Bulletin Experimental Biology and Medicine(English Translation)
Vol. 68 No. 7 July 1969

INVESTIGATION OF THE BIOLOGICAL ACTION OF MILLIMETER ELECTROMAGNETIC WAVES

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UDC 612.014.426

Chronic irradiation of albino rats with millimeter electromagnetic waves weakened their fundamental nervous processes and caused changes in the arterial pressure and morphological changes in the central nervous system.

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The energy of millimeter electromagnetic waves is absorbed mainly in the surface layers of the body. For this reason, differences can be expected between the biological action of millimeter waves and that of radiation of other wavelengths: centimeter and decimeter waves.

The object of this investigation was to study the biological action of millimeter electromagnetic waves: integral idices, state of function of the central nervous system (CNS) and cardiovascular system, morphological picture.

EXPERIMENTAL METHOD AND RESULTS

It has been shown that in the case of millimeter waves an intensity of irradiation of 5-7 mW/cm^2 is nonthermogenic, while the corresponding intensity for centimeter waves is 10-12 mW/cm^2.

The CNS function of the animals (albino rats) was tested in the course of chronic (5 months) irradiation with millimeter waves with an intensity of 10 mW/cm^2 for 60 min daily by means of a conditioned reflex method (L. I. Kotlyarevskii's motor-food method) and by exposure to acoustic stimulation (L. V. Krushinskii's technique).

Analysis of the results showed some shortening of the latent period of the conditioned reflex to a weak stimulus (red light) at the beginning of its application (20 tests). In some experiments a positive conditioned response to this stimulus was absent. The latent period and amplitude of the conditioned response to the sound of a bell showed no appreciable change.

The most marked changes occurred during investigation of active inhibition. A disturbance of active inhibition(de-inhibition of differentiation) was found in all animals to the extent of 70 ± 7.2% for the group, whereas in preliminary investigations a disturbance of differentiation was detected in only one animal (12.5 ± 5.8%), whereas in unirradiated animals (control group) differentiation was de-inhibited for the corresponding time interval in 27.5 ± 7.0% of cases.

With an increase in the number of irradiations, the changes in the conditioned reflexes were of a fluctuating character, although their trend pointed definitely to the inhibitory character of action of millimeter waves on functions of the higher levels of the CNS. This was expressed by lengthening of the latent period of the conditioned reflexes and by their frequent omission. Toward the end of irradiation (after 80 sessions) traces of absence of conditioned reflexes to positive stimuli were observed in all animals, amounting to 23 ± 3.5%, the conditioned reflex to a weak stimulus being omitted most frequently. Absence of conditioned reflexes occurred equally often before and after application of the differential stimulus. De-inhibition of differentiation was observed less frequently than in the initial period of irradiation, amounting to 25 ± 6.9% after irradiation for 5 months.

Institute of Work Hygiene and Occupational Diseases, Academy of Medical Sciences of the USSR, Moscow (Presented by Academician A. A. Letavet, Academy of Medical Sciences of the USSR.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 68, No. 7, pp. 37-39, July, 1969. Original article submitted October 6, 1968.

Conditioned-reflex activity was restored 3-4 weeks after the end of irradiation.

The results can be interpreted as evidence that exposure to millimeter waves predominently affects inhibition in the initial period, but later (after 40 sessions) it affects mainly excitation.

Differences in the response of the CNS to chronic irradiation by millimeter waves of low intensity were detected by the method of acoustic stimulation.

The animals used for this test were sensitive to acoustic stimulation, i.e., they responded to the sound of a bell by movements of different intensities which could terminate in a convulsion.

The earliest (by the 2nd month of irradiation) and characteristic change was lengthening of the latent period, as a rule in conjunction with a decrease in strength of the motor response. Parallel with these changes, changes were observed in other indices of the motor response: duration of the first wave of excitation and of the period of inhibition. The character of the changes detected at this period indicated lowering of excitability of the CNS.

During the subsequent months of irradiation, a progressive increase in the latent period was found, and toward the end of irradiation the response was considerably weakened.

Comparison of changes in CNS function produced by microwaves of different wavelengths under the same conditions of irradiation reveals that the changes after exposure to millimeter waves occurred later, in a smaller number of cases, and were less severe than those produced by waves in other bands. However, the end result of chronic irradiation by millimeter waves, as by centimeter and decimeter waves, is weakening of the fundamental nervous processes.

The response of the cardiovascular system to irradiation was estimated from changes in the blood pressure determined plethysmographically. Animals were irradiated with millimeter waves for 7 months at intensities of 40 and 10 mW/cm^2, the duration of daily exposure being 15 and 60 min respectively.

At an intensity of 40 mW/cm^2 (just as in the case of radiation of other wavelengths) during the first 4-6 weeks of irradiation a slight elevation of the blood pressure was observed, followed by a gradual decrease which amounted to 17% by the 26th week.

The pattern was different when the intensity was 10 mW/cm^2, for the level of the blood pressure fell gradually starting at the 3rd-4th week of irradiation, to reach 20% by the 12th-14th week.

During exposure to centimeter waves with an intensity of 10 mW/cm^2, initially the blood pressure rose, but then fell so that by the 22nd week of irradiation it was reduced by 9%.

After discontinuation of irradiation, the blood pressure of all animals gradually recovered and had almost regained its initial value by the 8th-10th week.

Morphological investigations of the organs and tissues of animals exposed to acute irradiation by millimeter waves of high intensity, just as after exposure to centimeter and decimeter waves, revealed marked vascular disturbances in the brain myocardium, liver, kidneys, testes, and the intestinal wall, accompanied by the ill-defined degenerative changes in the liver and kidneys and by acute swelling of nerve cells in different parts of the brain.

The characteristic features of the action of millimeter waves were distinctly revealed after the prolonged action of low-intensity irradiation. Marked changes, including histochemical changes, were demonstrated in the skin receptors, which showed reimpregnation and clearly visible deformation although changes in the interoceptors of the internal organs were negligible. In the skin, especially in its superficial layers, the nucleoprotein content was considerably reduced. Degenerative changes in the internal organs were slight after exposure to low intensities of irradiation, and were accompanied by proliferation of histiocytes in the liver and kidneys and of microglia in the brain.

Changes in interneuronal connections in the cortex after irradiation in high and low intensities were the same as those produced by the action of centimeter and decimeter waves, and consisted of disappearance of spines on the apical dendrites of the pyramidal neurons and the appearance of beads on them, but these changes were less marked, corresponding with the disturbances of function in the nervous system.

The experimental results show that exposure to millimeter microwaves differs in its results from the effect of waves in other bands, especially the decimeter band, when the lesions are predominantly found in

the internal organs and interoceptors. It may be assumed that millimeter waves are absorbed in the surface layers of the skin and that all degenerative changes in internal organs are reflex in origin, whereas decimeter waves, which penetrate deeper, may act directly on the internal organs and brain while leaving the skin intact. Centimeter waves, which are partly absorbed by the skin, may cause changes both in it and in deeper tissues.

Thus there is good evidence for concluding that the response of the organism to millimeter, centimeter, and decimeter waves is identical in character. Differences observed in the biological effect of millimeter waves are most probably determined by the depth of penetration and absorption of energy of these waves in the body tissues.