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FATTY ACID COMPOSITION OF BROWN
FAT IN THE RAT

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It is known that brown adipose tissue plays an important role in the ~~local oxidation~~ thermogenic response to cold by the local oxidation of triglycerides after lipolysis¹⁻⁵. On the other hand, the main function of white adipose tissue is the synthesis and storage of triglycerides and the release of free fatty acids into the blood stream when required. Thus, HEIM and KELLERMAYER⁶ claimed that brown fat is mobilized in response to cold but not during starvation, while white fat serves as a metabolic reserve and is used during starvation.

It might be presumed that the composition of brown fat triglycerides is temperature-dependent and relates to thermogenesis. Several reports appeared on the fatty acid composition of brown fat in the rat^{6,7}, mouse^{8,9}, newborn rabbit¹⁰, newborn human¹⁰ and bat^{11,12}. According to WILLIAMS and PLATTNER⁷, cold acclimation did not induce any significant increase in the relative level of unsaturation in brown fat of the rat and hamster, while white fat showed an increase in unsaturation under the same conditions. In their experiments on rats which were exposed to cold for 8 to 9 weeks, changes in the fatty acid composition in early phases of cold exposure were not observed. Since the fat content of brown adipose tissue is known to decrease very rapidly after exposure to cold, the proportion of fatty acid components may change during a relatively short period of cold exposure. The present study was attempted to analyze the fatty acids in brown, as well as in white, fat in rats exposed to cold. This report also dealt with sex differences and the effect of starvation on the composition of brown fat.

METHODS

Wistar rats of both sexes, 2 to 3 months in age, were used in this study. They were housed at a constant temperature of 20°C and received rat biscuit and water *ad libitum*. Cold-exposed rats were kept in individual wire cages at 0°C for 3 and 24 hours and at 5°C for 1 and 4 weeks. Gonadectomy was performed under Nembutal anesthesia and the rat were used for experiments 2 weeks after the surgery.

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The animals were sacrificed by decapitation. Interscapular brown adipose tissue, as well as epididymal or parametrial adipose tissue from male or female rats, respectively, were removed. The brown adipose tissue was trimmed with scissors to remove all white fat. The total lipids were extracted by the method of FOLCH et al.¹³⁾ and dry weight and water content were determined.

For the analysis of fatty acid composition, the tissue was extracted with chloroform-methanol (2:1), glycerides were saponified with 0.3N KOH in methanol, and fatty acids were converted to their methyl ester derivatives by treatment with 2% sulfuric acid in methanol. A Parkin-Elmer gas chromatographic instrument (Model 811) was used for the analysis of fatty acid methyl ester mixture. Separation of the methyl esters was achieved on a 12-foot glass column packed with diethylene glycol succinate polyester in Diabase A and operated at 180°C, using nitrogen as the carrier gas at a flow rate of 30 ml per minute.

RESULTS

1. Sex differences in the fatty acid composition of brown fat. TABLE 1 shows.

TABLE 1.
Sex differences in the fatty acid composition (in percentage)
of adipose tissues of the rat.

No. of rats	Brown fat		White fat	
	Male	Female	Male	Female
	10	9	10	8
C 12:0	0.2± .02	0.1± .01	0.1± .03	0.1± .03
P		<0.001		
C 14:0	3.4± .17	2.3± .33	1.8± .11	1.3± .09
P		<0.001		<0.01
C 14:1	0.4± .04	0.4± .05	0.6± .05	0.5± .05
C 16:0	29.2± .64	22.8± .91	27.0± .58	23.6± .42
P		<0.001		<0.001
C 16:1	5.9± .38	3.2± .36	6.5± .43	5.9± .65
P		<0.001		
C 18:0	7.9± .35	9.7± .29	3.3± .24	3.3± .29
P		<0.01		
C 18:1	31.5± .71	31.1± .96	31.6± .73	36.2± .64
P				<0.001
C 18:2	19.9±1.53	28.2±1.33	27.0± .79	26.6± .80
P		<0.001		
C 18:3	1.6± .18	2.4± .26	2.2± .28	2.6± .45
P		<0.02		
Total saturated	40.7±1.10	34.6±1.36	32.2± .64	28.2± .51
P		<0.01		<0.001

Mean± S. E.

the distribution of fatty acid components of rat brown and white adipose tissues. The figures on brown fat were not much different from those reported by others in the rat^{6,7)} and mouse^{8,9)}. Oleic (C 18:1), linoleic (C 18:2) and palmitic (C 16:0) acids were found to account for more than 80 percent of the total fatty acids in the brown fat. It can be seen, however, in the table that the proportion of linoleic acid was markedly higher and that of palmitic acid considerably less in female rats than in male ones, while

TABLE 2.
Effect of gonadectomy on the fatty acid composition of
interscapular brown adipose tissue of the rat.

	Female		Male	
	Control	Gonadex*	Control	Gonadex*
No. of rats	9	8	10	8
Body weight, g	230	235	300	315
Brown fat, mg/100 g	74±2	119±5	84±11	72±5
P		<0.001		
Dry matter, %	16.9±.80	12.5±.50	10.4±.72	13.2±.64
P		<0.001		<0.02
Fat, %	31.4±1.54	41.2±1.64	48.1±2.58	39.2±2.70
P		<0.001		<0.05
Water, %	51.7±1.58	46.3±1.46	41.5±2.00	47.7±2.57
P		<0.05		
C 12:0	0.1±.01	0.1±.02	0.2±.02	0.1±.01
P				<0.001
C 14:0	2.3±.33	3.0±.26	3.4±.17	3.1±.21
P		<0.02		
C 14:1	0.4±.05	0.3±.07	0.4±.04	0.3±.04
C 16:0	22.8±.91	25.1±1.24	29.2±.64	25.1±.93
P		<0.05		<0.01
C 16:1	3.2±.36	3.7±.29	5.9±.38	4.7±.41
P				<0.05
C 18:0	9.7±.29	11.3±.65	7.9±.35	10.9±.44
P		<0.05		<0.001
C 18:1	31.1±.96	28.2±.60	31.5±.71	27.8±.78
P				<0.01
C 18:2	28.2±1.33	26.4±1.25	19.9±1.53	26.0±1.18
P				<0.01
C 18:3	2.4±.26	1.9±.18	1.6±.18	2.1±.28
Total saturated	34.6±1.36	39.5±1.48	40.7±1.10	39.1±.62
P		<0.05		

* 2 weeks after the operation.

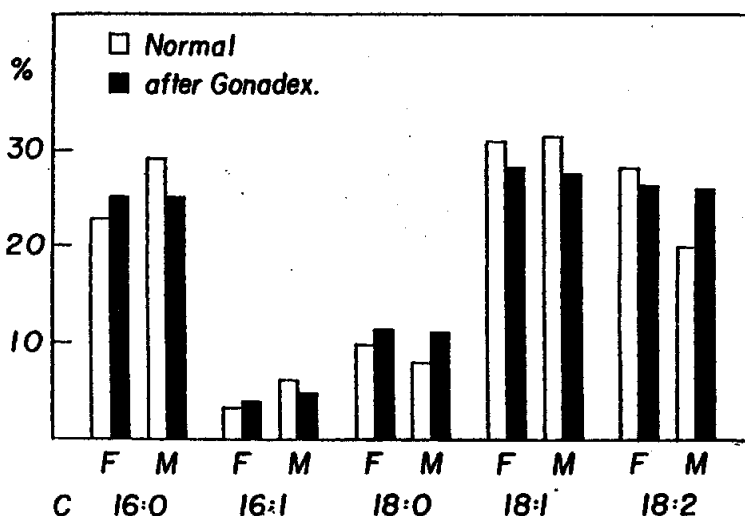


FIG. 1. Sex differences of fatty acid composition of brown fat and the effect of gonadectomy on the composition.

that of oleic acid was at the same level in both sexes. Although differences were small, the values of palmitoleic, myristic and lauric acids were less in females as compared with those of males. Percentages of total saturated fatty acids were 40.7 percent in males and 34.6 percent in females, the difference being highly significant. When total mono-unsaturated fatty acids were compared, the value was somewhat higher in males, while the percentage of total poly-unsaturated fatty acids was markedly higher in females, amounting to 30.6 percent, than in males (21.5 percent).

2. *Sex differences in the fatty acid composition of white fat.* White fat used in the present study was parametrial fat for female rats and epididymal fat for male rats. However, sex differences in the fatty acid composition were rather small (TABLE 1). Significant differences observed were a higher proportion of palmitic acid and a lesser proportion of oleic acid in males in comparison with the respective values in females. A small difference in myristic acid was also noticed, but the difference was essentially negligible. Total saturated fatty acids were significantly less in females (28.2%) than in males (32.2%), the difference being mostly due to a higher percentage of mono-unsaturated fatty acids in females (42.6%) than in males (38.7%).

3. *Effect of gonadectomy on the fatty acid composition.* The sex differences observed above might be produced by hormonal differences. To elucidate possible participation of sex hormones in the differences of fatty acid composition, gonadectomy was performed in rats of both sexes. Two weeks

after the surgery the fatty acids in brown and white adipose tissues were analyzed.

As shown in TABLE 2, in female brown fat the proportion of palmitic, stearic and myristic acids increased significantly after gonadectomy, while in male brown fat palmitic and oleic acids decreased. Small decreases in palmitoleic and lauric acids were also observed in males. Moreover, a marked increase in linoleic acid and a less increase in stearic acid were found in male fat after gonadectomy. It was of particular interest that the fatty acid patterns of brown fat after gonadectomy were almost the same in both sexes (FIG. 1).

The effect of gonadectomy on the fatty acids in white fat was rather small (TABLE 3). In male rats the only acid to show a significant change was

TABLE 3.
Effect of gonadectomy on the fatty acid composition
of white fat of the rat.

	Female		Male	
	Control	Gonadex*	Control	Gonadex*
No. of rats	9	8	10	8
Body weight, g	230	235	300	315
Dry matter, %	1.6 ± .13	1.8 ± .36	1.4 ± .09	1.4 ± .07
Fat, %	79.6 ± 2.45	79.8 ± 2.08	85.7 ± .70	87.1 ± .78
Water, %	18.8 ± 2.54	18.4 ± 1.76	12.9 ± .86	11.9 ± .68
C 12:0	0.1 ± .03	0.1 ± .01	0.1 ± .03	0.2 ± .05
C 14:0	1.3 ± .09	1.7 ± .15	1.8 ± .11	2.2 ± .19
P	<0.05			
C 14:1	0.5 ± .05	0.6 ± .05	0.6 ± .05	0.7 ± .05
C 16:0	23.6 ± .42	23.7 ± .59	27.0 ± .58	23.7 ± .71
P			<0.001	
C 16:1	5.9 ± .65	6.5 ± .33	6.5 ± .43	7.8 ± .55
C 18:0	3.3 ± .29	3.6 ± .45	3.3 ± .24	2.9 ± .28
C 18:1	36.2 ± .64	34.8 ± .65	31.6 ± .73	30.3 ± .58
C 18:2	26.6 ± .80	27.0 ± .65	27.0 ± .79	29.8 ± 1.14
C 18:3	2.6 ± .45	2.0 ± .20	2.2 ± .28	2.6 ± .12
Total saturated	28.2 ± .51	29.1 ± .66	32.2 ± .64	28.9 ± .90
P			<0.01	

Mean ± S.E.

* 2 weeks after the operation.

palmitic acid, which decreased after gonadectomy. In female rats no essential alteration was observed, except a small increase in myristic acid.

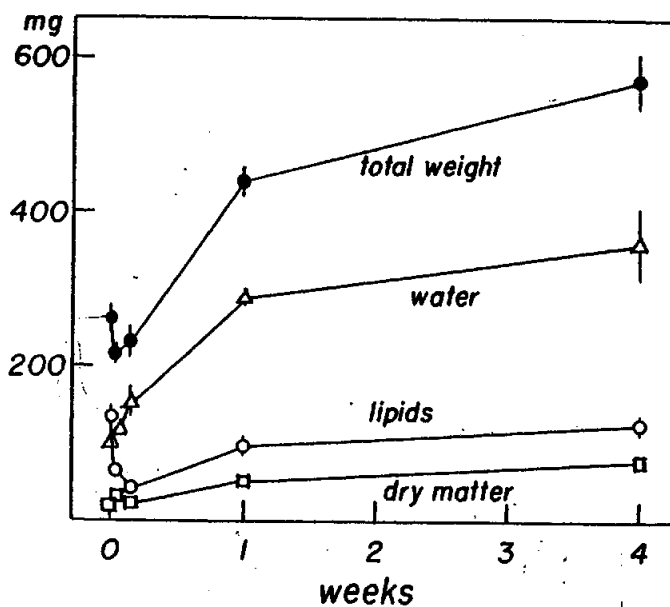


FIG. 2. Effect of cold exposure on the total weight and water, lipid and fat-free dry matter content of interscapular brown fat in male rats.

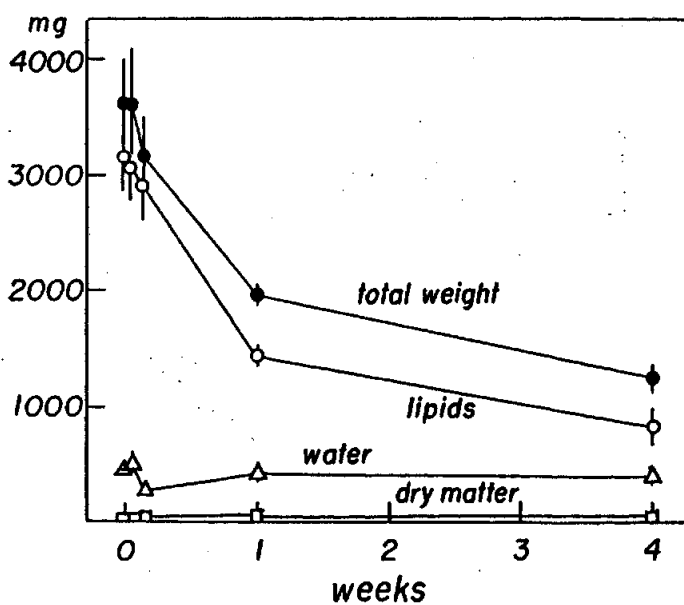


FIG. 3. Effect of cold exposure on the total weight and water, lipid and fat-free dry matter content of epididymal white fat in male rats.

4. *Effect of cold exposure on the fatty acid composition of brown fat.* Male rats were exposed to cold at 0°C for 3 and 24 hours and at 5°C for 1 and 4 weeks. Exposure to cold caused an initial decrease in the weight of brown adipose tissue, which is mostly ascribed to a decrease in fat content. However, the weight increased 40 percent over the control level after 1 week and 53 percent after 4 weeks, the increased weight was considered to be due to an increase in cytoplasmic constituents. The patterns of changes in lipids, water and fat-free dry mass are illustrated in FIG. 2.

As shown in TABLE 4, marked changes in the proportion of fatty acids in brown fat were produced by cold exposure. Oleic acid decreased progres-

TABLE 4.
Effect of cold exposure on the fatty acid composition of
interscapular brown adipose tissue in the male rat.

	Control	Cold exposure			
		0° 3hr	0° 24 hr	5° 1 w	5° 4 w
No. of rats	10	9	10	7	8
Body weight, g	300	310	300	250	295
BAT weight, mg	266	217	231	440	572
Fat, %	48±3	29±3	16±1	21±1	22±3
P		<0.001	<0.001	<0.001	<0.001
C 12:0	0.2±.02	0.1±.02	0.1±.01	0.1±.01	0.1±.02
P		<0.01	<0.001	<0.001	<0.01
C 14:0	3.4±.17	2.8±.13	1.5±.08	1.7±.10	2.2±.10
P		<0.02	<0.001	<0.001	<0.001
C 14:1	0.4±.04	0.4±.05	0.3±.05	0.3±.05	0.3±.03
C 16:0	29.2±.64	27.5±.85	26.1±.66	26.7±.63	28.6±1.35
P			<0.01	<0.02	
C 16:1	5.9±.38	5.4±.48	4.7±.35	3.0±.23	3.9±.54
P			<0.05	<0.001	<0.001
C 18:0	7.9±.35	8.3±.36	8.3±.36	9.1±.43	11.3±.16
P				<0.05	<0.001
C 18:1	31.5±.71	31.6±1.06	30.2±.30	26.9±.67	24.4±.85
P				<0.001	<0.001
C 18:2	19.9±1.53	21.8±2.12	27.2±.58	30.1±.82	26.7±1.47
P			<0.001	<0.001	<0.01
C 18:3	1.6±.18	2.0±.21	1.6±.17	2.2±.30	2.5±.36
P					<0.05
Total saturated	40.7±1.10	38.8±.84	36.0±.58	37.5±.97	42.3±1.42
P			<0.01		

Mean ±S.E.

sively during cold exposure, while linoleic acid increased. A small but significant increase in the percentage of stearic acid was also observed. Palmitic acid was found to decrease 24 hours and 1 week after the cold, and palmitoleic acid decreased progressively in the cold. The percentage of total saturated fatty acids decreased 24 hours after the cold, but tended to increase thereafter.

5. *Effect of cold exposure on the fatty acid composition of white fat.* During cold exposure there was a progressive decrease in the weight of white adipose tissue. As seen in FIG. 3, the change in total weight is considered to be mostly due to the loss of lipids from the tissue without essential alteration in the water content and fat-free dry matter.

In white fat of rats exposed to cold rather small changes were found in the fatty acid composition (TABLE 5). The only acid, which showed a noteworthy decrease, was palmitic acid. Initial changes which might appear in

TABLE 5.
Effect of cold exposure on the fatty acid composition of
epididymal adipose tissue in the male rat.

	Control	Cold exposure			
		0° 3 hr	0° 24 hr	5° 1 w	5° 4 w
No. of rats	10	10	7	8	8
Body weight, g	300	310	290	250	295
WAT weight, mg	3632	3682	2600	1984	1251
Fat, %	86 ± .7	84 ± 2.2	83 ± 2.1	74 ± 2.4	64 ± 4.2
P				<0.001	<0.001
C 12:0	0.1 ± .03	0.2 ± .03	0.1 ± .03	0.2 ± .06	0.2 ± .04
P		<0.05			
C 14:0	1.8 ± .11	1.8 ± .11	1.7 ± .16	1.8 ± .09	2.0 ± .23
C 14:1	0.6 ± .05	0.6 ± .06	0.6 ± .07	0.5 ± .04	0.5 ± .05
C 16:0	27.0 ± .58	26.2 ± .42	27.9 ± .99	27.2 ± .68	23.9 ± 1.13
P					<0.02
C 16:1	6.5 ± .43	6.4 ± .46	7.5 ± .40	6.4 ± .35	6.5 ± .76
C 18:0	3.3 ± .24	3.0 ± .15	3.2 ± .16	3.7 ± .27	3.9 ± .34
C 18:1	31.6 ± .73	29.5 ± .35	30.6 ± .83	31.9 ± .57	30.8 ± 1.53
P		<0.05			
C 18:2	27.0 ± .79	30.0 ± .76	26.5 ± .94	26.7 ± .66	29.3 ± 1.73
P		<0.05			
C 18:3	2.2 ± .28	2.4 ± .12	1.9 ± .15	1.6 ± .11	3.0 ± .31
Total saturated	32.2 ± .64	31.2 ± .59	33.0 ± 1.08	32.9 ± .78	30.0 ± 1.47

Mean ± S.E.

oleic and linoleic acids were restored to the respective control levels after 1 week in the cold.

6. *Effect of starvation on the fatty acid composition.* Male rats were starved for 5 days with free access to water. After this period of starvation the body weight decreased 15 percent, the weight of interscapular brown adipose tissue 25 percent and that of epididymal fat pads 36 percent. The percentages of total lipids of both adipose tissues were not altered by this treatment.

The relative proportion of fatty acids is shown in TABLE 6. A decrease

TABLE 6.
Effect of starvation (for 5 days) on the fatty acid composition
of adipose tissues in the male rat.

	Brown fat		White fat	
	control	fasted	control	fasted
No. of rats	10	6	10	6
Body weight, g	300	255	300	255
Tissue weight, mg	266	189	3632	2308
Fat, %	48±2.6	55±2.7	86±.7	88±1.5
C 12:0	0.2±.02	0.2±.02	0.1±.03	0.1±.03
C 14:0	3.4±.17	2.2±.09	1.8±.11	1.7±.12
P		<0.001		
C 14:1	0.4±.04	0.5±.09	0.6±.05	0.6±.07
C 16:0	29.2±.64	22.8±1.13	27.0±.58	19.6±.69
P		<0.001		<0.001
C 16:1	5.9±.38	4.5±.58	6.5±.43	6.1±.42
C 18:0	7.9±.35	12.0±.70	3.3±.24	5.6±.37
P		<0.001		<0.001
C 18:1	31.5±.71	33.9±1.19	31.6±.73	32.8±.78
C 18:2	19.9±1.53	22.4±1.99	27.0±.79	30.0±.68
P				<0.05
C 18:3	1.6±.18	1.7±.32	2.2±.28	3.5±.21
P				<0.01
Total saturated	40.7±1.10	37.2±1.14	32.2±.64	27.0±.58
P		<0.05		<0.001

Mean ± S.E.

of palmitic acid was the most striking change and an increase in stearic acid was also found in both adipose tissues. A decrease of myristic acid was observed only in brown fat, while there was an increase of linoleic and linolenic acids in white fat. In both adipose tissues total saturated fatty

acids decreased significantly, but the change was more pronounced in white fat.

DISCUSSION

The fatty acid composition of brown fat was different to some extent from that of white fat. In male rats the proportions of saturated myristic, palmitic and stearic acids were higher and that of unsaturated linoleic acid less in the brown fat than in the white fat. In female rats saturated myristic and stearic acids were higher and unsaturated palmitoleic and oleic acids were less in the brown fat (TABLE 1). Although CHALVARDJIAN⁶⁾ reported a higher proportion of linoleic acid in rat brown fat, our result of this acid in male rats was at a similar level found in mouse brown fat by others^{8,9)}. The proportion of individual fatty acids may differ from species to species, the difference being, at least in part, dependent on diet and metabolic status of animals.

Sex differences in the fatty acid composition of human depot fat have been found by a number of investigators¹⁴⁻¹⁷⁾. It was shown that stearic acid was higher and oleic acid less in males than in females. Myristic and palmitic acids also appeared to be higher in males. Results obtained in the present study with rat white fat were similar to the patterns in human depot fat, i.e., palmitic and myristic acids were higher and oleic acid was less in male rats than in female ones. The sex differences were more pronounced in brown fat. Our results were in accord with those reported by WELLS et al.¹¹⁾, who analyzed brown fat of the bat. The only disagreement between WELLS' results and ours was in the proportion of oleic acid. The former authors showed a higher value of oleic acid in males, while we failed to find a significant difference in this acid between sexes.

The effect of sex hormones on brown fat has received little study. In the present experiments it was clearly demonstrated that the differences in the fatty acid composition of adipose tissues had completely disappeared 2 weeks after gonadectomy (FIG. 1). Surgical removal of the gonads caused significant increases in palmitic and palmitoleic acids and a decrease in linoleic acid in female brown fat; inverse changes occurred in male brown fat. Stearic acid increased and oleic acid decreased to the same levels in both sexes after gonadectomy. The results suggest that both androgen and estrogen are related to the differences found in normal rats.

It is generally accepted that the lipid stores are an important source of energy for thermoregulatory heat production in animals exposed to cold. One aspect of lipid metabolism in cold-exposed animals is desaturation of depot fat. According to FAWCETT and LYMAN¹⁸⁾, white fat from hamsters kept at 23°C had an iodine value significantly lower than animals kept at

5°C. KODAMA and PACE^{19,20} also found a greater unsaturation in white fat of cold-exposed hamsters. Similar results were presented by YOUNG and COOK²¹, MEFFERD et al.²² and WILLIAMS and PLATNER⁷ in the rat, while FAWCETT and LYMAN¹⁸ showed no significant change in saturation of depot fat of rats exposed to cold. In the present study cold exposure of rats for 4 weeks induced rather small changes in the relative proportion of the individual fatty acids of white fat. The only acid to show a significant decrease

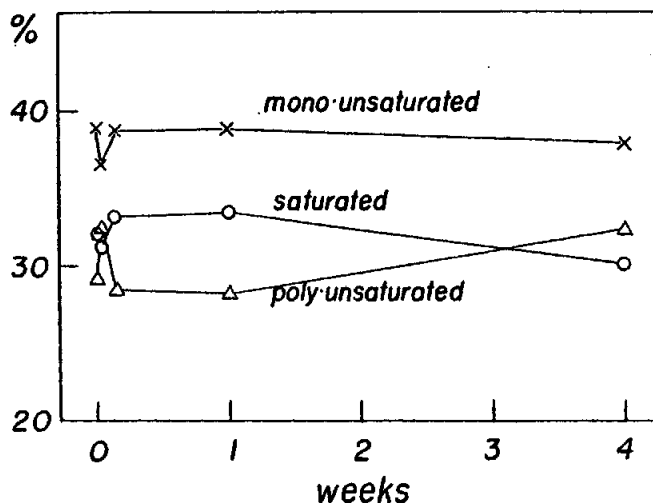


FIG. 4. Effect of cold exposure on the proportion of saturated, mono- and poly-unsaturated fatty acids in white fat of male rats.

was palmitic acid. However, as illustrated in FIG. 4, a considerable increment in the relative quantities of poly-unsaturated fatty acids was observed, indicating an increase in the degree of unsaturation of the white fat after exposure to cold.

As to the fatty acid composition of brown fat, WILLIAMS and PLATNER⁷ were unable to find a significant increase of unsaturation in rats exposed to cold. WELLS et al.¹¹ also failed to show increased level of unsaturation in the hibernating bat as compared to a non-hibernating group. However, PAULSRUD and DRYER¹² reported circum-annual rhythmic patterns of changes in the fatty acids of bat brown fat. Oleic acid levels were lower during the summer months and higher in the winter months, while levels of palmitic and linoleic acids reached maximal values in midsummer and fell significantly during the winter. The disagreement between these two reports on bat brown fat might be ascribed to the time of observations at selected points made by WELLS et al. Although WILLIAMS and PLATNER⁷ reported little change in the fatty acids of brown fat in rats exposed to cold, their experiments were made only after 8 to 9 weeks in the cold. It is quite possible

that there were changes in composition during the early phases of cold exposure, since fat content of brown fat decreases sharply during the initial stages in the cold. As already shown in TABLE 4, marked changes appeared in the relative proportion of individual fatty acids after 24 hours in the cold at 0°C when the lipid content of the tissue decreased to the minimum level of only 16% of wet tissue. During this period of cold exposure, percentage of total saturated fatty acids decreased from 40.7% to 36.0% ($P < 0.01$), but the percentage tended to return toward the control level thereafter, when the animals were kept at 5°C for 4 weeks (FIG. 5). Total mono-unsaturated fatty

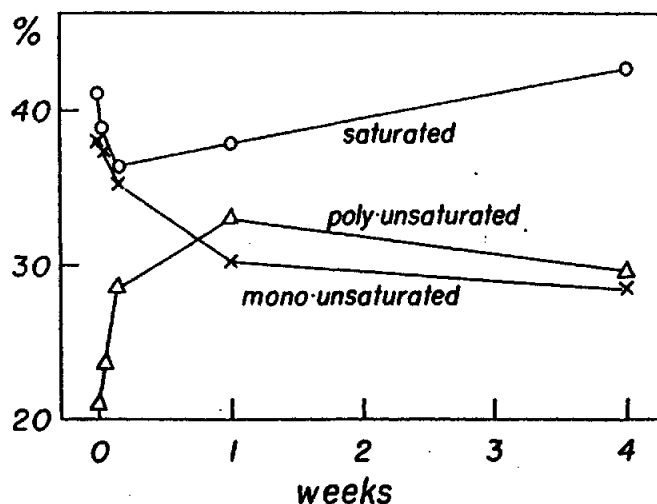


FIG. 5. Effect of cold exposure on the proportion of saturated, mono- and poly-unsaturated fatty acids in brown fat of male rats.

acids also decreased sharply during the first 24 hours in the cold at 0°C and remained at a low level by the end of this experiment, although rats were housed at 5°C. On the contrary, di- and tri-unsaturated fatty acids increased rapidly and remained at an elevated level (FIG. 5). The results indicate a marked increase in the relative unsaturation of brown fat in the early phases of cold exposure. It might be possible that after prolonged exposure to cold the degree of saturation returns to nearly control levels, as reported by WILLIAMS and PLATNER⁷, since the changes observed after 4 weeks appeared to be somewhat less than those after 1 week.

When the proportion of C-16 fatty acids was compared with that of C-18 fatty acids, an inverse relation was observed during cold exposure. The former acids decreased rapidly and the latter increased, as illustrated in FIG. 6. This fact may suggest that C-16 fatty acids are mobilized at a faster rate than C-18 fatty acids and that C-18 fatty acids are preferen-

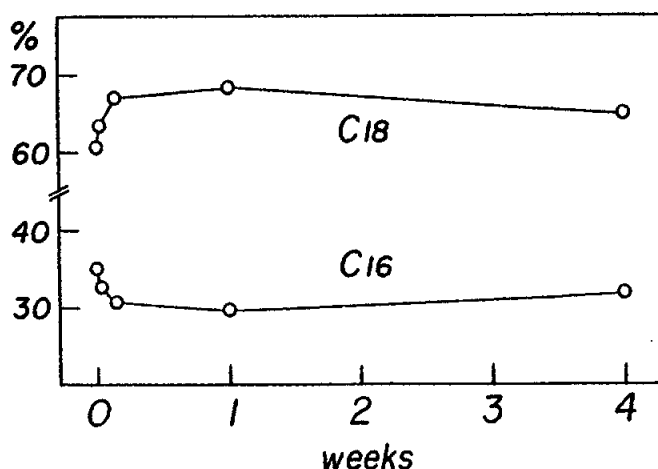


FIG. 6. Changes in C-16 and C-18 fatty acids in brown fat during cold exposure.

tially utilized for reesterification in the tissue. Further investigations are, however, needed to ascertain this possibility.

During starvation stored fat will be the main energy source and there is a reduction in the weight of adipose tissue. According to CHARVARDJIAN⁴⁰, starvation caused a relative decrease of palmitic acid and, to a less extent, of palmitoleic acid, and an increase in oleic and linoleic acids. He also found a decrease in myristic acid in brown fat and an increase in stearic acid in white fat of the rat. Our results (TABLE 6) were not much different from

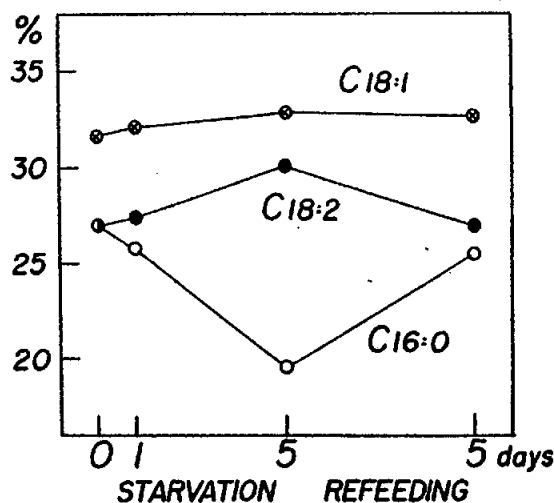


FIG. 7. Changes in the principal fatty acids in white fat during starvation and refeeding.

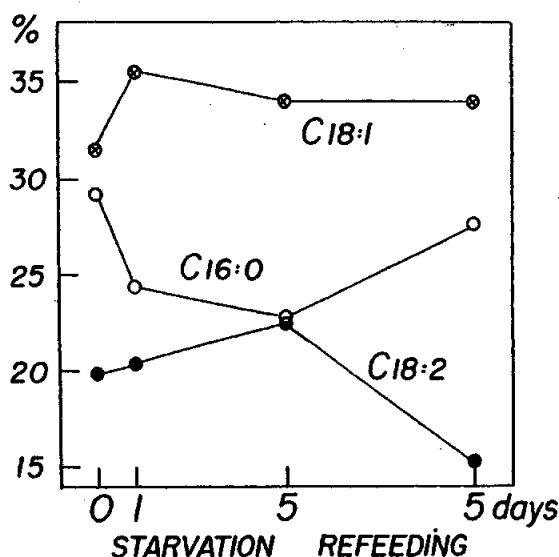


FIG. 8. Changes in the principal fatty acids in brown fat during starvation and refeeding.

the above finding by CHARVARDJIAN, although palmitoleic and oleic acids were not significantly altered by 5 days of starvation in our study. Time course patterns of changes in the principal fatty acids are shown in FIG. 7 for white fat and in FIG. 8 for brown fat. A marked decrease in palmitic acid in both adipose resulted from starvation and the fatty acid returned toward the control level after 5 days of refeeding. Thus, in the present study mobilization of lipids from brown fat was shown not only in response to cold but during starvation, this fact being different from the already mentioned concept of HEIM and KELLERMAYER⁵⁷.

SUMMARY

Fatty acid composition of brown, as well as white, fat of the rat was analyzed. Oleic, linoleic and palmitic acids accounted for more than 80 percent of the total fatty acids in brown fat. The proportion of linoleic acid was markedly higher and that of palmitic acid considerably less in the brown fat of female rats than in that of male rats. Although differences were small, palmitoleic, myristic and lauric acids were less in female brown fat. In white fat the sex differences were small. Total saturated fatty acids were significantly less in the ^{female} ~~males~~ than in the ^{males} ~~females~~ in both brown and white adipose tissues. The sex differences observed in normal rats disappeared 2 weeks after gonadectomy.

In brown fat of rats exposed to cold, oleic acid decreased progressively,

while linoleic acid and to, a less extent, stearic acid increased. The proportion of palmitic acid was reduced 24 hours and 1 week after the cold and palmitoleic acid progressively in the cold. The percentage of total saturated fatty acids decreased 24 hours after the cold, but tended to increase thereafter.

Changes in the fatty acid composition of white fat of rats exposed to cold were small. The only acid to show a significant decrease was palmitic acid.

Starvation for 5 days induced a relative decrease of palmitic acid and an increase in stearic acid in both brown and white adipose tissues. A decrease in myristic acid was observed only in brown fat and there was an increase in linoleic and linolenic acids in white fat. In both adipose tissues total saturated fatty acids decreased significantly, but the changes were more pronounced in white fat.

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