Effect of Constant Illumination on Catatonic Symptoms in Female GC Rats

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Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 146, No. 7, pp. 26-29, July, 2008
Original article submitted September 26, 2007

We studied the effect of constant illumination for 1 month on female GC (genetic catalepsy) and Wistar rats (control). Light exposure decreased the degree of cataleptic freezing in female GC rats (compared to the control). Norepinephrine concentration in cataleptic rats returned to normal under these conditions: this parameter increased in the corpus striatum and adrenal glands and decreased in the hypothalamus to a control level observed in intact Wistar rats.

Key Words: *illumination; catatonia; permanent estrons; norepinephrine; serotonin*

Light affects a variety of physiological functions in animals and humans, including psychopathological behavior. The exposure to bright light has a therapeutic effect on depressive patients [5]. A new strain of rats with genetic catalepsy (GC, V. G. Kolpakov) was bred at the Institute of Cytology and Genetics. These animals were selected by manifestations of catatonic and depressive behavior [4]. The relationship exists between these disorders and functions of the noradrenergic and serotoninergic system in male GC rats [3]. It is interesting to evaluate behavioral and neurochemical parameters in female GC rats under normal light/dark conditions and during constant illumination.

Here we studied the effect of constant light on catatonic symptoms in female GC rats. The concentrations of monoamines were measured in the brain and adrenal glands, which constitute the major structures of the adaptive system.

MATERIALS AND METHODS

Experiments were performed on female GC rats (62nd generation, n=32) and Wistar rats (control, n=32). The animals were maintained in a vivarium under standard conditions and had free access to water and food. From the second to the third month of life, 16 GC females and 16 Wistar females were exposed to constant light with an incandescent lamp (1 month). The average illumination of a cage floor was 200 lx.

Female GC and Wistar rats were tested for catalepsy at 1-week intervals. A total of 4 tests were performed from the second to the third month of life: the animal was placed into the corner of the cage and the forepaws were gently elevated with a stick. The time of retaining vertical posture after removal of this stick was recorded [2]. We studied the catatonic (waxy flexibility and muscle rigidity) and depressive symptoms (negativism, nervous reactions, and "nose in the corner" posture).

For evaluation of catecholamine content, the animals were rapidly decapitated and the frontal cortex, corpus striatum, hypothalamus, midbrain, and adrenal glands were isolated and stored at -80°C. The concentrations of norepinephrine (NE), serotonin (5-hydroxytryptamine, 5-HT), and 5-hydroxyindoleacetic acid (5-HIAA) were measured fluorometrically as described elsewhere [3]. Fluorescence of monoamines was measured on a Victor device (Perkin Elmeter) at 355/460 nm.

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0007-4888/08/1461-0022

The results were analyzed by Student's *t* test.

RESULTS

Daily examination of vaginal smears showed that 2-week exposure to constant light was followed by permanent estrous in all female Wistar and GC rats [6]. The same number of control females was maintained under natural light/dark conditions and had normal estrous cycle.

Constant light had no effect on freezing behavior in Wistar rats (4 tests; Fig. 1, *a*). The degree of freezing with waxy flexibility and muscle rigidity, as well as the severity of nervous reactions and negativism in GC rats decreased 1 week after the start of treatment (compared to the control). Further decrease in these symptoms was observed in the following three tests (Fig. 1, *b*).

Twenty-four-hour illumination considerably affected the noradrenergic system in the brain and adrenal glands of Wistar and GC females. Significant differences in NE concentration were revealed in all 3 regions of the central nervous system (except for midbrain) and adrenal medulla (Table 1). NE concentration in the frontal cortex of intact Wistar rats was higher than in GC females, which is consistent with published data on cataleptic males [1]. After exposure to constant light, NE concentration in the frontal cortex of Wistar females was higher than in GC rats. Light can be considered as a stress factor. Under these conditions, the concentration of NE in the frontal cortex remained unchanged in GC females, but increased in Wistar rats. Similar changes in neurotransmitter concentration were observed in Wistar and GC rats during immobilization [1].

The corpus striatum is responsible for manifestations of catalepsy. NE concentration in the corpus striatum of intact GC females was lower than in Wistar rats. Published data show that the concentration of this neurotransmitter also decreases in GC males [3]. No intergroup differences were revealed during constant illumination.

The hypothalamus plays the major role in the maintenance of the balance between neurotransmitters and hormones. NE concentration in the hypothalamus of intact GC females was higher than in Wistar rats. The increase in NE concentration is untypical of GC females, which requires further detailed investigations. After constant illumination, NE concentration in cataleptic animals decreased to normal (Wistar rats) and did not differ from that in intact females of the control strain.

Constant illumination had a similar "leveling" effect on NE concentration in the adrenal medulla from rats of both strains. NE concentration in GC females increased and did not differ from that in Wistar rats. NE concentration in the adrenal glands of intact GC females was also reduced (similarly to GC males [1]).

The four groups of Wistar and GC rats did not differ by the concentrations of NE, 5-HT, and 5-HIAA in the midbrain, the structure containing major clusters of monoamine-synthesizing neurons. Our previous studies showed that it is difficult to reveal differences in neurotransmitter concentration in the midbrain. The midbrain is a major source of neurotransmitters, which should not be affected by environmental factors.

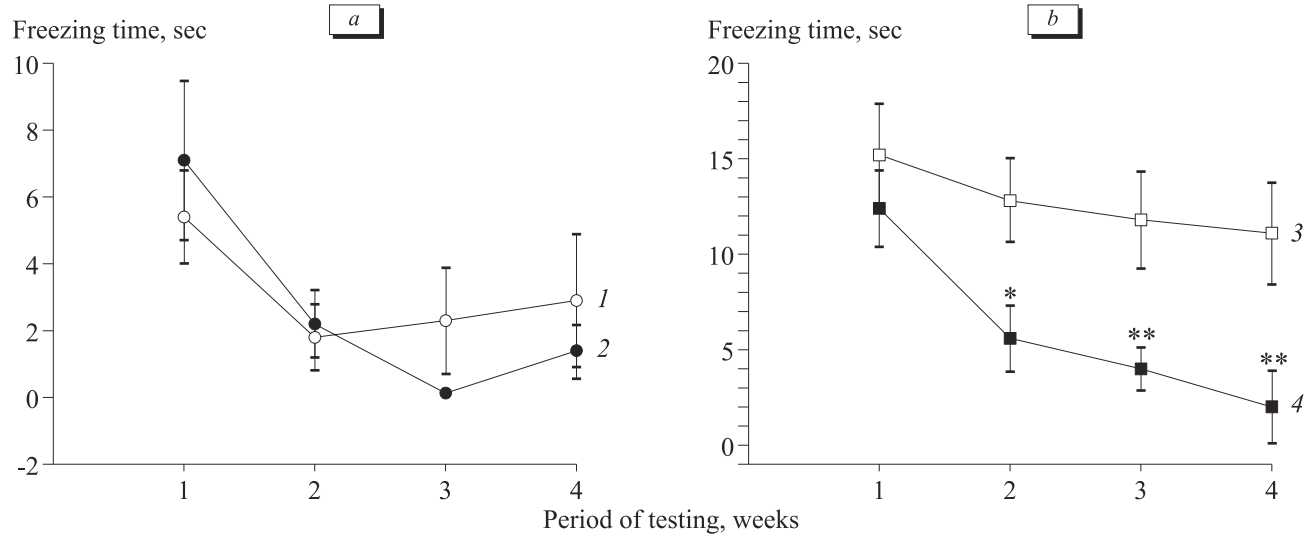

Fig. 1. Effect of constant light on cataleptic freezing in Wistar (*a*) and GC females (*b*). Wistar (intact, *1*); Wistar (constant light, *2*); GC (intact, *3*); GC (constant light, *4*). **p*<0.05 and ***p*<0.01 compared to *3*.

The effect of 24-h illumination on the serotoninergic system of the brain and adrenal glands was less significant compared to that on the noradrenergic system. Illumination had a modulatory effect on the corpus striatum in Wistar females. 5-HT concentration in Wistar females of the treatment group increased by more than 2 times compared to animals at the natural light/dark cycle. However, 5-HT concentration remained unchanged in GC females.

No differences were revealed in hypothalamic 5-HT concentration in intact Wistar and GC rats. After constant illumination, the concentration of 5-HT in GC females was higher than in Wistar rats. The hypothalamus maintains the balance between neurotransmitters. Reciprocal relationships between the noradrenergic and serotoninergic system probably occur in the hypothalamus. Illumination was followed by a significant decrease in NE concentration in GC females. No differences were found in NE concentration in intact GC females and Wistar rats. Constant illumination was followed by a significant increase in 5-HT concentration in GC females (as compared to Wistar rats).

Constant illumination decreased NE concentration in the adrenal glands of Wistar rats compared to that in intact animals, but had no effect on this parameter in GC rats. 5-HT concentration tended to decrease during constant illumination in Wistar rats ($p<0.07$), but remained unchanged in GC rats.

5-HIAA concentration did not differ in intact and experimental groups of Wistar and GC rats. Light probably produces an activating effect on the organism, which results in increased parameter variability (*e.g.*, 5-HIAA concentration in the adrenal glands of GC females). High variability of 5-HIAA concentration can be related to 5-HT degradation by the major serotonin, melatonin, and kynurenine pathways.

TABLE 1. Monoamine Concentration in Wistar and GC Females under Various Light/Dark Conditions

Group	NE	5-HT	5-HIAA
Frontal cortex			
Wistar (intact)	0.40±0.03 (13)	0.62±0.17 980	0.35±0.05 (8)
Wistar (constant light)	0.59±0.11 (14)	0.63±0.14 (9)	0.35±0.03 (9)
GC (intact)	0.30±0.04* (8)	0.69±0.11 (9)	0.37±0.03 (9)
GC (constant light)	0.27±0.02* (10)	0.69±0.09 (9)	0.42±0.04 (8)
Corpus striatum			
Wistar (intact)	0.77±0.10 (9)	0.31±0.13 (9)	1.20±0.39 (16)
Wistar (constant light)	0.51±0.05 (9)	0.70±0.09^{+} (9)	0.51±0.11 (14)
GC (intact)	0.49±0.05* (10)	0.58±0.17 (10)	0.46±0. 12 (10)
GC (constant light)	0.57±0.09 (8)	0.50±0.18 (8)	0.54±0.12 (9)
Hypothalamus			
Wistar (intact)	1.02±0.09 (8)	0.53±0.21 (7)	0.75±0.27 (7)
Wistar (constant light)	1.62±0.16^{++} (9)	0.49±0.10 (8)	1.07±0.48 (8)
GC (intact)	1.87±0.20** (9)	0.78±0.14 (10)	0.58±0.04 (10)
GC (constant light)	1.22±0.08^{++} (9)	1.00±0.22* (8)	0.57±0.08 (8)
Midbrain			
Wistar (intact)	0.35±0.08 (10)	0.24±0.02 (7)	0.21±0.08 (10)
Wistar (constant light)	0.31±0.02 (8)	0.22±0.06 (8)	0.38±0.10 (8)
GC (intact)	0.37±0.0.04 (10)	0.29±0.10 (10)	0.44±0.09 (10)
GC (constant light)	0.43±0.06 (9)	0.40±0.08 (9)	0.35±0.07 (9)
Adrenal glands			
Wistar (intact)	18.9±1.4 (12)	0.92±0.20 (16)	0.26±0.06 (10)
Wistar (constant light)	12.9±1.2^{++} (9)	0.46±0.15^{o} (13)	0.15±0.05 (9)
GC (intact)	12.9±1.0** (10)	1.06±0.73 (9)	0.55±0.25 (9)
GC (constant light)	14.8±1.8 (8)	1.16±0.37 (8)	0.57±0.26 (7)

Note. Number of animals is shown in brackets. *$p<0.05$ and **$p<0.01$ compared to Wistar rats; $^{+}p<0.05$ and $^{++}p<0.01$ compared to a normal level in rats of the same strain; $^{o}p<0.07$ compared to normal (tendency).

Our results show that constant illumination for 1 month decreased the degree of cataleptic freezing in GC females to a control level (Wistar rats) and eliminated nervous reactions and negativism in cataleptic animals. An equilibrium is set between NE concentrations in the hypothalamic-adrenal system and corpus striatum (major structure for motor disorders). We revealed that illumination reduces the severity of catatonic and depressive symptoms. This treatment partially normalizes the concentration of NE in GC females, which does not differ from the control level in Wistar rats. Our findings are consistent with published data on the general pathogenetic mechanism of 2 various diseases (catatonia and depression) [4].

This work was supported by the Russian Foundation for Basic Research (grant No. 06-04-49003).

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