EFFECT OF A VARIABLE MAGNETIC FIELD OF INDUSTRIAL FREQUENCY ON THYROID FUNCTION AND TISSUE THYROXINE UPTAKE IN RATS

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The uptake of ^{131}I by the thyroid gland and of thyroxine by the tissues of various organs, and also the protein-bound iodine (PBI) concentration in the blood plasma were studied in albino rats exposed to a variable magnetic field (VMF) with an intensity of 200 Oe, of industrial frequency, for different durations and at different intervals. In response to exposure for 15 min the PBI level rose. With an increase in the exposure to 6.5 h and, in particular, to 24 h the PBI level and thyroxine uptake by the tissues of the testes, heart, liver, and spleen fell. In the case of repeated exposure to a VMF (up to 6.5 h daily for 5 days) a significant increase was found in the ^{131}I concentration in the thyroid gland and the PBI level, whereas thyroxine uptake by the tissues was considerably reduced. It is suggested that the state of the thyroid function and the tissue response to thyroxine are modified depending on the duration and rhythm of exposure to a magnetic field.

KEY WORDS: *variable magnetic field; thyroid gland; thyroxine.*

With the continually increasing use of appliances producing magnetic fields (MF) in industry and other branches of the national economy, and with their therapeutic use in medicine [4, 5, 13], it becomes necessary to make a detailed analysis of the biological action of MF on man and animals. MF are stress factors [1, 6], and an important role in adaptation to them is played by the thyroid gland [9]. However, its state during exposure to a VMF has been inadequately studied.

The object of this investigation was to study the response of the thyroid gland and uptake of labeled thyroxine by the tissues of animals exposed to a VMF of industrial frequency under different conditions.

EXPERIMENTAL METHOD

Experiments were carried out on 280 noninbred albino rats weighing 150-180 g, exposed to a VMF with an intensity of 200 Oe and frequency 50 Hz for 15 min, for 6.5, and 24 h, and also for 6.5 h daily for 5 days. The thyroid function was assessed by the uptake of ^{131}I by the gland 2-48 h after subcutaneous injection of 0.5 μCi of the isotope on the DSU-61 apparatus. The protein-bound iodine (PBI) concentration in the blood plasma was determined in 1 ml heparinized plasma by the method in [5] on GAMMA apparatus (Hungary and USA). The concentration of thyroxine-^{131}I (Nuclear Research Institute, Poland), injected subcutaneously in a dose of 1 μCi/100 g body weight, was determined in the adrenals, heart, thymus, spleen, testes, hypothalamus, lymph nodes, liver, and thyroid gland 24 h after injection of thyroxine [8]. The isotope was injected immediately after the end of exposure to VMF, except in the case of exposure for 15 min to MF, which took place after injection of the isotope.

The results were subjected to statistical analysis by means of the Wilcoxon–Mann–Whitney criterion [3].

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TABLE 1. Effect of Exposures of Different Duration to VMF on Plasma PBI Concentration in Albino Rats (M ± m)

Time after exposure, h	Duration of exposure to VMF							
	15 mm		6½ h		24 h		for 6.5 h daily for 5 days	
	control	experiment	control	experiment	control	experiment	control	experiment
	Uptake of radioactive ^{131}I by thyroid gland, % of injected dose							
12	53,06±0,95 48,57±0,89	51,39±0,99 47,39±0,97	53,44±1,03 43,38±1,03	51,64±1,77 43,19±0,63	47,43±3,33 45,25±2,68	45,23±4,07 44,15±3,61	58,96±2,37 57,18±1,99	65,01±1,84* 59,63±1,02
	Blood plasma PBI (per 10 ml)							
24 48	2,94±0,59 4,35±0,33	4,72±0,88* 4,71±0,54	2,68±0,32 2,41±0,24	1,69±0,16* 2,62±0,24	0,475±0,122 1,60±0,23	0,245±0,042* 1,57±0,31	1,48±0,49 3,04±0,62	2,02±0,31* 3,41±0,53

* $P<0.05$.

TABLE 2. Uptake of Thyroxine-^{131}I by Tissues of Organs (in % of injected doses/1000 mg weight of organ) (M ± m)†

Organs tested	Duration of exposure to VMF					
	6½ h		for 6.5 h daily for 5 days		24 h	
	control	experiment	control	experiment	control	experiment
Testes	0,0953±0,0095	0,0898±0,0069	0,1394±0,0141	0,1141±0,0068*	0,1162±0,0101	0,0813±0,0021*
Adrenal glands	0,337±0,061	0,252±0,064	0,520±0,127	0,365±0,084*	0,569±0,102	0,498±0,031*
Heart	0,0959±0,0057	0,0935±0,0056	0,2589±0,0274	0,2034±0,0077*	0,2073±0,0198	0,1816±0,0211*
Liver	0,231±0,021	0,222±0,022*	0,640±0,046	0,385±0,026*	0,322±0,023	0,261±0,015*
Spleen	0,0693±0,0045	0,0563±0,0041*	0,129±0,012	0,108±0,007*	0,132±0,014	0,093±0,006*

* $P<0.05$.

†Results for hypothalamus, thymus, and lymph nodes, and also for exposure to VMF for 15 min are not given because they were not significant.

EXPERIMENTAL RESULTS

The experiments showed (Table 1) that a single exposure of 15 min to VMF significantly increased the plasma PBI concentration, but no marked accumulation of iodine by the thyroid gland was observed under these circumstances; the uptake of thyroxine by the tissues likewise was unchanged. A similar type of response of the thyroid gland was reported by other investigators [2].

The hypothalamus is known to be the structure most sensitive to the action of MF. Under the influence of MF an increase in ACTH synthesis also is observed [11]. Stimulation of secretion of pituitary thyrotropine hormone can be taken as the cause of activation of thyroid function.

Table 2 shows that with an increase in exposure to MF up to 6.5 h and, in particular, to 14 h, a negligible decrease in iodine uptake by the thyroid gland was accompanied by a significant decrease in the PBI level. Following exposure of 6.5 h, thyroxine uptake by the liver and spleen tissue was reduced, and after exposure for 24 h, uptake by the tissues of the heart, testes, and thymus also was reduced. The cause of these changes could be hypoxia resulting from exposure to the VMF [10, 12], for a decrease in thyroid function is characteristic of that state [1].

A response of a different character was found to repeated exposure to VMF (for 6.5 h daily for 5 days). Under these conditions both the iodine content in the thyroid gland and the PBI level rose, although incorporation of labeled thyroxine was significantly reduced in virtually all the organs tested (Table 2).

It can be concluded from the results of these experiments that a VMF (200 Oe) of industrial frequency has a significant effect on thyroid function. The ratio between the uptake of ^{131}I by the thyroid gland, the plasma PBI concentration, and the uptake of thyroxine by the tissues varies depending on the duration and rhythm of exposure to the alternating magnetic field.

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