

Oxygen Consumption in the Rat During Prolonged, Acute Starvation. (22698)

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The oxygen consumption of animals(1,2) and humans(1,2,3) is known to be depressed by starvation. There is also ample evidence that atrophic changes occur in the thyroid gland(1,4) and that histological and histochemical alterations appear in the anterior pituitary gland during inanition(1,4). These changes are assumed to be the explanation for the depression in oxygen consumption during starvation. It is, however, entirely probable that such changes are secondary to alterations of peripheral cellular metabolism.

The latter hypothesis was tested in hypothyroid, euthyroid and hyperthyroid rats subjected to prolonged, acute starvation.

Methods and materials. All animals were young, mature female rats of the Holtzman Farm weighing between 200-250 g. Thyroidectomy was performed under sodium pentobarbital (nembutal, 30 mg/kg I.P.). The soft tissues of the necks of random experimental animals were removed *en bloc*, sectioned serially and examined histologically for evaluation of completeness of surgical ablation of the gland. Animals were used 5 to 6 weeks after thyroidectomy. Hyperthyroid animals were prepared by subcutaneous, daily injection of 10 γ of 3-5-3' triiodothyronine.* Injections were begun 3 days prior to the commencement of starvation. Starvation was instituted by removal of food from the cages at 9:00 a. m. of the day on which the experiment was begun. At noon, the rats were weighed on a triple beam balance to the nearest 0.5 g. which was taken as the initial weight. Animals were weighed approximately the same time each day thereafter. After removal of food (Purina Laboratory Chow) the animals received water *ad libitum* but no food. All animals were housed in individual

TABLE I. Oxygen Consumption in the Normal, Thyroidectomized and Triiodothyronine Treated Rat.

Treatment	No. of animals	O ₂ *	S.D.†
Normal	52	6.63	.43
Thyroidectomized	6	5.20	.51
Triiodothyronine	11	8.10	.86

* O₂ = Oxygen consumption in liters/m²/hr.

† S.D. = Stand. dev. of mean.

Triiodothyronine was given for 3 days (10 γ /day subcut.) and oxygen consumption measured on 4th day. Animals were without food for 4 hr.

cages and kept in an airconditioned room (about 75-80°F.) Oxygen consumption was measured by a method described by Grad(5). At least three 15-minute determinations were averaged to establish each oxygen consumption point reported. The formula used to express the oxygen consumption is: Liters/m²/hr = $\frac{11.2 \times (\text{wt}^2)}{100}$ where weight is in kg and the figures corrected to standard temperature only.

Results. Determinations of oxygen consumption in a series of 52 normal animals resulted in a mean value of 6.63 ± 0.43 liter/m²/hr. A comparison of the oxygen consumption of normal, thyroidectomized and triiodothyronine treated rats on day zero (starting day of starvation) is shown in Table I.

Fig. 1 shows the daily oxygen consumption course of the starving rats in each treatment group. Because of space and time limitations it was impossible to measure each animal's oxygen consumption daily. Table II indicates number of animals used in determining each point of the graph. There was no selection of animals to be tested on any given day. No observation has been deleted from this report. The original size of the groups in the experiment was: 11 intact, 11 triiodothyronine treated animals and 12 thyroidectomized animals.

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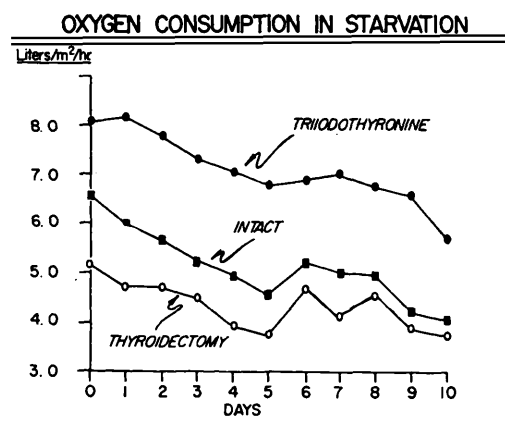


FIG. 1. Oxygen consumption during starvation of female rats. Triiodothyronine was given subcut. each day in the amount of 10 μ g and was started 3 days prior to the commencement of starvation. Thyroidectomized animals were prepared surgically and allowed 5-6 wk to develop hypothyroidism.

It will be noted that there is a decrease in oxygen consumption in all 3 groups subjected to progressive starvation. The decrement seems absolutely greater in the normal than in the triiodothyronine treated or in the thyroidectomized groups. The thyroidectomized group shows the least decline in oxygen consumption during acute starvation. In the triiodothyronine treated and thyroidectomized groups there seems to be a relative plateau reached at about the 4th day and maintained until about the 9th day. The triiodothyronine group showed a considerable mortality by this time (commencing on the 6th day of starvation), and the experiment was terminated on the 10th day of starvation (which is about 0.5 day longer than the mean survival time for intact starving rats in our laboratory; range 9 to 11.5 days). The thyroidectomized animals live 2 to 2½ times as long as the intact, starving animals.

There seems to be a marked similarity between the triiodothyronine treated and thyroidectomized curves, while the curve of the intact starving rats deviates somewhat from their general configuration by a more sustained and steeper oxygen consumption fall.

TABLE II. Number of Animals Determining Each Point on Graphs of Fig. 1.

Treatment	Day										
	0	1	2	3	4	5	6	7	8	9	10
Triiodothyronine	11	10	9	10	10	2	2	8	8	7	2
Intact	52	10	5	9	8	2	3	5	8	4	3
Thyroidectomized	6	5	8	3	5	2	1	5	5	3	3

Discussion. It is demonstrated that starvation is capable of reducing the oxygen consumption of the female rat independently of thyroid activity. This decrement in oxygen consumption is apparent in rats in which the thyroid gland is absent, as well as in animals rendered hyperthyroid by administration of 10 gamma of triiodothyronine per day.

It should be pointed out that administration of a constant daily amount of triiodothyronine to the starving rat amounts to an increasing daily dose when calculated on the basis of dose to body weight.

Whether this depression in oxygen consumption is due to loss of specific dynamic action of food, lack of sufficient available substrate at the cellular level, or other causes, can not be answered by the present experiment. Investigation of these various possibilities is in process.

Summary. Hypothyroid, hyperthyroid and euthyroid rats were subjected to acute starvation to extremis. Their oxygen consumption was measured daily. All groups showed an approximately equivalent early depression of oxygen consumption which is independent of the absolute level of the initial oxygen consumption.

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