THE EFFECT OF CALORIC RESTRICTION ON TESTICULAR HYPERTROPHY FOLLOWING HEMICASTRATION IN THE RAT

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Hemicastration in the rat is followed by hypertrophy of the remaining gonad (Heller, Heller & Sevringhaus, 1942), presumably as a result of increased pituitary secretion of gonadotrophins (Benson, Sorrentino & Evens, 1969). Howland (1972) recently demonstrated that caloric restriction interfered with ovarian hypertrophy and speculated that this was due to a decreased level of hypothalamic releasing factors. The present study was undertaken to determine if caloric restriction affected gonadal hypertrophy in the male as in the female.

Immature Sprague–Dawley male rats, weighing 35 to 40 g, were used since the mature male does not respond with gonadal hypertrophy when hemicastrated (Means & Hall, 1967). For comparison with the results obtained by Howland (1972), adult female rats weighing 160 to 180 g were used, but for comparison with the males, an immature female was used. Both sexes were hemicastrated by removing the right gonad. Within 24 hr of the operation, a food restriction of 50% was imposed and continued for 14 days; the animals were housed individually, the food intake of the intact and hemicastrated controls was measured daily and the experimental animals were fed 50% of these amounts. On the 15th day after the operation, the animals were killed and the left gonads from both the intact and hemicastrate rats were removed and weighed. Although different methods of observation from those of Howland (1972) were used, a 50% caloric restriction in the adult female prevented the ovarian compensatory hypertrophy; in the immature female, the hypertrophy was curtailed considerably. In the immature male rat, however, the gonadal hypertrophy was not affected (Table 1).

Since the hemicastrated male showed gonadal hypertrophy when fed a restricted diet for 2 weeks, a preoperative period of dieting was also studied. Immature male rats were allocated to two groups. Those in one group were restricted in caloric intake 10 days before hemicastration and, in the other group, at the time of operation. In both groups, the restriction was continued for another 14 days. The experimental animals were compared to intact rats having similar dietary regimens (Table 2).

At the time of the operation, the rats were 10 days older than those in the first experiment, which would account for the fact that the fully fed rats showed little or no gonadal hypertrophy. In those on a restricted intake for 14 and 24

Table 1. The effect of caloric restriction on gonadal hypertrophy in male and female rats

Treatment	Intact			Hemicastrated				Difference in gonad wt (mg)†
	No. of rats	Body wt (g)	Gonad wt (mg)	No. of rats	Body wt (g)	Gonad wt (mg)	% Hypertrophy	
Adult female Control 50% RD	5	221.2 ± 5.4	44.8 ± 1.8	5	219.3 ± 10.1	65.9 ± 10.1	47.1	21.1
	5	165.2 ± 2.5	29.0 ± 3.8	5	143.0 ± 8.0	29.5 ± 6.4	1.7	0.5
Immature female Control 50% RD	10	103.3 ± 4.9	16.2 ± 2.2	10	107.5 ± 3.1	26.3 ± 3.6*	62.6	10.1
	9	58.3 ± 0.9	9.3 ± 0.6	9	67.0 ± 1.1	11.9 ± 0.8**	22.8	2.6
Immature male Control 50% RD	5	103.5 ± 4.8	720.0 ± 28.0	5	97.5 ± 5.0	868.8 ± 42.3*	20.7	148.8
	5	53.8 ± 4.6	261.5 ± 51.4	5	54.6 ± 1.5	411.0 ± 15.1**	56.8	149.5

RD = restricted diet. Body and gonad weights expressed as means ± S.E.

$$\% \text{ hypertrophy} = \frac{\text{hemicastrate gonad wt} - \text{intact gonad wt}}{\text{intact gonad wt}}$$

* $P < 0.05$ versus intact rat with similar treatment.** $P < 0.02$ versus intact rat with similar treatment.

† Between intact and hemicastrated rats.

Table 2. The effect on gonadal hypertrophy in rats of caloric restriction 10 days before, and 14 days after, hemicastration

Treatment	Intact			Hemicastrated				Difference in testis wt (mg)†
	No. of rats	Body wt (g)	Testis wt (mg)	No. of rats	Body wt (g)	Testis wt (mg)	% Hypertrophy	
Control	5	176.2 ± 3.3	917.5 ± 22.6	5	155.3 ± 10.1	971.8 ± 48.0	5.9	54.3
50% RD (14 days)	5	111.9 ± 1.8	781.7 ± 20.3	5	105.1 ± 10.1	886.2 ± 18.5**	13.4	104.5
50% RD (24 days)	5	94.3 ± 5.0	615.0 ± 65.7	5	105.3 ± 1.6	824.8 ± 23.3*	34.1	210.8

RD = restricted diet. Body and gonad weights expressed as means ± S.E.

* $P < 0.05$ versus intact rat with similar treatment.** $P < 0.01$ versus intact rat with similar treatment.

† Between intact and hemicastrated rats.

Table 3. The effect of hemicastration and caloric restriction on serum FSH levels in rats

Treatment	Intact			Hemicastrated					Difference in testis wt (mg)†
	No. of rats	Body wt (g)	Testis wt (mg)	Serum FSH (ng/ml)	No. of rats	Body wt (g)	Testis wt (mg)	Serum FSH (ng/ml)	% Hypertrophy
Control	10	131.2 ± 2.7	601.2 ± 27.3	353.0 ± 14.1	10	140.2 ± 3.9	684.5 ± 38.2	465.4 ± 27.2**	13.9
50% RD	9	81.3 ± 1.7	403.2 ± 17.9	312.8 ± 31.9	6	81.4 ± 1.3	564.0 ± 28.1	625.0 ± 39.5***†	39.9
									83.3
									160.8

RD = restricted diet. Body and gonad weights and serum FSH levels expressed as means ± S.E.

** $P < 0.01$ versus intact rats with similar treatment.*** $P < 0.001$ versus intact rats with similar treatment.† $P < 0.01$ versus fully fed hemicastrates.

‡ Between intact and hemicastrated rats.

days, the growth of the testis in the hemicastrates exceeded the similarly fed intact controls by 13 and 34%, respectively. The weight change in both instances was statistically significant. Thus, caloric restriction in the hemicastrated immature rat stimulated postoperative gonadal growth beyond that obtained in fully fed animals.

In a third experiment, similar to the first, the serum FSH levels were determined by radioimmunoassay (Greenwood, Hunter & Glover, 1963; Berson, Yallow, Glick & Roth, 1964). The hemicastrated rats of both groups had serum FSH levels which were significantly greater than their intact controls, and the increase was significantly greater when the diet was limited (Table 3).

Root & Russ (1972) also found an increased serum FSH level in adult and immature starved male rats following castration, and suggested that the higher concentration of FSH might be associated with lowered plasma volume as a result of underfeeding. Both in their experiment and ours, however, the lowered volume of the intact underfed rat did not increase the FSH levels, nor did a decreased amount of testicular tissue, also found in the underfed rat, have any effect. The evidence implied that the greater FSH concentrations were the result of increased secretions of the hormone following castration (Root & Russ, 1972) or hemicastration and further augmented by a decreased feed intake.

It was notable that the increased gonadal growth was associated with the higher levels of FSH, a hormone which has been reported to stimulate the weight of immature rat testes (Lostroh, 1969).

The response of the immature male rat was different from that of the adult and immature female rat when subjected to a 50% restricted caloric intake. Instead of the imposed diet interfering with gonadal hypertrophy, as in the female, the immature male responded with an increased percentage testis growth over and above that of the fully fed hemicastrate. In fact, the longer the diet was imposed on the hemicastrate, the greater was the percentage of growth. In both hemicastrate groups, the degree of hypertrophy was accompanied by a commensurate increase in plasma FSH concentration which may be responsible for the testicular hypertrophy. The reason for this response to restricted feed intake in the hemicastrated male rat was not clear.

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