

Effect of Light and Darkness upon Thyroid Secretion Rate and on the Endocrine Glands of Female Rats* (34091)

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A systematic study of factors influencing the thyroid hormone secretion rate (TSR) of the rat has been in progress in this laboratory for several years. Recently, it was suggested that the pineal gland secreted a hormone, melatonin (1). It was then shown that constant light tended to depress the secretion of melatonin and darkness stimulated its production (2). Constant light has been reported to cause ovarian hypertrophy (3) and atrophy (11).

In the light of recent work on pinealectomy (4) and melatonin on TSR (5, 6), it seemed of interest to investigate the role of light and darkness on TSR in the rat. These data suggest that constant light should stimulate TSR and darkness should depress TSR. Orosz *et al.* (7) reported no change in the PBI of rats maintained in darkness or constant light but in darkness increased amounts of L-T₄ were present. In light, L-T₄ was reduced. L-T₃ levels were unaffected by the changes of light.

Materials and Methods. The thyroid hormone secretion rate (TSR) of 62 female rats of the Sprague-Dawley-Rolfmeyer strain (30 days of age, with average body weight of 51.0 g) was determined as 1.24 μg thyroxine (L-T₄)/100 g body wt by the method described by Grosvenor and Turner (8). They were maintained at a constant temperature of $78 \pm 1^\circ\text{F}$ in a room artificially illuminated during normal daylight hours. The rats were fed Purina Lab Chow and water *ad libitum*.

In this study, L-T₄ was administered in daily increments of 0.25 μg /100 g body

wt/day. The dose of L-T₄ which prevented further thyroidal I¹³¹ release, that is, 95 to 100% of the previous count, was estimated as the TSR of the animal. Correction was made for radioactive decay and background. The rats were divided into three groups, each having approximately the same mean TSR (1.25 μg /100 g body wt) at 30 days of age. Group I was kept under control conditions. Group II was placed in nearly constant total darkness. For brief periods each day, the rats housed in darkness were exposed to a faint light while being fed and cleaned. Group III was placed in continuous light in a naturally lighted laboratory. Two fluorescent lights, suspended above the cages of the animals, produced a continuous intensity of illumination of about 70 ft-c. Unfortunately, vaginal smears were not made of these rats to determine the timing and incidence of constant estrus which was reported to occur at variable times after exposure to constant light (12). When the TSR estimation were completed after 56 days of exposure when the rats were 112 days of age, they were sacrificed and the following glands were removed and weighed: ovaries, adrenals, thyroid, thymus, pituitary, and pineal. The balance was sensitive to 0.01 mg.

Results. The mean TSR of the groups of 62 female rats was 1.24 μg /100 g body wt when determined at 30 days of age. The rats were divided into three groups with equal mean TSR when 49 days of age. After 7 days of exposure to variable light, the TSR was again determined starting when 56 days of age. The mean TSR of Groups I, II, and III was $1.11 \pm .08$, $1.12 \pm .05$, and $1.19 \pm .08$ μg /100 g body wt respectively. The TSR of the light-treated group was 10.7% higher than the control group, whereas the dark

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group was unchanged. The TSR was again determined after 56 days of exposure. The mean TSR of Groups I, II, and II was $0.81 \pm .09$, $0.87 \pm .09$, and $0.98 \pm .06$ $\mu\text{g}/100$ g body wt respectively. The TSR of the light-treated group was increased 21% ($p < .05$) as compared to the control group.

Exposure of the rat to constant light for 56 days had a marked effect upon ovarian weight. A significant increase of 13%/100 g body wt ($p < .01$) in comparison to the control group was observed (Table I). This increase was reflected in a significantly increased uterine weight of 46%/100 g body wt ($< .01$). Light also stimulated a significant 37% increase in pituitary weight. On the other hand, a significant 25% decrease/100 g body wt was observed in the pineal gland. The weight of the adrenals, thymus, and thyroid glands was unaffected by light.

The endocrine gland weights of the group of rats maintained in continuous darkness were not significantly different from the control group.

Continuous darkness had no effect on the TSR and only a nonsignificant effect upon pineal weight. Since the daily injection of 20 $\mu\text{g}/\text{day}$ of melatonin depressed TSR 16%, it would appear that total darkness does not stimulate increased melatonin secretion to this degree in comparison to the control group. From these observations it would appear that continuous light can depress melatonin secretion to approximately the pinealectomy level but that continuous darkness has little stimulating effect upon melatonin compared to normal cyclic lighting.

Discussion. In a previous study it was shown that pinealectomy caused an increase of 11.8% in TSR (4). In the present study it was shown that continuous lighting for 56 days stimulated a significant increase of 21% in TSR compared to the control group. These observations suggest that continuous lighting markedly depressed the secretion of melatonin. This is further confirmed by the observation that adult female Holtzman rats exposed to continuous light showed a decrease in the activity of the pineal enzyme, hydroxyindole-*O*-methyl transferase (9), which synthesizes melatonin.

Constant light resulted in a significant decrease in pineal weight in agreement with that reported previously (10). A significant increase in ovarian weight was observed in agreement with one previous report (9), but opposite to that observed by others (11, 12), but uterine weight was significantly increased. Previous studies indicated a slight but nonsignificant increase in uterine weight (12), or no increase (11). Pituitary weight was significantly increased as reported previously (12). In a previous study (13) with Sprague-Dawley rats, it was reported that continuous light induced a highly significant reduction in adrenal weight in normal females. In the present experiment and in another report (11), adrenal weights were not altered. Thymus and thyroid glands were not affected.

Summary. Thyroid hormone secretion rate (TSR) of 62 female rats at 30 days of age was estimated as 1.24 $\mu\text{g L-T}_4/100$ g body wt. During the next 8 weeks the rats were maintained in continuous light or continuous darkness or a normal light-dark schedule. After 8 weeks of continuous light treatment, the TSR of this group was increased 21% ($p.05$) above the control group. The TSR of the control group and those in total darkness were not significantly different.

Constant light significantly increased ovarian, uterine, and pituitary weight. A significant decrease of 25% was observed in pineal weight. The weight of adrenals, thymus, and thyroid glands were unaffected. The weights of endocrine glands of the rats in continuous darkness were not significantly different from those of the control group.

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TABLE I. Effect of Continuous Light and Darkness on Endocrine Glands in Female Rats.

	Group I, control (day and night)		Group II (continuous darkness)		Group III (continuous light)		Significance level
	No. of rats						
No. of rats	25		15		22		
Body wt (g)	226		227		205		
Ovary wt (mg)							
Total \pm SE	49.25 \pm 2.90 ^a		50.10 \pm 1.30 ^b		58.21 \pm 4.80 ^c		<i>b</i> vs. <i>c</i> <i>p</i> < .10
Per 100 g body wt	21.79 \pm 1.37 ^d		22.00 \pm 0.92 ^e		28.40 \pm 2.30 ^f		<i>d</i> vs. <i>f</i> <i>p</i> < .01
Adrenal wt (mg)							
Total \pm SE	50.48 \pm 2.38 ^g		49.90 \pm 1.80		47.39 \pm 2.41 ^h		<i>g</i> vs. <i>h</i> <i>p</i> < .20
Per 100 g body wt	22.34 \pm 1.06		22.27 \pm 0.94		22.50 \pm 1.30		
Uterus wt (mg)							
Total \pm SE	427.48 \pm 24.50 ⁱ		423.00 \pm 28.00 ^j		550.26 \pm 44.60 ^k		<i>i</i> vs. <i>k</i> <i>p</i> < .01
Per 100 g body wt	189.50 \pm 14.90 ^l		186.30 \pm 14.70 ^m		275.60 \pm 23.30 ⁿ		<i>l</i> vs. <i>n</i> <i>p</i> < .01
Thymus wt (mg)							
Total \pm SE	350.38 \pm 21.25 ^o		335.00 \pm 17.00 ^p		209.25 \pm 20.32 ^q		<i>o</i> vs. <i>q</i> <i>p</i> < .10
Per 100 g body wt	155.04 \pm 5.60		147.60 \pm 3.40		150.55 \pm 5.40		
Pituitary wt (mg)							
Total \pm SE	8.97 \pm 0.52 ^r		9.10 \pm 0.40 ^s		11.20 \pm 0.50 ^t		<i>r</i> vs. <i>t</i> <i>p</i> < .005
Per 100 g body wt	3.98 \pm 0.24 ^u		4.01 \pm 0.21 ^v		5.46 \pm 0.20 ^w		<i>u</i> vs. <i>w</i> <i>p</i> < .025
Pineal wt (mg)							
Total \pm SE	1.27 \pm 0.13 ^x		1.20 \pm 0.10 ^y		0.88 \pm 0.07 ^z		<i>x</i> vs. <i>z</i> <i>p</i> < .005
Per 100 g body wt	0.56 \pm 0.03 ^l		0.53 \pm 0.04 ^z		0.42 \pm 0.04 ^z		<i>l</i> vs. ^z <i>p</i> < .005
Thyroid wt (mg)							
Total \pm SE	10.40 \pm 0.24		10.20 \pm 0.69		10.30 \pm 0.28		
Per 100 g body wt	4.59 \pm 0.11		4.49 \pm 0.12		5.00 \pm 0.43		

SE = Standard error of the mean.

p = Student *t* test, level of significance.

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