Plasma Lipid Levels in Diabetic Children

Effect of Diet Restricted in Cholesterol and Saturated Fats

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SUMMARY

Plasma lipids, blood glucose, and urinary glucose excretion were measured in 270 juvenile diabetic children upon admission to and throughout periods of summer camping during which the effect of a usual and a modified diabetic diet was assessed. The usual diabetic diet contained 700-1,500 mg. cholesterol daily with a polyunsaturated/saturated (P/S) ratio of 0.1, while the modified diet limited cholesterol to 300 mg. daily with a P/S ratio of 1.0. Both diets maintained calories with 40 per cent as fat, 40 per cent as carbohydrate, and 20 per cent as protein. Analysis of fasting blood glucose, qualitative and quantitative glucose excretion, and body weight indicated that groups were comparable except for the diet used.

Elevated mean levels of cholesterol and triglycerides were approximately equally distributed in diabetic children of both sexes upon admission to camp, with 24 per cent demonstrating hyperlipoproteinemia. Eleven per cent had type II, 10 per cent type IV, and 3 per cent type V hyperlipoproteinemia upon admission. After following the usual diet, 21 per cent were type II, 1 per cent type IV, and none type V, with no reduction in the over-all incidence of hyperlipoproteinemia despite lower triglyceride and glucose levels. After consumption of the modified diet, hyperlipoproteinemia was reduced to 5 per cent, with 4 per cent type II and 1 per cent type IV.

Results of this study indicated that plasma lipids in juvenile diabetics were elevated when first observed and that the control of blood sugar levels along with a diabetic diet with lower cholesterol and increased polyunsaturated fat significantly reduced the incidence of hyperlipoproteinemia more effectively than control of blood sugar levels alone. DIABETES *24*:672-79, July, 1975.

Life expectancy in diabetics is significantly curtailed by arteriosclerotic cardiovascular disease. As reviewed by Marble et al., arteriosclerosis was responsible for 79 per cent of deaths in diabetic patients at the Joslin Clinic in 1966.[1] This contrasts with a 54 per cent death rate due to cardiovascular disease in the total population during the same year. In addition, cardiovascular disease occurs at a much earlier age in the diabetic population.

Reports have varied as to the levels of cholesterol and the frequency of hyperlipoproteinemias in patients with diabetes mellitus. All agree that lipids may be elevated when blood glucose levels are extremely high and the disease is uncontrolled. With somewhat better blood gluocse control, lower levels of plasma lipids have been reported.[2] Wolff and Salt[3] reported higher levels of cholesterol, esterified fatty acids, and beta-lipoproteins in thirty-five juvenile diabetics whose blood sugar levels were above 200 mg. per 100 ml. New et al.[4] reported significantly higher levels of cholesterol in diabetics than in nondiabetics either under or over the age of thirty. Their study included 195 patients ranging in age from five to ninety-five years, thirty-seven of whom were juvenile diabetics. However, Traisman et al.,[5] using a higher range of normal for cholesterol (150-392 mg. per 100 ml.), did not confirm these findings. Although Stone and Connor[6] and Kinsell[7] have recommended reducing cholesterol and saturated fat in the diabetic diet, Lloyd[8] has placed the predominant emphasis on diabetic control, stating that "the finding of hyperlipidemia in a child with treated diabetes mellitus almost always indicates inadequate insulin control." It is uncertain, however, what the interrelationships are among diet cholesterol content, polyunsaturated/saturated fat ratio and degree of control of blood sugar in diabetic patients.

The goals of this study were, first, to determine the levels of plasma cholesterol, triglycerides, and lipoprotein patterns in juvenile diabetics when first observed upon admission to summer camps while consuming their usual diabetic diet, which is frequently rich in animal fat; second, to determine the optimal

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effect of insulin therapy with the "classical" or usual diabetic diet upon fasting lipids; and third, to determine the optimal effect of insulin therapy with a modified diet containing an identical amount of fat but with reduced cholesterol and increased vegetable fat upon these lipids.

This study, performed at camps for juvenile diabetics, provided a unique opportunity to monitor the lipids of a large number of children during normal physical activity while under close medical and dietary supervision. The results indicated that mean fasting plasma cholesterol levels of diabetic children consuming a "classical" diet tended to be elevated when compared with nondiabetics whereas triglyceride levels were similar to those of nondiabetics. Furthermore, a diet with low cholesterol, reduced animal fat, and increased vegetable fat significantly reduced the frequency of hyperlipoproteinemias.

These results were reported in preliminary form as part of a survey of diabetes in youth[9] and are reported in detail here.

METHODS AND MATERIALS

Subjects. During summer camping, 270 diabetic children were studied at the Clara Barton Birthplace Camp for girls and the Elliott P. Joslin Camp for boys. Both camps are located in a wilderness area, fifty miles west of Boston, Massachusetts. Subjects were studied during three camp periods as detailed on table 1. During the first and third periods, girls followed the modified diet while boys followed the usual diabetic diet. During the second period, boys followed the modified diet while girls followed the usual diabetic diet. This modified diet was selected so that, if desired, changes could later be initiated by patients without extreme demands for expensive or inaccessible foods.

TABLE 1

Diabetic Camp Study Design

Fasting venous blood samples were drawn on days 1 and 17 and 1 and 11. A total of 270 children were studied.

Group	Period I Days 1 and 17	Period II Days 1 and 17	Period III Days 1 and 11
Diabetic girls	Modified diet*	Usual diet	Modified diet
n=141	n=44	n=55	n=42
Diabetic boys	Usual diet†	Modified diet	Usual diet
n=129	n=28	n=50	n=51

*Modified diabetic diet: P/S ratio of 1.0 with <300 mg. cholesterol per day and 40 per cent as fat.

†Usual diabetic diet: P/S ratio of 0.1 with 700-1,500 mg. cholesterol per day and 40 per cent as fat.

Diet. The modified diabetic diet was designed to limit cholesterol to 300 mg. daily with sufficient reduction in saturated fat and increment in unsaturated fat to achieve polyunsaturated/saturated fat (P/S) ratio of 1.0 (50 per cent animal, 50 per cent vegetable fat). The total fat provided 40 per cent of the calories in both diets. Skim milk replaced whole milk, corn oil margarine replaced butter, and an egg substitute (Eggstra, kindly supplied by Tillie Lewis Foods, Stockton, Calif.) was used twice a week. This preparation has 20 per cent of the cholesterol content of whole eggs and was prepared as "scrambled eggs." Corn oil was used generously in cooking, while meat was trimmed and/or parboiled before serving. The hot dogs and bologna used contained less that 20 per cent animal fat, as against the usual 30-40 per cent fat by weight (kindly supplied by John Morrell and Co., Chicago). Chicken and turkey were served often. Salad dressing, peanut butter, and walnuts were used to increase the polyunsaturated fat content of the diet. When the modified diet was served, no other food was available in camp.

The usual diabetic diet (also 40 per cent as fat) included whole milk, butter, cheese, and daily eggs and resulted in a daily cholesterol intake of 700-1,500 mg. and a P/S ratio of 0.1 (about 90 per cent of the fat was animal, 10 per cent vegetable).

Diabetic campers were served meals at tables where food was weighed by the counselors. Careful records were kept of daily food consumed, with any changes in the diet noted in the final calculations.

Protocol. Upon admission, each camper underwent a physical examination. The study was explained to campers and parents, with participants chosen from those children who were above ten years. Informed consent was obtained from all parents. All children received the same diet prescribed for the period regardless of whether or not they participated in the study. All subjects who became ill or who did not conform to the protocol were excluded from the study.

Venous blood samples were drawn between 6:30 and 8:00 a.m. on the first and seventeenth days of periods I and II and on the first and eleventh days of period III (table 1). Almost all campers who remained from one period to the next had an additional blood sample drawn at the start of the next period.

Blood was collected in tubes containing potassium oxalate for the determination of blood glucose and in EDTA tubes for plasma lipids. Specimens were identified by number so that all determinations could be made in a blind fashion. Blood plasmas were kept at 4° C. until the chemical analyses were performed, within twenty-four hours. Whole blood glucose was measured by the ferricyanide method using the AutoAnalyzer.[10] Triglycerides were measured by the method of Kessler and Lederer[11] and total cholesterol by a modification of the Lieberman-Burchard reaction.[12] Both triglyceride and cholesterol determinations were performed simultaneously from isopropanol extractions with use of an AutoAnalyzer II.[12] Lipoprotein electrophoretic patterns were performed with Universal Agarose electrophoresis film stained with Red-O-Fat. The criteria of Frederickson et al. was employed for normal lipid levels and lipoprotein typing.[13]

Body weight was determined every five to seven days, and ideal body weights were calculated from percentile chart measurements developed by Harold C. Stuart, M.D., and associates[14] for children up to the age of thirteen years. For subjects over thirteen years, calculations were based upon the Metropolitan Life Insurance Tables, 1959.

Evaluation of diabetes control. Diabetes control was monitored by daily qualitative urine glucose determinations performed on second-voided specimens on fasting and 2.5 hours after each meal and using Benedict's reagent. Daily twenty-four-hour glucose excretion was also determined. Fasting venous blood glucose was measured once a week. In addition, 2.5-hour postprandial capillary blood glucose levels were determined on four to eight occasions during the camp period on a Dextrostix-Ames Reflectance Meter. The degree of diabetic control was judged by an arbitary Diabetes Control Score employing qualitative and quantitative urine glucose excretion and fasting blood glucose measurements as detailed below. The numerical value for an excellent score was 21-19, good 18-15, fair 14-10, and poor below 10. Twenty-four-hour urinary glucose excretions and over-all fractional urine specimens for glucose were weighted equally, while fasting blood glucose values received one-third the weight of the former measurements.[15]

RESULTS

Table 1 shows the number of subjects in each camp period, while table 2 lists demographic and biochemical characteristics of diabetic campers obtained at admission to camp. No significant differences were noted between sexes except for the fasting blood glucose, which was higher among the girl diabetics. Note that the mean cholesterol among 129 diabetic boys under the age of thirteen years was over 200 mg. per 100 ml.

TABLE 2

Characteristics of Diabetic Campers on Entering Camps (mean ± S.D.)

	Boys	Girls
N	129	141
Age (yr.)	12.6 ± 1.8	12.7 ± 1.7
Duration D.M. (yr.)	5.1 ± 3.2	6.1 ± 3.4
Ideal weight (%)	101.0 ± 14.0	101.0 ± 13.0
Fasting cholesterol (mg. %)	202.0 ± 44.0	193.0 ± 35.0
Fasting triglycerides (mg. %)	88.0 ± 41.0	96.0 ± 45.0
Fasting blood glucose (mg./100 ml.)	142.0 ± 75.0	182.0 ± 77.0*

*$p<0.001$.

Table 3 displays the fasting blood glucose, diabetic control scores, per cent ideal body weights, and fasting triglyceride and cholesterol levels at the beginning and end of each camp period for diabetic girls and boys. Among the girls, a significant reduction of blood glucose levels was observed during the first two periods, reaching a slightly lower level at the end of the usual diet period. Blood glucose levels were not significantly reduced among the boys during any period, although values were consistently lower at the end of each camp period. Also, the mean blood glucose values were quite similar regardless of the diet employed for both girls and boys. Diabetes control scores for all camp groups were not significantly altered from the beginning to the end of any period. Per cent ideal body weight was unchanged during four of the six periods. Among the girls a 2 per cent decrease was observed during the first period while the boys showed a 1 per cent increase during the third period.

Fasting plasma triglycerides were significantly reduced during each period in the girls' camp, while in two of three periods the triglycerides were reduced among the boys. The failure of triglyceride reduction during the third period in the boys' camp may be due to the relatively low value on admission. Plasma cholesterol levels changed independently of the triglyceride levels, with reductions during both modified-diet periods in the girls' camp and an increase during the one usual-diet period. In the boys' camp, the usual-diet periods produced no change in plasma cholesterol levels, whereas during the modified-diet period significant reduction of the mean fasting cholesterol level was observed.

The number of subjects with either normal or abnormal (with elevated cholesterol and/or triglyceride levels) lipoprotein patterns is depicted in table 4. By the end of each modified-diet period the number of abnormal lipemic subjects was decreased. However, by the end of each usual-diet period, the incidence of

TABLE 3

Fasting Blood Glucose, Diabetes Control Scores, Per Cent Ideal Body Weight, Fasting Triglyceride and Cholesterol Levels during Usual and Modified Diabetic Diets (Mean ± S.D.)

	Diabetic girls			Diabetic boys		
	Start period	End period	P	Start period	End period	P
	Period I: Modified diet			Period I: Usual diet		
Fasting blood glucose*	192±79	144±79	<0.001	152±82	125±70	n.s.
Diabetes control score	11± 4	11± 4	n.s.	14± 5	14± 5	n.s.
Ideal weight (%)	107±16	105±16	<0.001	101±13	101±13	n.s.
Fasting triglyceride†	102±53	70±25	<0.001	93±48	73±18	<0.005
Fasting cholesterol†	183±33	174±29	<0.01	200±67	212±62	n.s.
	Period II: Usual diet			Period II: Modified diet		
Fasting blood glucose*	185±72	126±58	<0.001	135±72	121±66	n.s.
Diabetes control score	12± 4	11± 4	n.s.	16± 5	16± 4	n.s.
Ideal weight (%)	98±11	98±11	n.s.	100±16	100± 9	n.s.
Fasting triglyceride†	94±46	78±21	<0.001	94±44	63±16	<0.001
Fasting cholesterol†	194±39	204±38	<0.01	206±37	168±31	<0.001
	Period III: Modified diet			Period III: Usual diet		
Fasting blood glucose*	167±81	149±75	n.s.	143±76	122±73	n.s.
Diabetes control score	13± 4	13± 4	n.s.	13± 4	13± 4	n.s.
Ideal weight (%)	100±11	100±11	n.s.	103±13	104±13	<0.05
Fasting triglyceride†	92±33	78±26	<0.005	76±31	70±17	n.s.
Fasting cholesterol†	203±32	184±29	<0.001	200±32	205±24	n.s.

Significance (P) levels based on paired comparisons.
*mg./100 ml. whole blood.
†mg./100 ml. plasma.

type IV patterns was decreased and the incidence of type II patterns was increased, while the number of normal subjects was not significantly increased.

An analysis of the changes in fasting plasma lipoproteins comparing the initial to final pattern of each diebetic camper for each period is also shown in figure 1. For the forty-four diabetic girl campers during period I (modified diet), it can be seen that two campers at the start of the diet period who were type V became normal (N). One normal became a type V. Of the type II patterns, one camper remained unchanged and two became normal. Of the type IV patterns, one changed to a type II, seven became normal, and none remained unchanged. Thirty campers with normal patterns were unchanged. During period III in the girl diabetics (modified diet), a large number (eight) of type II patterns became normal. A similar shift from type II to normal patterns was seen during period II (modified diet) in the boy campers. During usual-diet periods in both girls (period II) and boys (periods I and III), relatively large numbers of campers showed a shift from normal to a type II pattern.

Overall, hyperlipoproteinemia with elevated cholesterol and/or triglyceride levels was present in 24 per cent of 270 children on admission to camp, with no significant difference observed between sexes. Eleven per cent showed type II patterns, 10 per cent type IV, and 3 per cent type V. After seventeen days on the

TABLE 4

Lipoprotein Patterns—Numbers of Subjects

	Diet		Diabetic girls N	II	IV	V	Diet		Diabetic boys N	II	IV	V
Period I	Modified n=44	Start	31	3	8	2	Usual n=28	Start	22	2	1	3
		End	41	2	0	1		End	19	8	1	0
Period II	Usual n=55	Start	43	4	6	2	Modified n=50	Start	33	9	8	0
		End	40	14	1	0		End	49	1	0	0
Period III	Modified n=42	Start	30	9	3	0	Usual n=51	Start	46	4	0	1
		End	37	3	2	0		End	45	6	0	0

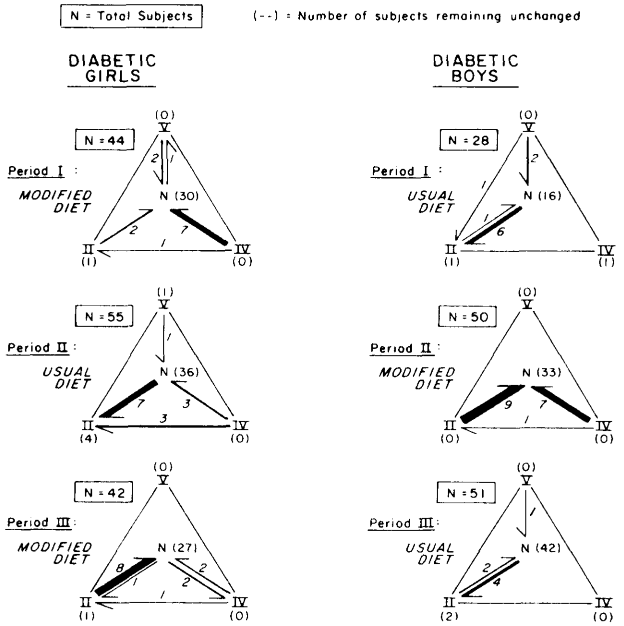


FIG. 1. Lipoprotein electrophoretic-pattern changes observed during diabetic camp among girls and boys while consuming the usual or modified diabetic diet. N, II, IV, and V refer to type of hyperlipoproteinemia.

usual diet, 21 per cent (twenty-eight of 134 children) were type II, 1 per cent type IV, and none type V. Therefore, no reduction in the incidence of hyperlipoproteinemia was observed with the usual diet. However, after seventeen days on the modified diet, only 4 per cent (six of 136 children) were type II, 1 per cent type IV, and none type V. The modified diet therefore produced a significant reduction in the over-all frequency of hyperlipoproteinemia compared with the usual diet (girls, $p < 0.001$; boys, $p < 0.01$) and particularly type II (girls, $p < 0.01$; boys, $p < 0.02$), but not in type IV patterns.

An analysis of mean fasting triglyceride levels is shown in table 5 with comparisons from a series of ninety-eight normal control subjects of comparable age employing identical methodology.[16] Both diabetic girls and boys on admission showed significantly higher levels than normals. However, despite a significant reduction in plasma triglycerides while following the usual diet, the diabetic groups still maintained higher-than-normal mean triglyceride levels. On the modified diet, the diabetic girls continued to demonstrate significantly higher triglyceride levels than normals while the boys showed a reduction and normalization of triglycerides compared to normals.

Mean fasting cholesterol levels of the groups along with those of normal control subjects are shown in table 6. Both diabetic girls and boys on admission and on the usual diet showed significantly higher mean cholesterol levels than normal control subjects. On the modified diet the mean cholesterol level of the diabetic girls was no longer elevated while the cholesterol level of the diabetic boys dropped slightly below the normal control values.

In figure 2, cholesterol levels are plotted as a percentile for the diabetic campers on the usual diet and modified diet as well as a recently published group of 358 normal controls of comparable age.[17] Comparing the male and female diabetic campers during the usual diet periods to the 75th percentile of Glueck's normal controls, it was found that this corresponded to 39 per cent at the start and 34 per cent at the end of the period. On the modified diet, 28 per cent were at this level at the start, but 74 per cent at the end of the period. Thus, the distribution of cholesterol levels was shifted toward normal but did remain to the right and slightly higher than normal for those diabetics on the modified diet.

A series of correlations were performed in order to identify statistical relationships between blood sugar control and plasma lipid levels. Significant correlations ($p < 0.05$) were present between the diabetes

TABLE 5

Fasting Triglycerides of Diabetic Children Compared with Normal Controls (mg./100 ml. plasma; mean ± S.D.)

		Start Period	End Period	
	Mean age (yr.)	Triglycerides	Usual diet Triglycerides	Modified diet Triglycerides
Normal controls (ref. 16)	13 ± 2	A. 59 ± 31 (98)	—	—
Diabetic girls	13 ± 2	B. 96 ± 45 (141)	C. 78 ± 21 (55)	D. 74 ± 26 (86)
Diabetic boys	13 ± 2	E. 88 ± 41 (129)	F. 71 ± 17 (79)	G. 63 ± 16 (50)

( ) = number of subjects.
A vs. B ($p<0.001$): A vs. E ($p<0.001$)
A vs. C ($p<0.001$): A vs. F ($p<0.005$)
A vs. D ($p<0.005$): A vs. G (p=n.s.)

TABLE 6

Fasting Cholesterol of Diabetic Children Compared with Normal Controls (mg./100 ml. plasma; mean ± S.D.)

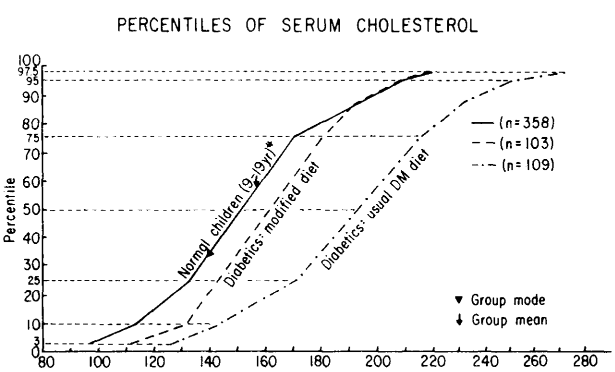
		Start Period	End Period	
	Mean age (yr.)	Cholesterol	Usual diet Cholesterol	Modified diet Cholesterol
Normal controls (ref. 16)	13 ± 2	A. 178 ± 24 (98)	—	—
Diabetic girls	13 ± 2	B. 193 ± 36 (141)	C. 204 ± 38 (55)	D. 179 ± 29 (86)
Diabetic boys	13 ± 2	E. 202 ± 44 (129)	F. 208 ± 43 (79)	G. 168 ± 31 (50)

( ) = number of subjects.
A vs. B ($p<0.001$): A vs. E ($p<0.001$)
A vs. C ($p<0.001$): A vs. F ($p<0.001$)
A vs. D (p=n.s.): A vs. G ($p<0.05$)

control scores and plasma triglycerides at the end of four of the six periods, with three of these correlations present during usual-diet periods. This would be consistent with better control of diabetes resulting in lower triglyceride levels. Likewise, the change in blood glucose from fasting versus the change in plasma triglycerides from fasting was significant in three of six periods, two of which were during usual-diet periods. However, only one significant correlation ($p<0.001$) between fasting blood glucose and plasma triglycerides was present (boys, period III). While consistent significant correlations were repeatedly observed between triglyceride and cholesterol levels during each camp period, neither the blood glucose level nor the diabetes control score was correlated with cholesterol levels during any period.

DISCUSSION

This study demonstrates that regardless of sex, diabetic children had higher fasting plasma triglyceride and cholesterol levels when observed at admission to summer camp than normal control values.



*Friedman, G., and Goldberg, S.J. JAMA 225:610-612, 1973

FIG. 2. Distribution of serum cholesterol levels in normal children compared with diabetic campers consuming the usual or modified diabetic diet.

Twenty-four per cent demonstrated hyperlipoproteinemia by the criteria of Frederickson et al.[13] These results support the findings of Wolff and Salt[3] and New et al.,[4] which used more recent biochemical methods and more specific normal limits for lipid levels. In addition, these results were observed during the summer, when cholesterol levels are seasonally lower,[18] and also during periods of increased physical activity, which should promote better diabetes control.

During the summer camp periods, particular efforts were made to keep groups on the usual or modified diets comparable in all regards other than diet. In fact, the levels of blood glucose and diabetes control scores were not different. It is noteworthy that the diabetes control score, which included a detailed analysis of both blood glucose values and qualitative and quantitative urine glucose excretion, failed to show significant changes from the first three days of camping to three days near the end of camping. The fact that fasting blood glucose levels were significantly reduced only during two of the six periods may be partially explained by the wide distribution of values and the relatively small numbers in each group. Over-all, a consistent decrease in blood glucose values was observed during every period, with boys always reaching lower levels than girls.

Decreased ideal body weight, observed during the girls' first period, may have contributed to the lower cholesterol and triglyceride levels. However, significant lowering of cholesterol occurred during the girls' third period, when weights were unchanged. Lower cholesterol levels were observed during the boys' second period, when no weight changes were recorded on the modified diet, while the slight increase during the third period did not appear to affect lipid levels. Over-all weight changes appeared to play a minimum role in affecting the observed lipid changes.

Lower blood glucose values were consistently associated with lower triglyceride levels. This may be explained by the activation of insulin-dependent lipoprotein lipase with the removal of abnormal chylomicrons. Likewise, with lower blood glucose levels, hepatic lipogenesis would be less stimulated[19,20] with the reduction of pre-beta lipoproteins as demonstrated by electrophoresis. These changes were observed and are shown in figures 1 and 2.

However, the lowering of cholesterol was not seen during periods when blood sugar and triglyceride levels were reduced and the usual diabetic diet was followed. Likewise, statistical correlations were observed between glucose and triglycerides but not between glucose and cholesterol under the conditions of this study. During each period, plasma cholesterol levels correlated with the dietary cholesterol intake. The mean level of plasma cholesterol either remained the same or increased slightly (12 mg. per 100 ml.) during periods when the usual diet was employed. This would suggest that the usual diabetic diet at camp was approximately the same in cholesterol and saturated fat as the diet employed at home.

During the three periods in which the usual diet was employed, it can be seen that a large number of lipoprotein patterns originally normal shifted to type II patterns with elevated cholesterol levels. In contrast, during the modified-diet periods there was a significant shift of both type II and type IV patterns to normal. Although one can see on table 3 that the mean levels of triglycerides do decrease during the usual diet, figure 1 indicates that there was no marked reduction or change of type IV patterns to normal. However, the conversion of type IV patterns to normal is clearly seen on figure 1 during the modified-diet periods.

The risk of atherosclerosis is sufficiently great in the diabetic population that all efforts should be made to reduce any identifiable risk factors. Elevated cholesterol was the best predictor of coronary artery disease in the Framingham studies.[21] At the same time that the general pediatric population is being cautioned about the risk of atherosclerosis,[22] pediatric patients with diabetes mellitus are at greater risk. A prudent diet with lower cholesterol and increased polyunsaturated fat should supplement proper control of blood glucose levels.

While it is difficult to evaluate the use of higher carbohydrate diets in adults with mild diabetes, as reported by Brunzell et al.,[23] success has been reported recently by Weinsier et al.,[24] which contrasts with the earlier results of Bierman and Hamlin, which suggested that hyperlipidemia may result from high-carbohydrate diets in diabetic subjects.[25] The experience during this study would suggest that lower cholesterol, lower saturated-fat diabetic diets can be designed to give 40 per cent as fat but that a slight decrease in fat to 35 per cent with a 5 per cent increase in carbohydrate might well be indicated.

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REFERENCES

[1]Marble, A., White, P., Bradley, R.F., and Krall, L.P.: *In* Joslin's Diabetes Mellitus. Philadelphia, Lea & Febiger, 1971, p. 419.

[2]Keiding, N.R., Mann, G.V., Root, H.F., Lawry, E.Y., and Marble, A.: Serum lipoproteins and cholesterol levels in normal subjects and in young patients with diabetes in relation to vascular complications. Diabetes *1*:434-40, 1952.

[3]Wolff, O.M., and Salt, H.B.: Serum lipids and blood sugar levels in childhood diabetes. Lancet *1*:707-10, 1958.

[4]New, M.I., Roberts, T.N., Bierman, E.L., and Reades, G.G.: The significance of blood lipid alterations in diabetes mellitus. Diabetes *12*:208-12, 1963.

[5]Traisman, H.S., Newcomb, A.L., Sever, J.L., and Hammes, R.: Blood lipid and protein levels in juvenile diabetes mellitus. Diabetes 9:481-84, 1960.

[6]Stone, D.B., and Connor, W.E.: The prolonged effects of a low cholesterol, high carbohydrate diet upon serum lipids in diabetic patients. Diabetes *12*:127-32, 1963.

[7]Kinsell, L.W., Walker, G., Michaels, G.D., and Olson,

F.E.: Dietary fats and the diabetic patient. N. Engl. J. Med. *261*:431-34, 1959.

[8]Lloyd, J.K.: Serum lipids in diabetic children. Postgrad. Med. J. *46*:600-03, 1970.

[9]White, P.: Life cycle of diabetes in youth. J. Am. Med. Wom. Assoc. *27*:293-317, 1972.

[10]Nelson, N.: Photometric adaptation of Somogyi method of determination of glucose. J. Biol. Chem. *153*:375, 1944.

[11]Kessler, G., and Lederer, H.: Fluorometric measurement of triglycerides. *In* Automation in Analytical Chemistry. Leonard Skiggs, Ed. New York, Mediad Incorp., 1965, pp. 341-44.

[12]Rush, R.L., Leon, L., and Turrell, J.: Automated simultaneous cholesterol and triglyceride determination on the AutoAnalyzer II instrument. Advances in Automated Analysis: Technicon International Congress *1*:503-07, 1970.

[13]Frederickson, D.S., Levy, R.I., and Lees, R.S.: Fat transport in lipoproteins—an integrated approach to mechanisms and disorders. N. Engl. J. Med. *276*:148-56, 1967.

[14]Stuart, Harold C., and Associates: The Children's Medical Center, Boston, Massachusetts. Anthropometric Chart.

[15]Karger, S.: Diabetes in juveniles. 2nd International Beilinson Symposium, Jerusalem, 1972.

[16]Glueck, C.J., Fallat, R.W., Tsang, C.R., and Buncher, C.R.: Hyperlipemia in progeny of patients with myocardial infarction before age 50. Am. J. Dis. Child. *127*:70-75, 1974.

[17]Friedman, G., and Goldberg, S.J.: Normal serum cholesterol values. Percentile ranking in a middle-class pediatric population. J.A.M.A. *225*:610-12, 1973.

[18]Paul, O., Lepper, M.H., and Phelan, W.H., et al.: A longitudinal study of coronary heart disease. Circulation *28*:20-31, 1963.

[19]Salans, L.B., and Reaven, G.M.: Effect of insulin pretreatment on glucose and lipid metabolism of liver slices from normal rats. Proc. Soc. Exp. Biol. Med. *122*:1208-13, 1966.

[20]Schersten, T., Nilsson, S., and Jonsson, J.: Hepatic lipogenesis in two cases with insulin-producing tumor of the pancreas. Acta Med. Scand.*190*:353-57, 1971.

[21]Kannel, W.R., Castelli, W.P., Gordon, T., and McNamera, P.M.: Serum cholesterol, lipoproteins, and the risk of coronary heart disease. The Framingham Study. Ann. Intern. Med. *74*:1-12, 1971.

[22]Kannel, W.B., and Dawber, T.R.: Atherosclerosis as a pediatric problem. J. Pediatr. *80*:544-54, 1972.

[23]Brunzell, J.D., Lerner, R.L., Hazzard, W.R., Porte, D., Jr., and Bierman, E.L.: Improved glucose tolerance with high carbohydrate feeding in mild diabetes. N. Engl. J. Med. *284*:521-24, 1974.

[24]Weinsier, R.L., Seeman, A., Herrera, M.G., Assal, J.P., Soeldner, J.S., and Gleason, R.E.: High- and low-carbohydrate diets in diabetes mellitus. Ann. Intern. Med. *80*:332-41, 1974.

[25]Bierman, E.L., and Hamlin, J.T., III: The hyperlipemic effects of a low-fat, high-carbohydrate diet in diabetic subjects. Diabetes *10*:432-37, 1961.