THE EFFECT OF THYROXIN ON GASEOUS EXCHANGE IN WHITE RATS OF VARIOUS AGE GROUPS

V. P. Al'khimenyuk

Department of Pathophysiology (Head — Professor S. M. Leites), All-Union Institute of Experimental Endocrinology (Dir. — Prof. E. A. Vasyukova, Moscow
(Presented by Active Member AMN SSSR V. V. Parin)
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The injection of thyroxin is known to increase the gaseous exchange in normal animals, and the effect occurs after a latent period of 18-24 hr. There are certain indications that the effect obtained depends on age. V. N. Nikitin, R. I. Golubitskaya, L. A. Dryuchina and others [6] have shown that in old rats the response to thyroid hormone is reduced. T. O. Dzgoeva [1] found that as little as 14 μg/100 g has no effect on the gaseous exchange of two-week or one-month rats, whereas the same doses increase it considerably in animals one year old. Old rats react more weakly than the one-year-olds to the same dose of thyroxin.

It has also been shown [2, 7] that there are marked seasonal variations in the rate of gaseous exchange in rodents, even when temperature and other conditions are maintained constant.

In the present work we have attempted to determine the effect of various doses of thyroxin on gaseous exchange of animals of various age groups, while taking into account seasonal variations in the basic metabolic rate.

METHOD

Rats of three age groups were used: Adults of 1–2 years weighing 180–240 g, sexually immature animals 22–35 days old weighing 35–49 g, and old rats of 2–3 years weighing 290–350 g.

Gaseous exchange was determined by the closed chamber method using M. N. Shaternikov's method for small animals as modified by N. A. Isichenko [3]. The experiment was started 16–18 hours after the rats had last fed. Gaseous exchange was measured before, and 18–20 hr after 50 and 200 μg/100 g had been injected subcutaneously. The absorption of O_2 and the liberation of CO_2 per hour were referred to 100 g body weight. Gaseous-exchange measurements in the animals of different age groups were continued for one year, and 70 animals were used.

RESULTS

Seasonal variations of gaseous exchange were particularly marked in the sexually immature rats. Absorption of oxygen in winter was almost twice as great as in summer (the increase being 0.2 liters/hr). The increased oxygen absorption in winter was less marked in the old and middle age groups, the winter value exceeding the summer by 0.03 and 0.04 liters/hr respectively.

The injection of 50 μg/100 g of thyroxin into rats of the middle-age group in summer caused no appreciable change in gaseous exchange. In autumn the same dose increased oxygen absorption by 0.03 liters/hr, and the liberation of CO_2 by 0.02 liters/hr, and there was an insignificant reduction of the respiratory quotient (Table 1). When 200 μg/100 g of thyroxin was given in either summer or winter, oxygen absorption was increased by 0.05 liters per hr, and CO_2 liberation by 0.03 liters/hr.

TABLE 1.

Changes in Gaseous Exchange in Rats of Middle Age Before (I) and After (II) the Injection of 50 and 200 μg/100 g of Thyroxin (average values)

No. of animals	Wt. (in g)	Month	Dose (in μg/100 g)	O_2 (100 liters per hr)		CO_2 (100 liters per hr)		Respiratory quotient	
				I	II	I	II	I	II
7	220	July	50	0,16	0,175	0,14	0,16	0,87	0,91
7	208	October	50	0,17	0,20	0,15	0,17	0,88	0,85
7	235	July	200	0,15	0,19	0,14	0,17	0,93	0,89
8	218	Dec.	200	0,19	0,24	0,18	0,21	0,95	0,87

TABLE 2.

Change in the Gaseous Exchange in Sexually Immature Rats Before (I) and After (II) the Injection of 50 and 200 μg/100 g of Thyroxin (average values)

No. of animals	Wt. (in g)	Month	Dose (in μg/100 g)	O_2 (100 liters per hr)		CO_2 (100 liters per hr)		Respiratory quotient	
				I	II	I	II	I	II
5	48	July	50	0,20	0,19	0,20	0,18	1,0	0,95
5	41	"	200	0,22	0,22	0,20	0,20	0,92	0,92
10	37	Sept.	200	0,31	0,31	0,29	0,27	0,93	0,87
12	39	Dec.	200	0,42	0,48	0,39	0,42	0,93	0,89
3	35	Oct.	200	0,35	0,40	0,32	0,35	0,91	0,87
3	35	"	200	0,41	0,38	0,36	0,35	0,88	0,92

TABLE 3.

Change in Gaseous Exchange in Old Rats Before (I) and After (II) Injecting 50 and 200 μg/100 g of Thyroxin (average values)

No. of animals	Wt. (in g)	Month	Dose (in μg/100 g)	O_2 (100 liters per hr)		CO_2 (100 liters per hr)		Respiratory quotient	
				I	II	I	II	I	II
7	305	August	50	0.16	0.16	0.15	0.15	0.94	0.94
6	283	October	50	0.16	0.18	0.14	0.15	0.88	0.83
6	290	July	200	0.14	0.16	0.13	0.14	0.93	0.88
6	319	Dec.	200	0.17	0.20	0.16	0.18	0.94	0.90

Thus in rats of medium age, small doses of thyroxin cause seasonal changes in reactivity: In summer they react weakly, but in autumn gaseous exchange is increased. When large doses are given, however, no seasonal changes in the extent of the reaction occur.

Unlike the rats of medium age, the sexually immature animals showed no change in the absorption of O_2 or the liberation of CO_2 when 50 or 200 μg/100 g were given in summer or autumn. If 200 μg/100 g was given to the sexually immature animals in winter, oxygen absorption was increased and the respiratory quotient depressed.

TABLE 4.

Change in Gaseous Exchange in Rats Before (I) and After (II) the Injection of 200 μg/100 g of Thyroxin as Related to the Original Basal Metabolic Rate

No. of animals	Wt. (in g)	Month	Dose (in μg/100 g)	O_2 (100 liters per hr)		CO_2 (100 liters per hr)		Respiratory quotient	
				I	II	I	II	I	II
1	245	July	200	0.13	0.22	0.12	0.19	0.22	0.86
2	210	"	200	0.19	0.21	0.17	0.18	0.89	0.86
3	328	October	200	0.13	0.20	0.13	0.15	1.0	0.75
4	360	"	200	0.22	0.21	0.17	0.16	0.77	0.76

It should be noted that the change in gaseous exchange in sexually immature rats produced when the thyroxin injection was given in October, between seasons, was variable, and the gaseous exchange rate might be either increased or decreased. The change was related to the initial basal metabolic rate, the gaseous exchange rate being increased when it is initially low, and vice versa (Table 2).

Like the sexually immature rats, the old animals did not react to 50 μg/100 g of Thyroxin given in summer, but showed some increase in metabolic rate when the same amount was given in autumn. A dose of 200 μg/100 g caused some increase in gaseous exchange rate, but it is not so marked as in rats of the medium-age group (Table 3).

To sum up, we may note first of all that seasonal variations in metabolic rate were more marked in the sexually immature than in the adult or old rats. The change in gaseous exchange caused by the injection of thyroxin depended also on the season; it was weaker in summer and more marked in winter, the difference being particularly well shown in the younger animals. The greater increase in gaseous exchange in these animals in response to thyroxin given in winter is probably adaptive, and associated with the necessary chemical heat regulation.

The sexually immature animals reacted less to thyroxin than did those of the other eight groups; No effect was produced by a dose of 50 μg/100 g, and in summer there was no response to one of 200 μg/100 g, whereas the same dose at the same season caused an increased gaseous exchange in the adults. The older animals reacted less to thyroxin, but more than did the sexually immature rats.

It is important to note that at high metabolic rates which were not due to seasonal influences there was a definite relationship between the initial rate and the response to thyroxin. When the initial rate was high, the response to thyroxin was less marked (Table 4); in many animals there might be even a paradoxical effect, when the absorption of oxygen was reduced. This phenomenon has been reported previously [4, 5].

SUMMARY

Seasonal variations of the BMR were established in rats; they were more pronounced in sexually immature than in adult or old animals. The sexually immature rats reacted less to thyroxin than did the adult or old animals. The reaction to thyroxin was greater in winter. In a number of experiments the response was diminished or even paradoxical when the initial metabolic rate was high.

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