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PONDERABLE INDICES IN THE OFFSPRING AND NUCLEIC ACIDS QUANTITY IN ENDOCRINE GLANDS OF RATS EXPOSED TO REAL AND SHAM VDU SCREENS

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Abstract. Adult female and male Imp: DAK rats were exposed beneath a real VDU screen (Erl groups) loaded with light-green characteristics due to computation of trigonometric functions in a loop program from a microcomputer. The control animals were exposed beneath a sham screen (Esh groups), being the front glass of vacuum devoid cathode ray tube covered with a transparent celluloidal sheet printed with light-green characteristics. The difference in body weight of foetuses from autopsied Erl and Esh females was due mainly to a one-day delay in the fecundation of Esh females. In other groups of Erl females, a prolongation of the oestrous cycle was found in comparison to that of the Esh females. In both Erl females and Erl males, a nonsignificant decrease of weight of anterior pituitary and adrenals was found. RNA quantity was augmented in the anterior pituitary of Erl females and DNA quantity was diminished in the hypothalamus of Erl males. The obtained results suggest the suppression of hypothalamo-hypophyseal function in rats exposed to a real VDU screen.

INTRODUCTION

Video display units (VDUs) are sources of several well recognized physical factors, i.e. broad band pulsing electromagnetic fields, steady magnetic fields, monochromatic light, static electricity, disequilibrated concentration of negative and positive air ions, ultrasound, and power frequency electric fields due to electric energy supply to VDUs. A source of the power frequency electric field is also bulbs of electric lamps used for work post illumination at VDUs. If electric lamps are positioned near the head of the operator, the intensity of the 50 Hz electric field at that space may be up to 200 V/m. Such an exposure

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should be taken into consideration in the case of deliberation of physical hazards encountered at VDU work posts. The detrimental effect of the Hz electric field is evident from experiments described in this paper.

MATERIALS AND METHODS

Adult female and male Imp: DAK rats were used in three experimental tests. The animals in groups of 10 were caged in an animal house with a controlled temperature of 22 ± 2°C, relative humidity of 50–60% and a light-dark cycle 12/12 hrs. The animals had free access to murigran food and to degased tap water except for a 4-hour daily period of experimental procedures. In females, the oestrous cycle was checked by vaginal smears.

Both experimental and control animals were moved for the time of exposure to plastic cages with perforated walls and a screen polymetacrylane window. Front glass as real and sham VDU replaced the covers of the cages. Thus, the animals were exposed at a distance of 25 cm beneath a 14 inch screen (with the light from the top).

Groups of 5 experimental animals were repeatedly exposed 4 hrs daily beneath a real screen (Erl) of VDU type IMP-85 (IMP Ltd., Poland) and groups of 5 animals were exposed for another contemporaneous 4 hrs daily beneath a sham screen (Esh) being a vacuum devoid cathode ray tube of comparable size to that in the DU IMP-85. The real VDU screen was loaded with light-green characteristics due to computation of trigonometric functions in a loop program from a microcomputer with a repetition cycle of 20s. The front glass of the sham screen was lined from inside with a transparent sheet printed with light-green numerical characteristics. The sham screen was illuminated with an inserted 15 W bulb in the 1st test, and with a 40 W bulb in the 2nd and 3rd tests. In the 1st test both experimental and control animals were exposed in a simple unechoic chamber with the metal shield between sets of exposures. In the 2nd and 3rd tests, the experimental animals were exposed in the same unechoic chamber and control animals were exposed in a cylindrical container (80 × 100 cm) made from 2 mm copper plates. At the time of exposure, the environmental conditions were comparable for experimental and control animals.

The electric field intensity of the broad-band electromagnetic field before the real VDU screen was measured with a multirange electromagnetic field meter (MEH-1a) with a large dipol capacitive antenna and having perforated round plates (15 cm diameter) at both ends (product of Wroclaw Technical University, Poland). The 50 Hz electric field intensity in the vicinity of the real VDU screen and the sham screen was measured with an electric field meter ME – 2 for the range from 20 Hz to 15 kHz (product of Wroclaw Technical University, Poland). The source of 50 Hz electric field in the 1st test was one 15 W electric bulb and a configuration of three feeding cables lying at a distance of 60 cm from the exposure box with the control animals (Esh group). The three feeding cables were eliminated in the 2nd and 3rd tests, so the source there of the 50 Hz electric field was only the 40 W bulb used for illumination of the sham screen.

In the 1st test after 20 exposures 5 Erl and 5 Esh females were caged with males (1 Erl female & 1 Esh female to 1 male) for 68 hours during one weekend, excluding two periods of 2 × 4 hrs of exposure. After a further 17 exposures the females were quotopsied and the number of foetuses, their individual weight and macroscopic defects checked.

In the 2nd test 5 Erl and 5 Esh females, after an initial 8 control days, were exposed for 25, 26 or 27 days, and they were autopsied during their oestrous phase immediately after the last exposure. Their anterior pituitary glands, hypothalamus, adrenals and ovaries were weighed and dissected in cold acetone for quantification of nucleic acids (DNA and RNA). In the 3rd test 5 Erl and 5 Esh males were exposed for 38 days and autopsied immediately after their last exposure. The hypothalamus, anterior pituitary glands, adrenalas and testicles were weighed and dehydrated in cold acetone for subsequent quantification of nucleic acids.

In samples of acetone-dehydrated and dried endocrine organs, the quantity of DNA and RNA was investigated. DNA was determined by the fluorimetric method (OPTON Spectrofluorometer) with Hoechst reagent 33258 re DNA "SIGMA" (1, 4). RNA was determined by colorimetric reaction with orcinol re Uridine 3(2)-phosphoric acid "CALBIOCHEM" (6). The results in Erl and Esh animals were compared statistically with the Student's t-test for the limited number of data.

RESULTS

At the bottom of exposure cage, i.e. 25 cm beneath the real screen, the intensity of the electric field of the broad-band electromagnetic field was 7 – 12 V/m in each of three tests. Beneath the sham screen the intensity of the 50 Hz electric field was up to 70 V/m in the 1st test and below 1 V/m in the 2nd and 3rd tests.

In the 1st test, the Erl and Esh females were of comparable initial body weight and gained comparable body mass after 20 initial exposures before their coupling with males. Three Erl females were pregnant, having 12, 13 and 14 foetuses, with an average body weight of 1512 mg, 1401 mg and 1387 mg, respectively, at the time of autopsy. Two Esh females were pregnant having 12 and 14 foetuses with an average body weight of 894 mg and 464 mg, respectively, at the time of autopsy (Table 1). No macroscopic defects in foetuses were noted. Vaginal smears indicated a one day delay in fecundation of Esh females in comparison to day of fecundation of Erl females (diagram in Table 1).

In the 2nd test the Erl and Esh females were of comparable initial and final body weight. Significant prolongation of the oestrous cycle due to prolongation of non-oestrous phases in Erl females was found (table below Fig. 1). The weight of the anterior pituitary and adrenals was lower and RNA quantity in the anterior pituitary was higher in Erl females in comparison to those in Esh females, but the differences were not significant (Table 2).

In the 3rd test, the initial body weight was comparable in Esh and Erl males, but there was non-significantly higher final body weight in Erl males

TABLE 1. Pregnancy outcome and offspring size in female rats exposed repeatedly at real (Erl) or at sham (Esh) VDU screen in 1st test

Number of female rats and kind of exposure	Initial body weight (g)	Body weight before coupling with males (g)	Number of exposures before/ after coupling with males (4 hrs period)	Period of coupling with males and day of fecondation (vag. smears)	Number of foetuses ( ) and their average body weight (mg)
5 Esh females (exposed at sham scr.)	138 ± 3	175 ± 3	20/19	Females 1–5	(14) 464 ± 24 (12) 894 ± 36
5 Erl females (exposed at real scr.)	138 ± 7	174 ± 4	20/19	Females 1–5	(14) 1377 ± 125 (13) 1401 ± 73 (12) 1512 ± 77

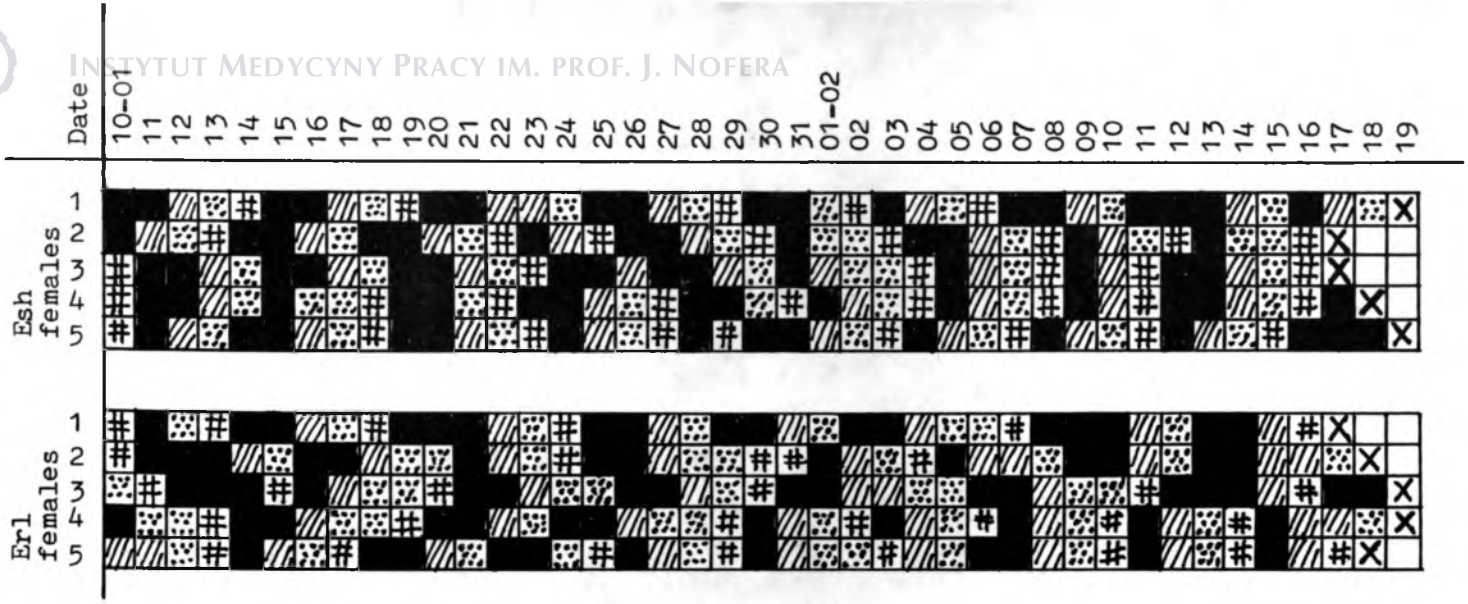
Denotations: ⌐¬ period of coupling with males
↑ presence of spermatozoa in vaginal smears

oestrus
metoestrum
dioestrum
prooestrum

TABLE 2. Some biological indices in rats exposed at sham (Esh) or at real (Erl) VDU screen. The figures denote average value and standard deviation.

Biological indices	2nd test Female rats in groups of 5 exposed to the sham (Esh) or real (Erl) VDU screen 4 hrs/day for 25, 26 or 27 days		3rd test Male rats in groups of 5 exposed to the sham (Esh) or real (Erl) VDU screen 4 hrs/day for 38 days	
	Esh	Erl	Esh	Erl
Body weight (g):				
initial	155 ±9	157 ±14	84 ±4	82 ±9
final...	198 ±15	194 ±5	269 ±18	272 ±34
increase (%)	128	124	321	332
Adenohypophysis:				
weight (mg)	9.32 ±1.71	8.66 ±.89	7.80 ±1.00	7.34 ±.50
DNA, µg/1 mg	1.63 ±.24	2.04 ±.47	2.87 ±.55	2.98 ±.70
RNA, µg/s mg	27.17 ±9.63	34.12 ±5.40	11.64 ±2.60	14.40 ±9.60
Adrenals:				
weight (mg)	59.0 ±3.7	53.1 ±9.7	53.2 ±4.6	47.7 ±6.3
DNA, µg/1 mg	2.86 ±.52	2.63 ±.69	3.70 ±.30	4.27 ±1.00
RNA, µg/1 mg	15.10 ±.60	16.52 ±2.30	18.25 ±2.70	20.28 ±2.40
Ovaries/Testicles:				
weight (mg)	74.0 ±7.5	72.4 ±9.3	2828 ±152	3040 ±408
DNA, µg/1 mg	2.27 ±.40	2.52 ±.70	1.70 ±.14	1.48 ±.24
RNA, µg/1 mg	16.00 ±4.00	17.80 ±2.00	10.99 ±.86	11.08 ±1.62
Hypothalamus:				
DNA, µg/1 mg	...	...	*3.53 ±.55	*2.35 ±.30
RNA, µg/1 mg	...	...	9.14 ±3.00	9.42 ±2.20

*Difference significant at $p < 0.01$



Phase of oestrous cycle	5 Esh females	5 Erl females
Oestrous	1.64 ± 0.17	1.74 ± 0.38
Metoestrum Dioestrum Prooestrum	*2.66 ± 0.11	*3.18 ± 0.30
Oestrous cycle	**4.26 ± 0.23	**4.92 ± 0.19

Figures denote duration in days: $\bar{X} \pm$ S.D.

Differences significant at: $^{**}p < 0.002$ and $^{*}p < 0.01$

Fig. 1. Course of the oestrous cycle in Esh and Erl females. Figures in the table indicate significant prolongation of the oestrous cycle and

than Esh males. The weight of the anterior pituitary and adrenals was lower, and the weight of testicles higher in Erl males than Esh males, but the differences were not significant. A significantly lower DNA quantity was found in the hypothalamus of Erl males than in the Esh males (Table 2).

DISCUSSION

The coupling of Erl and Esh females with males in the 1st test for one weekend (for practically 68 hrs excluding periods of exposure) resulted in fecundation of three Erl females during the first 24 hr period and of two Esh females during the second of this weekend. The delay in fecundation of Esh females was certainly the cause of the much lower body weight of their foetuses than the foetuses of Erl females at the autopsy of all females on the same day before expected delivery. The earlier fecundation of Erl females could be related to stimulation of their hypothalamo-hypophyseal system for release of the gonadotropic hormones. There is a retino-thalamo-hipocampal pathway in rats (7), and pulsatile release of LH (Luteinizing Hormone) due to stimulation of the pituitary dependent on hypothalamic LH-RH (Luteinizing Hormone – Releasing Hormone) release in rats (8). In previous investigations the adverse effect of VDU exposure on reproduction was observed in rats (5). The actual results in the 1st test, indicating non-effect of VDU exposure on reproduction, could be masked by non-intentional exposure of Esh females to a 50 Hz electric field of an intensity up to 70 v/m due to the configuration of three feeding cables lying near the box with Esh females during their sham exposures. In the 2nd and 3rd tests, such unwanted exposure has been eliminated (as described in Materials and Methods).

The prolongation of the oestrous cycle, the diminished weight of the anterior pituitary and adrenals, and augmentation of RNA quantity in the anterior pituitary of Erl females in comparison to those in Esh females, though non significant, in the 2nd test indicate some depression of these descriptors in females subjected to VDU exposure. Fairly similar tendencies were obtained in the 3rd test indicating the diminished weight of the anterior pituitary and adrenals, and the DNA quantity in hypothalamus with some weight augmentation of the testicles in Erl males in comparison to such descriptors in Esh males. The results of both these tests indicate the involvement of the hypothalamo-pituitary system in the reaction of adult female and male rats to long term exposure near a VDU. The quantity of DNA and RNA in endocrine glands may be changed by surgical or hormonal intervention in the endocrine regulatory system (2, 3). VDUs are known to be sources of various physical factors, e.g. electromagnetic fields, static electricity, light pulsation, which could influence the hypothalamo-pituitary system – very sensitive to various external stimuli.

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