COMPARISON OF LIPID AND LIPOPROTEIN LEVELS IN DIABETIC AND NON-DIABETIC JUVENILES OF EASTERN KENTUCKY

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Disorders of carbohydrate metabolism associated with diabetes have long been recognized to be paralleled by some alteration in lipid metabolism. A 1978 study by the Kentucky Diabetes Commission revealed a higher rate of diabetes in Eastern Kentucky--6.8 per cent of the population as opposed to a 2.2 per cent average nationally. Diabetes and its complications in this area was responsible for the majority of hospitalizations and 30 deaths per 100,000 people. The prevalence of diabetes in Kentuckians aged 17 and younger is 1.6 times higher, and 2.17 times higher in Kentuckians aged 17-45, than the national average. Lipoprotein and lipid studies of diabetics are of great importance since heart and vascular disease represent the most serious complication in the life of the diabetic.

A diabetic group consisting of 12 outpatients whose age ranged from 13-19 years was involved in this study. Fasting blood specimens for patients were drawn on at least two different occasions. All patients were on insulin treatment and a regulated diabetic control diet. A control group consisted of a normal non-diabetic population of comparable age.

Venous blood samples were collected after overnight fasts, and assayed for glucose, total serum cholesterol, HDL cholesterol, LDL cholesterol, and serum triglycerides, and polyacrylamide electrophoresis of lipoproteins. Total serum cholesterol was assayed according to the Liebermann-Buchard method. HDL cholesterol was determined using heparin-manganese precipitation, and the method previously described for total serum cholesterol. Triglycerides were assayed by an enzymatic determination of glycerol. LDL cholesterol was calculated according to the following formula:

$$C_{VLDL} = TG/5$$

$$C_{LDL} = C_{Serum} - C_{HDL} - TG/5$$

Where C = concentration of cholesterol in the LDL, VLDL, HDL, fractions or in serum expressed in mg/100 ml

TG = serum triglycerides expressed in mg/100 ml

Glucose was assayed by the enzymatic method of Trinder. Lipoprotein electrophoresis was performed using a modified polyacrylamide gel technique.

Within the diabetic group 67 per cent were found to be hyperlipidemic. Hyperlipidemic juveniles were classified on the basis of total cholesterol, LDL-cholesterol, and triglycerides as verified by polyacrylamide gel electrophoresis. These juveniles were classified as types IV, IIa, IIb in order of frequency. When diabetic juveniles were compared with non-diabetic juveniles, statistically significant elevations of total cholesterol, LDL-cholesterol, and a decreased HDL-cholesterol were observed. An increase in triglyceride was also observed in the diabetic population, but was not statistically significant. Statistical tests were based on the standard pooled t test.

The diabetic group was subdivided into two groups based on good or poor diabetic control. The poor control group consisted of patients in whom only sporadic control was noted, however, all were outpatients at the time of sampling, and none were ketotic.

The most common features in hyperlipidemic juvenile diabetics were an increased total cholesterol, LDL-cholesterol, and a decreased HDL-cholesterol. Hypertriglyceridemia was resolved with good diabetic control, which is well substantiated by other studies, which directly related degree of control with triglyceride levels. Cholesterol levels, both total and lipoprotein fractions, showed mean differences as compared to the non-diabetic group, regardless of control. The higher mean values of total cholesterol and LDL-cholesterol, and the decreased HDL-cholesterol in the diabetic cases indicate a disturbed lipid metabolism in the diabetic juvenile.

Major risk factors for the development of atherosclerosis seem to be prominent in diabetes mellitus, since hypercholesterolemia, elevated LDL-cholesterol fraction or a decrease in the HDL-cholesterol fraction represent a greater risk than in the non-diabetic. The ratios of Total Cholesterol/HDL-Cholesterol, LDL-Cholesterol/HDL-Cholesterol, were 3.8 and 2.5 times higher respectively, in the diabetic juvenile when compared to the non-diabetic juvenile. These ratios have been found to be indicators of cardiovascular risk in

previous studies. These findings indicate an accelerated risk for these individuals since there is an alteration in lipoprotein metabolism, and possibly an alteration in the metabolism of the arterial walls, at an early age in the juvenile diabetic.

Accepted by:

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COMPARISON OF LIPID AND LIPOPROTEIN LEVELS IN DIABETIC AND NON-DIABETIC JUVENILES OF EASTERN KENTUCKY

A Thesis

Presented to

The Faculty of the School of Science and Mathematics

Morehead State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in

Biology

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by

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Accepted by the faculty of the School of Science and Mathematics, Morehead State University, in partial fulfillment of the requirements for the Master of Science degree.

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Feb. 27, 1981
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ACKNOWLEDGEMENTS

The author wishes to express her sincere appreciation to the many people who assisted and advised in this research. I especially wish to thank the following:

Dr. D. J. Saxon, the major advisor for this research, who suggested the topic for this work, and who assisted in preparing this thesis.

Dr. D. T. Magrane, who suggested the use of the polyacrylamide electrophoretic technique, and supplied references for the same. Also, for his kind assistance in preparing the methods section and the tables which appear in the discussion.

Dr. M. E. Pryor, who assisted in proofreading this paper, and provided insight in the form of this thesis.

Dr. J. H. Black, and the Morehead Clinic, who provided the patients to be used in this study, and also their facilities.

My sister, Libby, who typed endless drafts of this paper and never missed a deadline.

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INTRODUCTION

Disorders of carbohydrate metabolism associated with diabetes mellitus have long been recognized to be paralleled by some alteration in lipid metabolism.[17,21,22,23] Investigators have reported elevated serum concentration of cholesterol and triglyceride in diabetes.[17,21,22,23] The identification of hypercholesterolemia and hypertriglyceridemia as two of a number of coronary risk factors, and the susceptibility of diabetics to atherosclerosis, have directed interest toward abnormalities of lipid metabolism in diabetes.[23] Lipoprotein and lipid studies of diabetics are of great importance since heart and vascular disease represent the most serious complication in the life of the diabetic.[13,17,21,22,23]

Coronary atherosclerosis is characterized by an accumulation of lipid, primarily cholesterol, in the arterial wall. Evidence that this may be due, in part, to a filtration into the arterial intima of low density (LDL) lipoprotein cholesterol has been well documented.[3,11,15,19] There is also evidence that the transport of cholesterol from the peripheral tissues to the liver for catabolism and excretion may be a function of plasma high-density lipoprotein (HDL), which also inhibits the uptake of LDL by the peripheral tissues.[3,4,11,15,19] This would account

for an inverse relationship between HDL and the cardiovascular risk. The amount of plasma HDL has been found to be decreased in diabetes,[15] and elevated levels of cholesterol and triglycerides have been reported in 25 to 50 per cent of diabetics.[13,22,23]

A biochemical pathway to show how human cells gain access to the cholesterol esters bound to LDL has been proposed by Goldstein and Brown.[11] The sequential steps involved in this pathway are as follows: (1) Cells requiring cholesterol synthesize a receptor that becomes localized on the cell surface. (2) LDL binds to this receptor with high affinity. (3) The bound LDL is then taken up by the cell via an endocytotic process. (4) The membrane receptor-LDL complex invaginates into the cell, forming an endocytic vesicle which migrates through the cytoplasm and fuses with a lysosome. (5) The protein of the LDL is hydrolyzed by lysosomal proteases to amino acids. (6) The cholesterol esters are hydrolyzed by a lysosomal acid lipase. (7) The free cholesterol produced passively crosses the lysosomal membrane, and gains access to the cellular compartment.[11]

The cell suppresses its own cholesterol synthesis, having obtained cholesterol from LDL, by reducing the activity of a rate controlling microsomal enzyme, 3-hydroxy-3-methyl glutaryl coenzyme A reductase (HMG CoA

reductase). When excess cholesterol enters the cell through the LDL pathway, it is stored in the cell in the form of cholesterol ester droplets. The formation of cholesterol esters is triggered by the activation of acyl CoA: cholesterol acyl transferase (ACAT), a microsomal enzyme that attaches a long fatty acid to free cholesterol.[11]

It has been postulated that HDL works in an opposing manner. Studies of the metabolism of arterial smooth muscle cells show that HDL binds to the surface receptor of smooth muscle cells as effectively as LDL, but HDL is degraded much more slowly. When cells were incubated with an equal or higher concentration of HDL, no net increment of cholesterol was noted. The presence of HDL in the medium inhibits uptake and degradation of LDL.[4]

A second mechanism is proposed whereby HDL serves to clear cholesterol from the arterial wall. As the membranes of arterial cells exhibit biological turn over, and as cells die and are renewed, cholesterol is released from the tissues. This cholesterol binds to HDL, where it is converted to cholesterol esters by the enzyme lecithin-cholesterol acyl transferase (LCAT).[11] This form of cholesterol is then returned to the liver for excretion.

It has become increasingly apparent that the process of atherosclerosis has a long natural history beginning

in early childhood.[2] The fact that hyperlipoproteinemia is present in a large percentage of middle-aged diabetics suggests that an alteration in carbohydrate metabolism of juvenile diabetics may also produce an observable change in lipid metabolism at an early age. This metabolic alteration may enhance the atherogenic process in these juveniles. The study of lipid profiles in these juveniles also affords a study of the atherogenic process, uncomplicated by other chronic disease processes frequently seen in older diabetics.

The purpose of this study was to compare triglyceride, total cholesterol, HDL cholesterol and LDL cholesterol levels in the serum of diabetic and non-diabetic adolescents of Eastern Kentucky. The study was also designed to analyze data for the identification of factors of potential risk in the pathogenesis of atherosclerosis. A conclusion that increased risk of atherosclerosis could exist, would indicate that in the juvenile diabetic, lipid metabolism, as well as carbohydrate metabolism, should be monitored and controlled.

MATERIALS AND METHODS

A diabetic group consisting of 12 outpatients whose age ranged from 13-19 years was involved in this study. Blood specimens from fasting patients were obtained on at least two different occasions. All patients were being treated with insulin and a regulated diabetic diet. A control group consisted of a normal non-diabetic population of comparable age.

Venous blood samples were collected after overnight fasts, and assayed photometrically for glucose, total serum cholesterol, HDL cholesterol, LDL cholesterol and serum triglyceride. HDL and LDL levels were qualitated by polyacrylamide electrophoresis of lipoproteins.

Blood Glucose

Glucose was assayed by the method developed by Trinder.[24] Glucose is oxidized by glucose oxidase to gluconic acid and hydrogen peroxide. The hydrogen peroxide reacts in the presence of peroxidase, with phenol and 4-amino phenazone to form a 0-quinone imine dye which is measured photometrically.

Procedure

1. Label tubes blank, standard, control, and sample.

2. Pipet 4.0 ml of glucose reagent (Boehringer-Mannheim cat. no. 189197) into all cuvettes (13 x 100 mm).
3. Add 0.02 ml of sample, standard, control and distilled water to the respective cuvettes.
4. Mix all tubes well and incubate at 37°C for 10 minutes.
5. Read absorbance of standard, control and sample at 540 mm.
6. Calculate concentration of glucose as follows:

   mg glucose/100 ml =

$$\frac{\text{Absorbance of unknown}}{\text{Absorbance of standard}} \times \text{concentration of std.}$$

Total Serum Cholesterol

The Liebermann-Buchard method, as modified by Huang, was used for cholesterol assays. Cholesterol reacts strongly with sulfuric acid to produce green colored bis-cholestadienyl-monosulfonic acids.[12]

Procedure

1. Label tubes, standard, control, sample and reagent blank.
2. Pipet exactly 3.0 ml of cholesterol reagent (Stanbio Laboratory Co., Dallas, Tex.) into test tubes.

3. Add 0.1 ml of cholesterol standard, control, sample and distilled water into the appropriate test tube.
4. Mix all tubes well and incubate at room temperature for 20 minutes.
5. Read absorbance of standard, control and sample at 610 nm.
6. Calculate cholesterol concentration by the following formula:

$$\text{mg cholesterol/100 ml} = \frac{\text{Absorbance of unknown}}{\text{Absorbance of standard}} \times \text{Concentration of std.}$$

HDL Cholesterol

HDL cholesterol was determined using the Liebermann-Buchard method as described for total serum cholesterol, in conjunction with heparin-manganese precipitation to eliminate the VLDL and LDL fractions.

Procedure

1. Label tubes control and sample.
2. Pipet 1.0 ml of serum and controls into test tubes, and add 0.1 ml of precipitating reagent (Stanbio Laboratory, Dallas, Tex.).
3. Mix all tubes well, centrifuge at 3,500 rpm for approximately 10 minutes, then decant.

4. Add 0.2 ml of the supernatant to 3.0 ml of cholesterol reagent (Stanbio Laboratory Co., Dallas, Tex.).
5. Mix all tubes well and incubate at room temperature for 20 minutes.
6. Read the absorbance of the solution at 610 nm.
7. Calculate the HDL cholesterol concentration by the following formula:

$$\text{mg HDL cholesterol/100 ml} = \frac{\text{Absorbance of unknown}}{\text{Absorbance of standard}} \times \text{concentration of x·5 standard}$$

Triglyceride

Triglyceride content was determined using an enzymatic method. Triglycerides are saponified in the presence of alcoholic potassium hydroxide to fatty acids and free glycerol. Glycerol then undergoes a series of coupled reactions, and the amount of NADH oxidized during the reaction is then measured. The amount of NADH oxidized is proportional to the amount of glycerol in the specimen.

Procedure

1. Label tubes control and sample.
2. Pipet into a test tube 0.2 ml of sample or control and 0.5 ml alcoholic potassium hydroxide.

3. Mix all tubes well, seal and incubate for 20-30 minutes at between 55-70°C.
4. Allow tubes to cool to room temperature, then add 1.0 ml of 0.15 M magnesium sulfate. Mix tubes and centrifuge. Decant supernatant.
5. Add 0.5 ml of the supernatant to 2.5 ml of triglyceride reagent (Boehringer-Mannheim, cat. no. 125032).
6. Mix all tubes and incubate at room temperature for 5 minutes.
7. Measure initial absorbance (A_1), at 340 or 366 nm.
8. Add 0.2 ml of glycerokinase to all tubes and mix. Let all tubes stand for approximately 10 minutes, then read final absorbance (A_2); $A = A_1 - A_2$.
9. Calculate triglyceride concentration according to the following formula:

$$\frac{A \times V_a \times MW \times 8.5}{a \times D \times V_s \times 10} = \text{mg triglyceride/100 ml}$$

A = Difference in absorbance between initial and final readings.

V_a = Total assay volume = 3.04 ml

MW = Average molecular weight of triglycerides in human serum = 885.

a = Absorbency coefficient = 3.30 cm^2/μ mole at 366 nm.

D = Light path = 1 cm

V_s = Volume of the supernatant = 0.50 ml

10 = Conversion to mg/100 ml

8.5 = Dilution factor due to saponification and neutralization of specimen

mg triglycerides/100 ml = 1386 x A

LDL Cholesterol

LDL cholesterol was calculated according to the following formula:

$$C_{VLDL} = TG/5$$

$$C_{LDL} = C_{Serum} - C_{HDL} - TG/5$$

where

C = Concentration of cholesterol in the LDL, VLDL, HDL fractions or in serum expressed in mg/100 ml

TG = serum triglycerides expressed in mg/100 ml

Polyacrylamide Gel Electrophoresis

Polyacrylamide gel electrophoresis is a technique in which separation is dependent upon electrophoretic mobility and molecular size.[6,10,15] This type of disc electrophoresis sharply delineates lipoprotein bands, and is the more rapid of the electrophoretic methods used for separating lipoproteins. The sample is prestained with Sudan

Black B in a sample gel. It is then resolved by electrophoresis in a discontinuous pH system consisting of a sample gel, concentrating gel and separating gel.

Reagents

Solution A. Dissolve 36.6 g of Tris ("Trizma base," Sigma Chemical Co., St. Louis, Mo.) and 0.23 ml of "TEMED" (Eastman Organic Chemicals, Rochester, N.Y. cat. no. 8178) in approximately 100 ml of distilled water. Add 48 ml of 1_NHCL and dilute to 200 ml with distilled water. The pH should be 8.9. It is stable for three months at 4°C in a brown bottle.

Solution B. Dissolve 5.98 g of Tris (Trizma base) and 0.46 ml of TEMED in 25 ml of distilled water. Add .48 ml of 1_NHCL and dilute to 100 ml with distilled water. The pH should be 6.7. It is stable for three months at 4°C in a brown bottle.

Solution C. Dissolve 15.0 g of acrylamide (Eastman, cat. no. 5521) and 0.40 g of bisacrylamide (Eastman, cat. no. 8383) in 75 ml of distilled water, and dilute to 100 ml with distilled water. It is stable for three months at 4°C in a brown bottle.

Solution D. Dissolve 20.0 g of acrylamide and 5.0 g of bisacrylamide in water and dilute to 200 ml with

distilled water. It is stable for three months at 4°C in a brown bottle.

Solution E. Dissolve 8.0 mg of riboflavin (Sigma Chemical Co., St. Louis, Mo.) in 100 ml of distilled water. It is stable for three months at 4°C in a brown bottle.

Solution F. Dissolve 200 g of sucrose in 400 ml of water and dilute to 500 ml with distilled water.

Solution G. Dissolve 0.14 g of ammonium persulfate in 50 ml of distilled water in a 100 ml volumetric flask, and dilute to volume with distilled water. It is stable for one week at 4°C in a brown bottle.

Dye Solution. Add 250 mg of Sudan Black B to 30 ml of absolute ethanol, mix well, and dilute to 100 ml with distilled water. It is stable for one month at room temperature in a brown bottle.

Separating Gel Solution. Remove the desired amount of solutions A, C, and G from their refrigerated bottles, place suitable amounts in containers, and bring to room temperature before combining them. Combine solutions A, C, and G in the ratio of 1:1:2, by volume. Prepare approximately 1.0 ml of the separating gel solution per separating gel required. The separating gel solution should be prepared just before use.

Concentrating Gel Solution. Mix solutions B, D, E, and F in the ratio of 1:2:1:4, by volume. It is stable for one month at 4°C in a brown bottle.

Sample Gel Solution. Just before use, add 8 parts of concentrating gel solution to 1 part of dye solution and mix by gentle inversion.

Reservoir Buffer. Dissolve 6.0 g of Tris (Matherson, Coleman & Bell, no. 7060) and 28.8 g of glycine (Sigma) in about 850 ml of distilled water. If necessary, adjust the pH to 9.5 with Tris or glycine. Dilute to 1 liter with distilled water. The reservoir buffer may be used for 7 days (based on two runs per day).

Equipment

The Buchler Polyanalyst gel system and power supply were used for electrophoretic separations (Buchler-Cotlove Instruments). The Gelman densitometer (Model DCO-16) was used to evaluate band migration (Gelman Instrument Co., Ann Arbor, Mich.).

Procedure

1. Add 1.0 ml of freshly prepared separating gel solution to each gel tube. Carefully add water on top of the gel solution to prevent a curved meniscus from forming as the gel polymerizes.

The separating gel polymerizes, if undisturbed, in 30 minutes at room temperature. (All polymerization procedures must be performed under intense light.)

2. After photopolymerization is complete, invert the tubes and blot on absorbent paper.
3. Add 0.05 ml of concentrating gel solution. Layer the gel solution as above, and allow tubes to remain undisturbed for 10 minutes.
4. After polymerization is complete, invert the tubes and blot on absorbent paper.
5. Add 0.02 ml of serum and 0.1 ml of sample gel solution to each tube. Mix each tube by inversion and layer each tube with reservoir buffer. Allow the tubes to remain undisturbed for 20-30 minutes.
6. Insert the tubes into the electrophoretic cell. Electrophoresis should be run for 25-30 minutes at 5 millamperes per gel tube.
7. Densitrometric scans are made following electrophoresis using a 615 nm interference filter. There is no need to remove the gel from the tube. If densitometry cannot be immediately performed, the tubes should be refrigerated and shielded to avoid color fading.
8. Chylomicrons remain in the sample gel. VLDL are

retained near the origin of the separation gel. LDL migrates about half the distance of the separating gel, and HDL is the fastest migrating anodic fraction, migrating to near the end of the tube.

RESULTS AND DISCUSSION

Within the diabetic group 67 per cent were found to be hyperlipidemic. Hyperlipidemic juveniles were classified, on the basis of total cholesterol, LDL-cholesterol and triglycerides, as lipoprotein phenotypes IV, IIa, IIb, in order of decreasing frequency.[8] These results were then verified, qualitatively, by densitometric analysis of the polyacrylamide gels. When diabetic juveniles were compared with non-diabetic juveniles, statistically significant elevations of total cholesterol, LDL-cholesterol, and a decreased HDL-cholesterol were observed (Table I). An increase in triglyceride was also observed in the diabetic population, but was not statistically significant. Statistical tests were based on the standard pooled t test.

The diabetic group was subdivided into two groups based on good or poor diabetic control. The poor control group consisted of patients in whom only sporadic control was noted, however, all were outpatients at the time of sampling, and none were ketotic. Juvenile diabetics in good control were found to have significantly lower triglyceride levels when compared to

diabetics with poor control (Table II). There were no statistically significant differences in HDL-cholesterol, total cholesterol, and LDL-cholesterol. Although the cholesterol and LDL-cholesterol were higher, HDL-cholesterol was lower in the poor control group.

Table I

Diabetic Juveniles vs. Non-Diabetic Juveniles

	Non-Diabetic Group	Diabetic Group
Glucose (mg/100 ml) ± S.D.	90 ± 14.3	254 ± 124.3
Triglyceride (mg/100 ml) ± S.D.	132 ± 34.8	145 ± 68.1
Total Cholesterol (mg/100 ml) ± S.D.	161 ± 26.4	224 ± 44.1
HDL-Cholesterol (mg/100 ml) ± S.D.	46 ± 8.1	33 ± 9.4
LDL-Cholesterol (mg/100 ml) ± S.D.	91 ± 20.3	162 ± 42.5

Statistical tests are based on standard pooled t test ($p < 0.05$), where $n = 12$ for non-diabetic group and $n = 12$ for diabetic group. Significant deviations are underscored.

Table II

Good Control Diabetic Juveniles vs. Poor Control Diabetic Juveniles

	Good Control	Poor Control
Glucose (mg/100 ml) ± S.D.	129 ± 14.5	342 ± 78
Triglyceride (mg/100 ml) ± S.D.	87 ± 21.5	186 ± 58.3
Total Cholesterol (mg/100 ml) ± S.D.	205 ± 37.8	238 ± 46.3
HDL-Cholesterol (mg/100 ml) ± S.D.	31 ± 6.5	34 ± 6.8
LDL-Cholesterol (mg/100 ml) ± S.D.	144 ± 44.6	166 ± 44.9

Statistical tests are based on standard pooled t test ($p < 0.05$) where $n = 5$ for good control diabetics and $n = 7$ for poor control diabetics. Significant deviations are underscored.

Statistical comparison of good control diabetics with the non-diabetic population illustrated that while control does lower the triglyceride levels, triglyceride levels were statistically significantly lower in the diabetic group than in the non-diabetic group. However, both were within normally used clinical limits. This is

in agreement with the lipid study by Wille.[22] LDL-cholesterol levels were still significantly higher, and HDL-cholesterol levels were significantly lower for juveniles of the same age (Table III).

Table III

Good Control Juvenile Diabetics vs. Non-Diabetic Juvenile Group

	Good Control Diabetics	Non-Diabetic Control
Glucose (mg/100 ml) ± S.D.	129 ± 14.5	90 ± 14.3
Triglyceride (mg/100 ml) ± S.D.	87 ± 21.5	132 ± 34.8
Total Cholesterol (mg/100 ml) ± S.D.	205 ± 37.8	161 ± 26.4
HDL-Cholesterol (mg/100 ml) ± S.D.	31 ± 6.5	46 ± 8.1
LDL-Cholesterol (mg/100 ml) ± S.D.	144 ± 44.6	91 ± 20.3

Statistical tests are based on standard pooled t test ($p < 0.05$) where $n = 5$ for good control diabetics, and $n = 12$ for non-diabetic control. Significant deviations are underscored.

When poorly controlled diabetics were compared with the non-diabetic controls, total cholesterol, triglyceride and LDL-cholesterol levels were also significantly different (Table IV). HDL-cholesterol levels were again observed to be significantly decreased.

Table IV

Poor Control Diabetic Juveniles vs. Non-Diabetic Control Juveniles

	Poor Control Diabetics	Non-Diabetic Controls
Glucose (mg/100 ml) ± S.D.	342 ± 78	90 ± 14.3
Triglyceride (mg/100 ml) ± S.D.	186 ± 58.3	132 ± 34.8
Total Cholesterol (mg/100 ml) ± S.D.	238 ± 46.3	161 ± 26.4
HDL-Cholesterol (mg/100 ml) ± S.D.	34 ± 6.8	46 ± 8.1
LDL-Cholesterol (mg/100 ml) ± S.D.	166 ± 44.9	91 ± 20.3

Statistical tests are based on standard pooled t test ($p < 0.05$) where $n = 7$ for poor control diabetics, and $n = 12$ for non-diabetic controls. Significant deviations are underscored.

Age, sex, age at onset and duration of disease were found to be non-significant factors in hyperlipidemic patients. All patients used in this study were not hypertensive, and the diabetic patients were treated with insulin and a regulated diet alone at the time of sampling.

The most common features in hyperlipidemic juvenile diabetics were an increased total cholesterol and LDL-cholesterol levels, and a decreased HDL-cholesterol. Hypertriglyceridemia was resolved with good diabetic control. This observation is in agreement with other studies which also directly related degree of diabetic control with triglyceride levels.[1,5,13,14,22,23] Cholesterol levels, both total and lipoprotein fractions, showed mean differences when compared to the non-diabetic group, regardless of control. The higher mean values of total cholesterol and LDL-cholesterol, and the decreased HDL-cholesterol in the diabetic cases indicate a disturbance of the normal lipid metabolism in the diabetic juvenile.

Major risk factors for the development of atherosclerosis seem to be prominent in diabetes mellitus, since hypercholesterolemia, elevated LDL-cholesterol fraction or a decrease in the HDL-cholesterol fraction represent a

greater risk than in the non-diabetic.[21] The ratios of total cholesterol/HDL-cholesterol and LDL-cholesterol/HDL-cholesterol were 2.0 and 2.5 times higher respectively in the diabetic juvenile than in the non-diabetic juvenile. These ratios have been found to be indicators of cardiovascular risk in previous studies.[8] These results suggest an accelerated risk for diabetic juveniles since there is an alteration in lipoprotein metabolism, and probably an alteration of the metabolism in the arterial walls, which is initiated at an early age in the juvenile diabetic.[19]

Therefore, in the juvenile diabetic, even those diabetics exhibiting controlled blood glucose, there are prominent lipid and lipoprotein levels that elevate the risk of cardiovascular disease. The total cholesterol, LDL-cholesterol, HDL-cholesterol and triglyceride levels should be monitored, even in the diabetic with controlled blood glucose levels.

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