Published in final edited form as:

J Clin Lipidol. 2016 ; 10(5): 1240–1247. doi:10.1016/j.jacl.2016.07.010.

Body mass index and glycemic control influences lipoproteins in children with type 1 diabetes

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Abstract

Background—Patients with Type 1 Diabetes Mellitus (T1DM) have an extremely high risk of cardiovascular disease (CVD) morbidity and mortality. It is well-known that dyslipidemia is a subclinical manifestation of atherosclerosis.

Objective—To analyze presence and predicting factors of lipoprotein abnormalities prevalent in children with T1DM and whether race specific differences exists between non-Hispanic White (NHW) and non-Hispanic Black (NHB) in the lipoprotein characteristics.

Methods—A retrospective electronic chart review including 600 (123 NHB and 477 NHW) T1DM patients, ages 7.85 ± 3.75 years who underwent lipoprotein analysis.

Results—Relative to NHW counterparts, NHB T1DM subjects had a higher HbA1c, total cholesterol (TC), low density lipoprotein cholesterol (LDL), apoB 100, lipoprotein (a), and high density lipoprotein cholesterol (HDL), HDL-2 and -3. Body mass index (BMI) was positively associated with TC, LDL, apoB 100, and non-HDL and inversely associated with HDL, HDL-2, and HDL-3. HbA1c was positively associated with TC, LDL, apoB100, non-HDL, and HDL-3. Multilinear regression analysis demonstrated that HbA1c was positively associated with apoB 100 in both NHB and NHW, and BMI was a positive determinant of apoB 100 in NHW only.

Conclusion—Poor glycemic control and high BMI may contribute to abnormal lipoprotein profiles. Glycemic control (in NHB and NHW) and weight management (in NHW) may have significant implications in T1DM. ApoB100 concentrations in subjects with T1DM were determined by modifiable risk factors, BMI, HbA1C, and blood pressure, indicating the importance of adequate weight-, glycemic-, and blood pressure control for better diabetes care, and likely lower CVD risk.

Keywords

Lipoprotein abnormalities; Type 1 Diabetes Mellitus; Cardiovascular disease risk; Glycemic Control; BMI; ApoB100

Introduction

Diabetes is considered a CVD risk factor. [1–3]. CVD is the leading cause of mortality for individuals with T1DM, affecting approximately 75% of these patients [4]. Although T1DM is known to be associated with less advanced dyslipidemia than with T2DM or the general population [5], CVD development remains as a significant cause of death in T1DM patients [6]. If glycemic control is well-maintained, HDL cholesterol is often similar or higher and triglycerides and LDL cholesterol are often lower in T1DM relative to non-diabetics [7]. Very little information exists on determinants of abnormal lipoprotein profile in patients with T1DM, perhaps given the relatively normal lipid profile and use of standard markers for characterization [8]. Direct contradiction of increased CVD mortality despite relatively normal standard lipid profile observed in subjects with T1DM requires a thorough evaluation of lipoprotein profiles in these patients.

Tracking from childhood to adulthood for many CVD risk factors is common [9,10], yet very few studies have evaluated lipid profile in the pediatric population, and even fewer in the T1DM pediatric population ([11–13]). Of those that have been completed, it has been shown that patients with T1DM may present with low HDL cholesterol levels, high total cholesterol (TC), or with abnormal HDL/TC composition [14,15]. In recent years, determining qualitative aspects beyond simple concentration of lipid parameters, has garnered recognition for its importance in cardiovascular risk categorization. Despite frequently reported standard lipid profile analysis, characterization of lipoprotein composition or components [apoB 100, or HDL and Lp(a) sub particles] and the contribution to the atherogenic process is less explored in this population of subjects. In the context of the standard lipid profile, it is well-established that insulin insufficiency and subsequent poor glycemic control suppresses free fatty acid release into the liver, thereby increasing hepatic production of triglyceride, VLDL cholesterol and apo B 100. In turn, VLDL triglyceride is exchanged for cholesteryl ester transported in HDL, resulting in easily degradable HDL particles and increased circulation of LDL particles.

Lipoprotein (a) [Lp(a)] is an atherogenic family of lipoproteins consisting of LDL and an apolipoprotein [apoA], which is bound to apolipoprotein B 100 (apoB 100), the carrier of the LDL particle. Several meta-analyses have provided support for an association between Lp(a) and CVD. Further, there is an interaction between Lp(a) and other risk factors for CVD. Although the physiological role of Lp(a) is unknown, a majority of studies implicate Lp(a) as an independent CVD risk factor. Notwithstanding, limited information is available on the prevalence of Lp(a) and apo B 100 in children with T1DM.

Despite consistent reports of greater prevalence of CVD relative to whites, Blacks have lower incidence of dyslipidemia (e.g., higher HDL and lower triglycerides) (34). Visceral adiposity is also less apparent in Blacks relative to Whites, and visceral adiposity is a known causal factor in insulin resistance, which paradoxically is greater in Blacks relative to Whites [16]. Thus, race-related differences in lipid profile and contributing factors to dyslipidemia should be considered in T1DM patients warrants investigation.

The key objective of this study was to analyze the type and nature of lipoprotein abnormalities prevalent in children with T1DM. Because lipoprotein abnormalities generally vary by race, we also tested race-specific differences and contributing characteristics to apoB 100 and Lp(a) concentrations in this cohort.

Methods

The study cohort consisted of 607 children who had been diagnosed with T1DM who were managed by the University of Alabama at Birmingham (UAB), Department of Pediatric Endocrinology at Children's of Alabama. After IRB approval, data was obtained from electronic medical records using the International Classification of Diseases (ICD-9-CM) diagnosis codes of 250.01 and 250.03 to identify all potentially eligible patients with T1DM. Only those who had a diagnosis of T1DM and underwent vertical autoprofile (VAP), which is a density gradient rapid ultracentrifugation (Atherotech, Birmingham, AL) were included. Patients with insufficient data and those with new onset hypothyroidism diagnosed at the time of VAP testing were excluded. Due to the demographics of the patients attending the Children's Hospital, we did not have sufficient numbers of Hispanic or Asian or other minority groups of children with T1DM for inclusion into this the study.

The following clinical information was obtained from the EMR: age, gender, self-reported race, height, weight, body mass index (BMI), blood pressure, glycosylated hemoglobin (HbA1C), urine microalbumin to creatinine ratio, VAP-measured lipoprotein profile, and the use of lipid lowering medications. All children with T1DM received similar diabetes and nutritional education according to the UAB Endocrine Division policy and patients were given similar instructions to contact the treating physician frequently for medication adjustments to maintain euglycemia. BMI for age and sex was calculated according to the Centers for Disease Control and Prevention growth charts [17]. Hypertension was diagnosed according to the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents [18]. A systolic or diastolic blood pressure (SBP or DBP) of greater than or equal to the 95th percentile for age, gender, and height (single blood pressure reading) was classified as hypertension. VAP analysis provided information on TC, LDL, HDL, apoB100, LDL pattern, HDL subclasses and Lp(a). Measurements were determined by single vertical spin density gradient ultracentrifugation and then analyzed by a multi-channel Vertical Auto Profile Analyzer which uses a Roche cholesterol specific enzyme kit. Total apoB100 is calculated using VAP cholesterol results. HDL/TC ratio was calculated. As the fasting status could not be guaranteed due to the retrospective nature of the study, we excluded triglycerides and VLDL from analysis. Adequate glycemic control, was defined as a HbA1C of <7.5% [19] and microalbuminuria was defined as urine albumin between 30–299 mcg/mg of creatinine [20].

Statistical Analysis

Descriptive statistics were generated for the overall sample and stratified according to race and sex. The Kolmogorov-Smirnov test and graphical inspections of data were used for evaluating distribution for normality. All variables were normally distributed. The unpaired sample t-test was used to identify differences between groups. For the overall sample,

frequency of T1DM co-morbidities were assessed for elevated LDL and non-HDL, systolic and diastolic hypertension, and microalbuminuria. In addition, simple Pearson correlation analysis was performed to investigate BMI as a correlate of lipid parameters.

General linear regression analysis was performed to identify race-specific determinants of apoB 100 and Lp(a). Interaction variables were tested to determine whether there were differences in the associations by race for any characteristic. Control variables included age, gender, BMI, SBP, DBP and duration of diabetes. Statistical significance was accepted at $P = 0.05$ for all tests using SAS software (version 9.4, SAS Institute Inc., Cary NC).

Results

There were total of 600 subjects, 477 NHW and 123 NHB. Baseline demographic and laboratory characteristics are demonstrated in Table 1. Males with T1DM had a lower BMI (21.3 ± 4.0 vs. 22.5 ± 4.7 , $P = 0.0006$), HbA1C (8.6 ± 1.6 vs. 9.0 ± 1.7 , $P = 0.0063$), total cholesterol (169.0 ± 35.0 vs. 180.6 ± 39.5 , $P = 0.0001$), LDL (93.8 ± 28.4 vs. 101.2 ± 32.7 , $P = 0.0029$), HDL (55.4 ± 13.9 vs. 58.9 ± 13.6 , $P = 0.0018$), non-HDL (113.6 vs. 121.7 mg/dl, $P = 0.0060$), apo B100 (79.9 vs. 83.9 mg/dl, $P = 0.0199$), HDL 2 (15.1 vs. 16.4 mg/dl, $P = 0.0113$ and 3 (40.3 vs. 42.5 mg/dl, $P = 0.0011$ - see Table 1.

NHB subjects had higher TC (186.5 vs. 171.5 mg/dl; $P < 0.0001$), LDL (104.3 vs. 95.6 mg/dl; $P < 0.01$), HDL (63.7 vs. 55.4 mg/dl; $P < 0.0001$), apoB 100 (85.6 vs. 80.9 mg/dl; $P < 0.05$), Lp(a) (11.2 vs. 9.0 mg/dl; $P < 0.001$), HDL-2 (18.9 vs. 14.9 mg/dl; $P < 0.0001$), HDL-3 (44.7 vs. 40.5 mg/dl; $P < 0.0001$), HbA1c (9.8 vs. 8.6% ; $P < 0.0001$).

Of all subjects, 11.0% had LDL greater than 130 mg/dl, 9.9% had non-HDL greater than 160 mg/dl, 18.2% had systolic hypertension, 1.3% had diastolic hypertension, and 11.7% had microalbuminuria. A total of 22.7% had none of these T1DM co-morbidities, 45.5% had at least one, 20.6% had at least two, 20.6% had at least three, 1.5% had at least four, and 0.3% had all five T1DM comorbidities assessed.

BMI was positively correlated with TC ($r = 0.1$, $P = 0.01$), LDL ($r = 0.2$, $P < 0.0001$), apoB 100 ($r = 0.2$, $P < 0.0001$), non-HDL ($r = 0.2$, $P < 0.0001$), and inversely associated with HDL, HDL-2 and HDL-3 (each $r = -0.2$, $P < 0.0001$). There was a negative association between BMI and Lp(a) ($r = -0.08$, $P = 0.0575$), which was marginally significant. BMI as not correlated with HDL:TC or HbA1C.

Table 2 shows the crude and independent association of variables modifying apoB 100 concentrations by race. HbA1C was positively associated with apoB 100 in both NHB ($\beta = 4.16$, $P < 0.0001$) and NHW ($\beta = 4.90$, $P < 0.0001$), which persisted after adjusting for age, gender, BMI, SBP, DBP and duration of diabetes. DBP was positively associated with apoB in NHB ($\beta = 0.54$, $P = 0.0403$) and NHW ($\beta = 0.58$, $P < 0.0001$); however, after adjusting for covariates (age, gender, BMI, HbA1C, SBP, duration of diabetes), the associations were attenuated ($\beta = 0.29$, $P = 0.2910$; $\beta = 0.22$, $P = 0.0744$; respectively). Among NHW, male gender ($\beta = -5.61$), BMI ($\beta = 1.16$), SBP ($\beta = 0.28$) and duration of diabetes ($\beta = 1.06$) were associated with apoB 100 (all $P < 0.01$); however, when adjusting for

covariates the relationship remained only for BMI ($\beta=0.73$, $P=0.0008$). There were no differences in the associations by race for apoB and any characteristic.

Table 3 shows the crude and independent associations of variables modifying Lp(a) concentrations by race. Duration of diabetes was negatively associated with Lp(a) in NHB after adjusting for potential confounding variables ($\beta=-0.48$, $P=0.03$). BMI was negatively associated with Lp(a) in NHW after adjusting for potential confounding variables ($\beta=-0.19$, $P=0.004$). There were no differences in the associations by race for Lp(1) and any characteristic.

Discussion

T1DM is recognized as a risk factor for CVD. In this study we found that HbA1C and BMI influenced the lipoprotein profiles in children with T1DM.

Race

The ideal lipoprotein profile for minimizing cardiovascular risk would be normal-to-high HDL and high HDL-2/HDL-3 ratio and low TC and LDL. Despite having similar weight status and a better HDL profile, NHB were found to have an elevated TC, LDL, apoB100, and Lp(a) in our study, which heightens their CVD risk. Our group has previously reported poor glycemic control and higher dyslipidemia in African American children with T2DM [21]. An increased CVD risk is well known for NHB with T2DM, and our results demonstrate that this is true in T1DM as well. In addition to having a higher prevalence of abnormal lipoprotein profiles, NHB with T1DM also had worse glycemic control.

Sex

Colhoun et. al. describe that for the risk of CVD in patients with T1DM, the risk increase is greater in women than men, such that the sex difference in coronary heart disease mortality is abolished by diabetes [22]. Our study showed that females with T1DM had a higher BMI, HbA1C total cholesterol, LDL, HDL, non-HDL, apo B100, HDL 2 and 3. Further research as to why females are more predisposed to dyslipidemia is warranted. It is unclear why females tended to have worse glycemic control and higher BMIs but this is important to address clinically as both have adverse effects on CVD risk among other medical issues.

BMI

Data from the SEARCH for Diabetes in Youth study have shown that although elevated apoB 100 and occurrence of small dense LDL were less concerning for T1DM relative to T2DM, maintenance of glucose control is essential as CVD risk is substantially increased with poor glycemic control in both T1DM and T2DM [23]. This may be related to BMI, as the T1DM youth had lower BMI. Our study showed that in patients with T1DM, BMI is strongly associated with total cholesterol, LDL, apoB100 and non-HDL. In concordance with other published reports we also found BMI to be inversely associated with HDL and also with HDL-2, and HDL-3. Hence weight management may necessitate further consideration in T1DM. Small, dense LDL particles have been shown to be more susceptible to oxidation and more atherogenic than their larger counterparts; furthermore, an increase in

the proportion of small particles, representing LDL pattern B profile, appears to impart atherogenicity. This may be attributable to elevated TG concentration, which results in increased VLDL production and impaired capacity for VLDL clearance [24,25].

Hemoglobin A1C

Poor glycemic control is a recognized adverse contributor to lipid profiles in patients with T1DM. A Lithuanian study of CVD risk in children with T1DM reported a positive association between HbA1c total cholesterol, LDL, TG, and atherogenic coefficient values, albeit no relationship with HDL was observed [26]. Insulin therapy is known to promote efficient clearance of VLDL. Our data showed that HbA1C is a determinant of apoB 100. This emphasizes the importance of glycemic control in patients with T1DM as chronically elevated blood glucose significantly impacts the risk of developing cardiovascular disease.

Apolipoprotein B100

ApoB-100 is synthesized in the liver and binds in a 1:1 ratio each circulating pro-atherogenic moiety, (LDL, VLDL, and IDL) [27,28]. ApoB is consistently associated with an increased mortality in T1DM [29]. Walldius et. al. described that elevated levels of apo B 100, a constituent of atherogenic lipoproteins, and reduced levels of apo A-I, a component of anti-atherogenic HDL, are associated with increased cardiac events [27]. Our study found that among both NHB and NHW children with T1DM, HbA1C is a determinant of apoB 100 concentrations, even after adjusting for potential confounders (i.e., gender, BMI, SBP, DBP, and duration of diabetes). In NHW only, BMI was also an independent determinant of apoB 100. These findings point towards the importance of adequate glycemic control and, for NHW, also weight control, for better cardiovascular health.

Lipoprotein (a)

Lp(a), is a distinct lipoprotein that contains apoprotein(a) [apo(a)]. Apo(a) contains *kringle* (K) domains, which give rise to heterogeneity in Lp(a) isoform size. The levels are usually also genetically determined and remain relatively stable over an individual's lifetime. Blacks generally have higher Lp(a) levels than Whites, which is in concordance with our findings. Lp(a) levels are reportedly elevated in diabetic nephropathy and is a risk factor for CVD [30]. Results of studies investigating Lp(a) levels in patients with Type 1 diabetes are inconsistent. Several studies have reported that Lp(a) levels were increased in patients with Type 1 diabetes, while in others, a significant relationship was not observed [30]. Our finding that LDL and non-HDL are determinants of Lp(a) is not surprising given that every Lp(a) has a single molecule of apoB 100 attached to the surface. Duration of diabetes was the predictor of Lp(a) in our study. Thus management of disease complications (i.e. dyslipidemia), may be imperative for reducing overall CVD risk. Even though previously it was reported that HbA1C was associated with Lp(a) [31], HbA1C was not a determinant of Lp(a) in our study.

Strengths of our study were a robust sample size, inclusion of both NHB and NHW, and qualitative lipoprotein analysis as opposed to traditional lipid profile analysis. However, this study was not without limitations. The retrospective nature of chart review did not allow us to evaluate effect of treatment of abnormal lipid values. We also did not have sufficient

numbers of patients from the Hispanic or Asian ethnicities, and findings may not be generalizable to these groups.

Conclusions

Our study indicate that in children with T1DM, lipid profile and glycemic control may have significant implications in reducing CVD risk T1DM, particularly among NHB. Weight management may be impactful for reducing long-term CVD risk, particularly for NHW children with T1DM.

Acknowledgments

A.A. and S.V conceived the study. S.V. collected the data from electronic medical records and wrote the manuscript. L.H. and R.G performed statistical analysis. All authors reviewed/edited the manuscript. All authors were involved writing the paper and had final approval of the submitted and published versions. All authors take full responsibility for the work as a whole, including the study design, access to data, and the decision to submit and publish the manuscript.

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Table 1

Baseline characteristics and anthropometric measures of children with type 1 diabetes by race

	All subjects (n=600)	NHB (n=123)	NHW (n=477)	p-value*
Age (years) at diagnosis*				
Mean (95% CI)	7.9 (7.6,8.2)	7.7 (7.1,8.4)	7.9 (7.6,8.3)	0.59
Median (IQR)	8 (5,11)	8 (5,10)	8 (5,11)	0.49
Age at Lipid profile				
Mean (95% CI)	12.9 (12.7,13.2)	13.0 (12.4,13.5)	12.9 (12.7,13.2)	0.90
Median (IQR)	13 (10,15)	13 (10,15)	13 (11,15)	0.95
Duration of diabetes at lipid profile				
Mean (95% CI)	4.2 (3.9,4.5)	4.4 (3.8,5.0)	4.1 (3.8,4.5)	0.49
Median (IQR)	3 (1,6)	4 (1,6)	3 (1,6)	0.59
Male (%)	314 (52.3)	59 (48.0%)	255 (53.5%)	0.31
Mean Weight (kg)	54.7±17.2	55.8 ± 15.4	54.5 ± 17.7	0.43
Mean Height (cm)	156.1±15.2	155.8 ± 13.5	156.2 ± 15.7	0.82
Mean BMI (kg/m ²)	21.9±4.4	22.5 ± 4.1	21.7 ± 4.4	0.08
BMI percentile	69.6±25.5	74.7±70.5	68.3±66.0	0.0141
Mean BMI z score	0.0±1.0	0.12±0.95	-0.03±1.00	0.12
Mean Systolic blood pressure (mmHg)	113.4±12.0	113.1 ± 12.8	113.4 ± 11.9	0.81
Mean SBP z score	0.0±1.0	-0.04±1.00	0.01±0.98	0.59
Mean Diastolic blood pressure (mmHg)	64.2±7.9	64.6 ± 8.1	64.1 ± 7.9	0.51
Mean DBP z score	0.0±1.0	0.05±0.94	-0.01±1.00	0.57
Mean TC (mg/dl)	174.6±37.6	186.5 ± 42.0	171.5 ± 35.8	<0.0001
Mean LDL-cholesterol (mg/dl)	97.3±30.7	104.3 ± 37.3	95.6 ± 28.5	0.0049
Mean HDL-cholesterol (mg/dl)	57.1±13.8	63.7 ± 13.1	55.4 ± 13.5	<0.0001
Mean Triglycerides (mg/dl)	122.3±105.5	118.5±112.4	123.2±103.8	0.6571
VLDL (mg/dl)	19.9±12.1	18.4±7.7	20.3±12.9	0.0438
Mean Non-HDL (mg/dl)	117.5±36.4	122.7 ± 40.5	116.2 ± 35.2	0.07
Mean HDL/TC Ratio	0.4±0.9	0.35 ± 0.1	0.38 ± 1.1	0.78
Mean ApoB 100 (mg/dl)	81.9±20.7	85.6 ± 24.6	80.9 ± 19.5	0.03
Mean Lp(a) (mg/dl)	9.4±5.7	11.2 ± 6.5	9.0 ± 5.4	0.0002
Mean HDL 2 (mg/dl)	15.7±6.5	18.9 ± 7.1	14.9 ± 6.0	<0.0001
Mean HDL 3 (mg/dl)	41.4±8.3	44.7 ± 7.5	40.5 ± 8.2	<0.0001
LDL pattern (%)				
A	344 (57.3)	66 (53.7%)	278 (58.3%)	0.60
A/B	166 (27.7)	36 (29.3%)	130 (27.3%)	
B	69 (15.0)	21 (17.1%)	69 (14.5%)	
Mean HbA1c (%)	8.8±1.6	9.8 ± 2.2	8.6 ± 1.4	<0.0001

* Estimated from t-test or Wilcoxon rank sums test for means and medians, respectively, or chi-square test for categorical variables

† NHB: non-Hispanic blacks; NHW: non-Hispanic whites; TC: total cholesterol; LDL: low density lipoprotein cholesterol; HDL: high density lipoprotein cholesterol

[‡]Data are presented as frequency or mean $\pm$ SD

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Table 2

Baseline characteristics and anthropometric measures of children with type 1 diabetes by sex

	Males (n=314)	Females (n=286)	p-value [*]
Age (years) at diagnosis [*]			
Mean (95% CI)	8.1 (7.7,8.6)	7.6 (7.2,8.0)	0.09
Median (IQR)	8.5 (5.0,11.0)	8.0 (5.0,10.0)	0.09
Age at Lipid profile			
Mean (95% CI)	13.1 (12.8,13.4)	12.8 (12.4,13.1)	0.20
Median (IQR)	13.0 (11.0,15.0)	13.0 (10.0,15.0)	0.23
Duration of diabetes at lipid profile			
Mean (95% CI)	4.0 (3.6,4.4)	4.4 (4.0,4.8)	0.18
Median (IQR)	3.0 (1.4,5.0)	4.0 (1.0,6.0)	0.14
Race (%)			
Black	59 (18.8)	64 (22.4)	0.2769
White	255 (81.2)	222 (77.6)	
Mean Weight (kg)	55.6 ± 17.8	53.7 ± 16.5	0.17
Mean Height (cm)	159.6 ± 15.7	152.2 ± 13.8	<0.0001
Mean BMI (kg/m ²)	21.3 ± 4.0	22.5 ± 4.7	0.0006
BMI percentile	66.5±26.6	73.0±23.9	0.0019
BMI z score	-0.15 (-0.26, -0.05)	0.17 (0.05,0.29)	<0.0001
Mean Systolic blood pressure (mmHg)	114.7 ± 12.2	112.0 ± 11.6	0.006
Mean SBP z score	0.11 (0.00,0.22)	-0.13 (-0.24, -0.01)	0.003
Mean Diastolic blood pressure (mmHg)	63.5 ± 8.0	65.1 ± 7.8	0.01
Mean DBP z score	-0.09 (-0.20,0.02)	0.10 (-0.01,0.21)	0.02
Mean TC (mg/dl)	169.0 ± 35.0	180.6 ± 39.5	0.0001
Mean LDL-cholesterol (mg/dl)	93.8 ± 28.4	101.2 ± 32.7	0.003
Mean HDL-cholesterol (mg/dl)	55.4 ± 13.9	58.9 ± 13.6	0.002
Mean triglycerides (mg/dl)	119.5±80.7	125.3±127.4	0.5103
VLDL (mg/dl)	19.3±6.9	20.5±15.9	0.2376
Mean Non-HDL (mg/dl)	113.6 ± 33.2	121.7 ± 39.2	0.006
Mean HDL/TC Ratio	0.41 ± 1.3	0.34 ± 0.1	0.34
Mean ApoB 100 (mg/dl)	79.9 ± 19.0	83.9 ± 22.3	0.02
Mean Lp(a) (mg/dl)	9.0 ± 5.2	6.2 ± 0.4	0.07
Mean HDL 2 (mg/dl)	15.1 ± 6.4	16.4 ± 6.5	0.01
Mean HDL 3 (mg/dl)	40.3 ± 8.4	42.5 ± 8.1	0.001
LDL pattern (%)			
A	176 (56.1%)	171 (60.0%)	0.74
A/B	91 (29.0%)	76 (26.6%)	
B	48 (15.3%)	45 (15.7%)	
Mean HbA1c (%)	8.6 ± 1.6	9.0 ± 1.7	0.006

^{*} Estimated from t-test or Wilcoxon rank sums test for means and medians, respectively, or chi-square test for categorical variables

[†]NHB: non-Hispanic blacks; NHW: non-Hispanic whites; TC: total cholesterol; LDL: low density lipoprotein cholesterol; HDL: high density lipoprotein cholesterol

^{*}Data are presented as frequency or mean $\pm$ SD

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Table 3
Crude* and adjusted* associations of variables modifying ApoB 100 concentrations stratified by race

	Non-Hispanic Black				Non-Hispanic White			
	Crude		Adjusted		Crude		Adjusted	
	β	p-value	β	p-value	β	p-value	β	p-value
Age	0.84	0.1590	0.86	0.2327	-0.07	0.7820	0.22	0.4727
Male gender	2.09	0.6407	-0.34	0.9306	-5.61	0.0017	-2.37	0.1666
BMI	0.56	0.3088	0.72	0.1509	1.16	<0.0001	0.73	0.0008
HbA1C	4.16	<0.0001	4.17	<0.0001	4.90	<0.0001	4.15	<0.0001
Systolic blood pressure	0.04	0.8315	-0.19	0.3213	0.28	0.0002	0.10	0.2295
Diastolic blood pressure	0.54	0.0403	0.29	0.2910	0.58	<0.0001	0.22	0.0744
Duration of diabetes	0.39	0.5128	0.86	0.2004	1.06	<0.0001	0.54	0.1060

* Estimated from general linear regression adjusted for other variables in model

[†] P-value for interaction between race and respective variable

Significant differences between groups (bolded) were considered at $P = 0.05$

Table 4

Crude and adjusted* associations of variables modifying Lp(a) concentrations stratified by race

	Non-Hispanic Black				Non-Hispanic White			
	Crude		Adjusted		Crude		Adjusted	
	β	p-value	β	p-value	β	p-value	β	p-value
Age	0.03	0.8412	-0.39	0.0911	-0.10	0.1306	-0.09	0.3417
Male gender	-1.24	0.2956	-2.31	0.0635	-0.69	0.1662	-0.38	0.4649
BMI	0.02	0.9179	-0.07	0.6435	-0.15	0.0093	-0.19	0.0042
HbA1C	0.35	0.2386	-0.09	0.7630	-0.11	0.5454	-0.21	0.2823
Systolic blood pressure	0.03	0.4838	0.06	0.3083	-0.01	0.7422	0.01	0.6090
Diastolic blood pressure	0.05	0.4563	-0.02	0.8085	-0.01	0.6911	-0.02	0.6573
Duration of diabetes	-0.11	0.5023	-0.48	0.0331	-0.01	0.8777	-0.03	0.7335

* Estimated from general linear regression adjusted for other variables in model

[†] P-value for interaction between race and respective variableSignificant differences between groups (bolded) were considered at $P = 0.05$