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Puberty Onset in Males and Females Fed a High Fat Diet (41062)

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Abstract. Balanopreputial separation and vaginal opening and ovulation were observed in males and females as markers of sexual maturation. Animals fed a high fat diet containing the same protein content as a low fat diet showed normal pubertal onset. Both males and females fed a diet reduced in protein consisting of a mixture of dry chow and Crisco in a ratio of 2:1 showed delayed pubertal onset although their total daily caloric intake was similar to the animals fed a high fat diet with adequate protein. It is concluded that puberty onset in both males and females is sensitive to changes in dietary intake.

In the course of some studies on the control of puberty onset, we elected to use a high fat diet to elicit precocious vaginal opening and ovulation. Such diets have been reported to advance puberty (1, 2). Since we had previously used a two parts dry chow: one part Crisco mixture to study feeding behavior in prepubertal rats (3), we tried the same diet to induce pubertal changes and discovered that puberty was actually delayed by this dietary regimen. One goal of this project was to test whether a recently rediscovered marker of male sexual maturation, balanopreputial separation (4), would also be delayed by a condition that delays puberty in females. A secondary purpose was to determine whether the delay was due to a reduction in protein intake associated with the high fat Crisco diet since protein deficiency has been cited as a cause of puberty delay in females (5).

Materials and Methods. Sprague–Dawley derived rats were obtained from Sasco Laboratories at 21 days of age and housed in individual metabolic cages. One group were given powdered dry chow (Lab Chows, certified rodent chow No. 5002). This chow contains by 20% protein, 4.5% fat, 49.8% carbohydrate (from mixed sources), 2.5% minerals, and the remainder crude fiber and ash. A second group received dry chow mixed 2:1 with Crisco. The resultant high fat chow contains 35% fat and 15% protein. The third and fourth groups received powdered low fat and high fat Teklad diets, the compositions of which are shown in Table I. The food was placed in small metal dishes in each cage and left there for 24 hr. Food consumption was measured by weighing the food left in the dishes and spillage that accumulated on waxed paper beneath the cages. Very little spillage of the diets occurred, particularly of the high fat diet because the food dishes had partially covered, curved edges.

The animals were weighed daily at 0800–0900 hr and the daily food consumption, water consumption, and body weight gain were recorded. At the conclusion of the experiment, the daily records of individual animals were compared by considering the day of balanopreputial separation or vaginal opening as Day 0 and plotting the data as days before and after these events.

The data were analyzed by Duncan's multiple range test. Results are given as mean ± SEM, 10 rats/group.

Results. The Teklad diets, which were selected to resemble the composition of diets reported to advance puberty onset in females (1, 2), failed to alter either balanopreputial separation or vaginal opening and ovulation in these animals (Table II). Despite the fact that the diets differed in fat content, both groups consumed the same daily amounts of protein and the same total caloric intake. Mean food intake increased from 9.4 ± 0.6 g at 15 days before balanopreputial separation in males on the low fat diet to 21.1 ± 1.2 g 5 days after this event. No significant change occurred in the 5 days preceding balanopreputial separation. Protein intake also increased from 1.9 ± 0.1 to 4.2 ± 0.2 g during the same period and

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TABLE I. PERCENTAGE OF TOTAL CALORIES CONTRIBUTED BY VARIOUS DIET COMPONENTS

Components	Teklad low fat (TD 79092)	Teklad high fat (TD 79381)
Protein	19.3	19.3
Corn starch	14.4	14.4
Sucrose	53.4	16.9
Corn oil	12.0	48.5
Crude fiber	0	0
Mineral and vitamin mix	0.9	0.9

caloric intake rose from 35.3 ± 2.2 to 79.3 ± 4.5 kcal/day. Males on the high fat Teklad diet consumed 2.4 ± 0.2 g of protein and 45.5 kcal/day 15 days before balanopreputial separation and 4.4 ± 0.2 g of protein and 81.2 kcal/day 5 days after balanopreputial separation. Average intake increased steadily during this period, with no sudden changes. The amount of food consumed per day in grams was reduced, however ($P < 0.01$), beginning 10–15 days before puberty onset. Although diarrhea did not occur, the animals may have found the diets less palatable.

Animals fed a mixture of dry chow and Crisco in a ratio of 2:1 showed a significant delay in puberty onset (Table II). In addition to consuming less food per day, the animals on the high fat diet obtained less protein than controls but did not consistently differ from controls with respect to daily caloric intake (Table III).

Females responded to the diets in the same way as males and the data are, therefore, not included.

Both sets of high and low fat fed animals gained weight at a similar rate during the prepubertal period.

Discussion. It has been shown before that balanopreputial separation can serve as a puberty marker in males and that it correlates well with changing plasma testosterone levels (4). Using this index of maturation, we have shown here that a factor that influences puberty onset in females also affects maturation in males. A high fat diet deficient in protein delayed puberty significantly in both sexes. A different high fat diet that was not deficient in protein did not affect puberty onset in this experiment although similar diets have been reported to advance the time of puberty onset in females in other experiments (1, 2). In those cases as well as in this study, fat was substituted isocalorically for carbohydrate, although, in the other two cases, starch alone was used as carbohydrate while in the present study both starch and sucrose were used. Perhaps this accounts for the difference in the two sets of results. The importance of protein calorie deficiency as well as amino acid deficiency in delaying puberty onset has been reported before in females (5) and in males (6). It is possible, of course, that other dilutions of the dry chow diet by adding fat might account for the differences. Corn starch, crude fiber and the vitamin mix were also reduced in the chow:Crisco mix.

The results support the hypothesis that the underlying pubertal process in males and females is responsive to similar modifying conditions. This is suggested by previous observations on the changes in pro-

TABLE II. EFFECT OF HIGH FAT DIETS ON PUBERTAL ONSET IN MALES AND FEMALES

Diet	Balanopreputial separation: Age in days	Balanopreputial separation: Body weight in gm	Vaginal opening: Age in days	Vaginal opening: Body weight in g	Ovulation Age in days
Dry chow (4.5%)	35.5 ± 0.5	142.0 ± 2.7	32.4 ± 1.0	106.9 ± 5.2	33.3 ± 1.2
Dry chow:Crisco [2:1] (35%)	40.4 ± 1.3*	161.0 ± 8.9	40.9 ± 1.5*	124.3 ± 7.0	41.2 ± 1.4*
Teklad (low fat, 5%)	30.9 ± 1.1	134.7 ± 4.6	31.9 ± 0.9	98.0 ± 4.0	32.9 ± 1.1
Teklad (high fat, 25%)	31.0 ± 1.5	138.2 ± 9.9	30.1 ± 0.9	90.9 ± 4.6	30.9 ± 0.7

* Significantly different from low fat-fed controls, P 0.01; 10 rats/group; percentage fat shown in parentheses.

TABLE III. PROTEIN AND CALORIC INTAKE WITH REFERENCE TO THE TIME OF BALANOPREPUTIAL SEPARATION

Dry chow (low fat)	Food intake in g	Protein intake in g[a]	Caloric intake in kcal[b]
−10[c]	*9.6 ± 0.4*	*2.2 ± 0.1*	31.7 ± 1.3
−5	*14.3 ± 0.6*	*3.3 ± 0.2*	*47.2 ± 1.9*
−1	*17.0 ± 0.7*	*3.9 ± 0.2*	56.1 ± 2.3
BPS (35.5 ± 0.5 days)	*18.1 ± 0.5*	*4.2 ± 0.1*	59.7 ± 1.7
+5	*20.9 ± 0.6*	*4.8 ± 0.1*	68.9 ± 1.9
Chow:Crisco 2:1 (high fat)			
−15	6.1 ± 0.9	0.9 ± 0.1	32.3 ± 4.7
−10	8.3 ± 0.4	1.2 ± 0.1	43.9 ± 2.1
−5	10.1 ± 0.4	1.5 ± 0.1	53.5 ± 2.1
−1	11.4 ± 0.3	1.7 ± 0.0	60.4 ± 15.9
BPS (40.4 ± 1.3 days)	11.3 ± 0.5	1.7 ± 0.1	59.9 ± 2.7
+5	12.4 ± 0.7	1.9 ± 0.1	65.7 ± 3.7

[a] Calculated as 0.5 g/g for high fat and 0.23 g/g for dry chow.
[b] Calculated as 5.3 kcal/g for high fat and 3.3 kcal/g for dry chow.
[c] 10 rats/group, BPS = balanopreputial separation; numbers refer to days before and after BPS (mean ± SEM for BPS in days is indicated in parentheses); italicized values different ($P < 0.01$) from high fat group.

lactin secretion in the prepubertal period (7) and by the present data showing that dietary factors affect puberty, as defined by a sex steroid sensitive marker, in similar ways in males and females.

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