in mammals are one of the most objective criteria for assessing the influence of external factors on the state of homeostasis, it is known that the most frequently used parameters for studying metabolic processes are the indices of oxygen consumption, the amount of exhaled carbon dioxide and the intensity of heat exchange. This is due to the fact that the maintenance of these parameters at the optimal level is possible only in conditions of integration and coordination of the activity of various functional systems of the body. So the theme of this work is the research of metabolism reactions of experimental animals (rats) on weak microwave radiation coded by pulse modulation inherent to the activity of neurons in the brain in specific motivations [7].

2. Technique and Instrumental Complex

The researches were carried out on eight male Wistar rats weighing 285.0 + 6.1 g. The statement of experiments was guided by the 'Rules for carrying out work using experimental animals', approved requirements of the World Animal Welfare Society (WSPA), and the European Convention for the Protection of Experimental Animals.

The structure and composition of the new instrumental complex are shown in Figure 1.

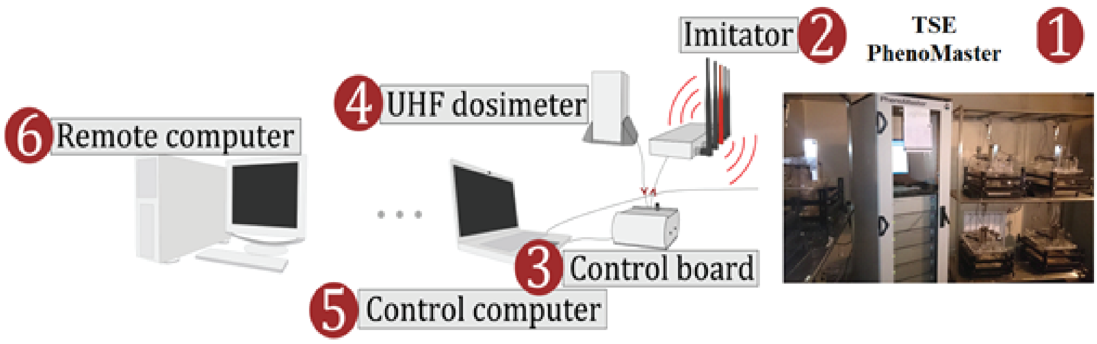

Figure 1: Structure of research instrumental complex (Units; 1 – 6).

Unit 1 – Indices of metabolic rate in rats under different experimental conditions were determined using an automated modular installation of Phenomaster (TSE Systems

GmbH, Germany), which allows monitoring diurnal fluctuations in physiological parameters. The composition of this software and hardware complex includes metabolic cells (36 × 45 cm) for the individual placement of animals. Indirect calorimetry was carried out using the CaloSys module, which allows measuring energy consumption with the help of gas sensors for metabolic phenotyping. Calorimetric indicator – heat release rate (H, kcal/h/kg) – calculated by the amount of oxygen consumed by the animals (VO_2, ml/h/kg) and exhaled carbon dioxide (VCO_2, ml/h/kg) per unit time, considering the mass rats. The registration of these parameters was carried out daily for 6 hours. Determination of the intensity of heat release, the volume of consumed oxygen and the carbon dioxide released in animals from the 1st to the 4th day of the experiment was carried out according to the following scheme: the first 2-hour period – background (no effect), the second 2-hour period – modulated low-radiation (impact), the third 2-hour period – aftereffect. On the 5th and 6th day, rats were placed in metabolic cells with the registration of the aforementioned parameters in the absence of a microwave source (background). At the end of the study – the 7th day – the rats were again exposed to 2-h irradiation; the parameters of metabolic processes were evaluated before, during and after the exposure (similar to the 1st–4th day of the experiment). It should be noted that the background parameters recorded on the first day of the experiment were subsequently taken as reference values.

Unit 2 – Imitator. In the background of Figure 1, the antenna of the generator (imitator), providing the irradiation of biological objects with modulated microwave has been shown. A photograph of this block is demonstrated in Figure 2. The imitator operates in five frequency bands from 0.9 to 2.4 GHz.

The animals were exposed to microwave radiation with the values of the energy flux densities corresponding to the requirements of SanPiN 2.1.8/2.2.4.1383-03. The repetition period of the patterns was 150 msec. The number of pulses in the pattern is 3, the duration is 50 ms. The pulse fill factor in the pattern is 0.98. The choice of this type of microwave modulation in our researches was based on the results of previous experiments [7]. It has been established that in the number of brain structures (lateral hypothalamus, hippocampus, reticular formation, thalamus and others), group discharge activity of neurons arises; the spike intervals of 5–10 and 150 msec prevail on the interval histograms. In other motivational states in conditions of immobilization and drinking deprivation, the 'carrier frequency' corresponding to an interval of 150 msec was preserved. However, under these experimental conditions, there were significant changes in the interspike intervals characterizing a certain dominant motivation. Based on these data, it was concluded that different motivational states specifically differ in

Figure 2: Photo of the microwave imitator (generator).

the small intervals between the discharges of neurons. After satisfying the animals with corresponding needs, the interval pattern of the electrical activity of brain nerve cells was reorganized from group to regular single type with the dominance of one interval on histograms. In our experiments, we used a modulating signal corresponding to the initial motivational and emotional state in defensive behavior.

Unit 4 – microwave dosimeter. This new device allows controlling some basic dosimetric parameters, such as the flux density of the incident microwave energy (EFD, W/cm^2) and specific absorption rate (W/kg); specific dose absorbed energy (J/kg) [8]. Photo of microwave dosimeter shown in Figure 3.

Units 3 and 5 control all units of the complex, collection and preliminary processing of information from all measuring devices.

Unit 6 (remote computer) allows remote controlling the blocks and provides the ultimate information processing. The results of the experiment were processed using the STATISTICA 12.0 and Microsoft Office Excel 2010 software packages. Since the distribution of the values obtained was different from the normal one, nonparametric tests were used to perform a comparative evaluation and to determine the reliability of the intergroup differences of the analyzed parameters – the Wilcoxon T-test and the Mann–Whitney U test. Differences were considered statistically significant at a value of $p < 0.05$. Numerical data are given as M $\pm$ SEM.

Figure 3: The photo of the microwave dosimeter.

3. Results of the Experimental Researches

The dynamics of changes in the volume of consumed oxygen (VO_2), the amount of exhaled carbon dioxide (VCO2) and the heat dissipation (H), considering the body weight of the rats at different stages of the study, is presented in Table 1.

At the first stage of the study, the nature of the effect of multiple low-intensity EMP on the consumption of oxygen by animals was analyzed. It has been established that single microwave radiation does not lead to significant changes in this index. On the 2nd day, a statistically significant decrease in the volume of oxygen consumed by the animals during the period after irradiation was detected (by 7.6% compared to the initial reference value, $p < 0.05$). This parameter slightly increased on the 3rd day of the experiment and did not differ from the control index. Beginning from the 4th day, rats were characterized by a decrease in oxygen consumption both in the background state (before irradiation) and during and after exposure to modulated microwave radiation: by 11.8, 12.4 and 13.0%, respectively ($p < 0.01$ compared with the control). It should be emphasized that the indicators of the volume of consumed oxygen remained significantly less than the baseline level on the 5th and 6th day of the experiment, when the animals were not subjected to EMR ($p < 0.01$–0.001). The background value of the analyzed indicator on the 7th day was less than the control parameter by 22.8% ($p < 0.001$). During this period of research, the amount of oxygen consumed by the rats progressively decreased during and after exposure to microwave

Table 1: The calculated values of the volume of oxygen consumed (VO2, ml/h/kg), the amount of exhaled carbon dioxide (VCO2, ml/h/kg) and heat release per unit time (H, kcal/h/kg) (M ± SEM).

Day	Experiment Conditions	VO_2	VCO_2	H
1^{st}	Background 1 – Control	1079.71 ± 41.87	991.25 ± 39.86	5.35 ± 0.21
	Impact – 1	1112.00 ± 34.86	1045.29 ± 41.13	5.54 ± 0.18
	Aftereffect – 1	1102.83 ± 44.75	1042.62 ± 56.98	5.49 ± 0.24
2^{nd}	Background – 2	1034.33 ± 38.11	1082.87 ± 37.64*	5.27 ± 0.19
	Impact – 2	1043.79 ± 31.72	1026.12 ± 36.47	5.25 ± 0.16
	Aftereffect – 2	997.25 ± 27.94*	970.62 ± 27.3	5.00 ± 0.14
3^{rd}	Background – 3	1136.83 ± 45.07	1136.50 ± 46.46**	5.74 ± 0.23
	Impact – 3	1109.33 ± 43.69	1065.21 ± 44.29	5.55 ± 0.22
	Aftereffect – 3	1047,25±38,72	1018,42±38,19	5,25±0,19
4^{th}	Background – 4	952.17 ± 38.86**	1019.37 ± 33.73	4.88 ± 0.18
	Impact – 4	945.87 ± 30.93**	929.58 ± 30.74	4.76 ± 0.15**
	Aftereffect – 4	939.17 ± 28.27**	928.50 ± 26.8	4.73 ± 0.14**
5^{th}	Background – 5_1	910.58 ± 31.29**	944.25 ± 36.23	4.63 ± 0.16*
	Background – 5_2	836.46 ± 21.50***	864.71 ± 22.91**	4.25 ± 0.11***
	Background – 5_3	861.63 ± 30.48***	898.08 ± 33.07*	4.34 ± 0.16***
6^{th}	Background – 6_1	893.92 ± 24.29***	915.83 ± 27.20*	4.53 ± 0.12***
	Background – 6_2	863.42 ± 23.69***	880.83 ± 22.52*	4.38 ± 0.12***
	Background – 6_3	934.83 ± 23.70**	957.08 ± 24.46	4.74 ± 0.12*
7^{th}	Background – 7	833.46 ± 27.42***	911.50 ± 29.3	4.29 ± 0.14***
	Impact – 7	821.13 ± 31.47***	844.83 ± 31.47**	4.17 ± 0.16***
	Aftereffect – 7	820.87 ± 21.1***	843.54 ± 22.53**	4.17 ± 0.11***

Note: *$p < 0.05$; **$p < 0.01$; and ***$p < 0.001$ in comparison with the corresponding indicators of 'Background-1 – Control'.

radiation: by 23.9 and 24.0%, respectively ($p < 0.001$ compared to the control). We studied the dynamics of the amount of carbon dioxide expired by animals under conditions of a low-intensity modulated EMP. Single exposure was not accompanied by reliable fluctuations of the analyzed indicator; there was only a tendency to increase during and after microwave radiation (by 5.5 and 5.2%, respectively, compared with the control). The release of carbon dioxide during irradiation of rats on days 2 to 4, as well as in the corresponding periods of exposure, did not differ from the initial value. Statistically significant excess of the control level was noted only for background indices on the 2nd and 3rd days of the experiment (by 9.2 [$p < 0.05$] and 14.6% [$p < 0.01$], respectively). However, on the 5th and 6th day of the experiment, when the animals were not subjected to EMR, the intensity of carbon dioxide emission was lower compared to the control ($p <$ 0.05–0.01). Repeated irradiation on the 7th day resulted in a decrease in the volume of exhaled carbon dioxide (14.8%, $p < 0.01$), which persisted after exposure (by 14.9%, $p < 0.01$). At the final stage of the work, the analysis of heat release in rats in the dynamics of repeated microwave radiation was carried out. Irradiation in the 1st–3rd day of the study practically did not change the parameters studied both during and after the exposure. However, by the 4th day, the level of heat release by animals significantly decreased with EMR, remaining lower in the subsequent period (by 11.0 and 11.6%, respectively, $p < 0.01$ compared to the control). The index of metabolic rate in rats on days 5 and 6 in the absence of irradiation was practically the same as that observed at the previous stage of the experiment, and was significantly less than the initial value (p <0.01–0.001). The background heat release parameter for the 7th day was less than the control level by 19.8% ($p < 0.001$). During this period, the value of heat release by rats was expressed during the microwave radiation and did not change during the subsequent testing (22.1% less compared to the control, $p < 0.001$). Consequently, repeated effects on animals of modulated low-intensity microwave radiation are accompanied by complex changes in indicators characterizing the intensity of metabolism. The amount of oxygen consumed and the level of heat release are reduced to the 4th day of intermittent irradiation, remaining lower for the next 2 days in the absence of an EMP source. The amount of carbon dioxide exhaled by rats increases slightly during the first three irradiation sessions, but decreases significantly during recovery on the 5th and 6th days. The most pronounced changes in metabolic parameters were noted on the 7th day of the experiment. This is manifested in a decrease in oxygen consumption, the release of carbon dioxide and the level of heat exchange, not only during irradiation, but also in the period between exposures.

4. Summary

The obtained results substantially supplement the available scientific information on the problem under study. Due to significant technological progress and extensive use of electronic equipment, people are constantly exposed to microwave. This is what causes the growing interest of researchers to study the nature of the effect of low-intensity radiation on the human body. In connection with the complexity or inability to conduct such observations in humans, most of the work in this area is performed on animals. In the classical experiments conducted by S. F. Korbel et al. as early as 1971 [9], it was found that microwave irradiation of laboratory rats (500 MHz, 0.43–0.15 mV) for 38 days leads to pronounced violations of their behavior. This manifested itself in a decrease in the activity of animals not only during but also after the termination of repeated experimental influences. Recent studies have demonstrated that electromagnetic waves, as one of the most serious and widespread physical factors, can have a negative impact on cognitive and other functions in mammals [10]. It is shown that difference in the duration of exposure to the low-frequency radiation cause changes in metabolism and motor behavior in rats that largely depend on the frequency characteristics of EMR. The revealed disorders were associated with fluctuations in the content of neurotransmitters and neurohormones, which indicate the stressor character of the observed reactions. When studying the cellular mechanisms of biological effects of EMP, it was found that low-intensity microwave radiation leads to functional changes in the electron transport chain of mitochondria and subsequent metabolic reprogramming of these structures [3]. Under these conditions, enhanced production of superoxide radicals and NO was revealed, which can contribute to the subsequent development of neurodegenerative diseases, tumors, and metabolic abnormalities.

Thus, the previously published data and the results of our experiments indicate that exposure to mammalian EMP can lead to changes in metabolic processes that are most significant under conditions of repeatedly repeated irradiation and persist even in a state of physiological dormancy. Thin mechanisms underlying the development of metabolic, behavioral and functional disorders under the influence of modulated low-intensity microwave radiation are the subject of further research.

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