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Regional Adipose Tissue and Lipid and Lipoprotein Levels in HIV-Infected Women

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Abstract

Background—HIV infection and antiretroviral therapy are associated with dyslipidemia, but the association between regional body fat and lipid levels is not well described.

Methods—Multivariable linear regression analyzed the association between magnetic resonance imaging–measured regional adipose tissue and fasting lipids in 284 HIV-infected and 129 control women.

Results—Among African Americans, HIV-infected women had higher triglyceride (116 vs. 83 mg/dL; $P < 0.001$), similar high-density lipoprotein (HDL; 52 vs. 50 mg/dL; $P = 0.60$), and lower low-density lipoprotein (LDL; 99 vs. 118 mg/dL; $P = 0.008$) levels than controls. Among whites, HIV-infected women had higher triglyceride (141 vs. 78 mg/dL; $P < 0.001$), lower HDL (46 vs. 57 mg/dL; $P < 0.001$), and slightly lower LDL (100 vs. 107 mg/dL; $P = 0.059$) levels than controls. After adjustment for demographic and lifestyle factors, the highest tertile of visceral adipose tissue (VAT) was associated with higher triglyceride (+85%, 95% confidence interval [CI]: 55 to 121) and lower HDL (−9%, 95% CI: −18 to 0) levels in HIV-infected women; the highest tertile of leg subcutaneous adipose tissue (SAT) was associated with lower triglyceride levels in HIV-infected women (−28%, 95% CI: −41 to −11) and controls (−39%, 95% CI: −5 to −18). After further adjustment for adipose tissue, HIV infection remained associated with higher triglyceride (+40%, 95% CI: 21 to 63) and lower LDL (−17%, 95% CI: −26 to −8) levels, whereas HIV infection remained associated with lower HDL levels (−21%, 95% CI: −29 to −12) in whites but not in African Americans (+8%, 95% CI: −2 to 19).

Conclusions—HIV-infected white women are more likely to have proatherogenic lipid profiles than HIV-infected African American women. Less leg SAT and more VAT are important factors associated with adverse lipid levels. HIV-infected women may be at particular risk for dyslipidemia because of the risk for HIV-associated lipodystrophy.

Keywords

dyslipidemia; fat distribution; HIV infection; lipid levels; lipodystrophy; women

Lipid abnormalities in HIV infection, including elevations in triglycerides and reductions in high-density lipoprotein (HDL) and low-density lipoprotein (LDL) cholesterol (HDL-C and LDL-C, respectively), were first described before the era of potent antiretroviral therapy in patients with advanced HIV infection.^{1–4} Soon after the introduction of protease inhibitor (PI)–containing antiretroviral therapy, increases in total cholesterol (TC), LDL-C, and triglycerides were observed.^{5–10}

HIV-infected women were thought to be at particular risk for dyslipidemia because of simultaneous reports of body fat changes, including fat loss or lipoatrophy, mainly in the face and limbs, and, more notably in women, fat accumulation or lipohypertrophy in the abdomen and breasts.^{11–13} In the general population, truncal obesity has been associated with an increased risk of dyslipidemia. In HIV-infected individuals, these body fat changes accompanied by dyslipidemia and insulin resistance were described as an HIV-associated lipodystrophy syndrome that was initially attributed to PIs.¹⁴ Subsequent studies found that PI-induced changes in lipid levels seemed to precede changes in body composition.^{6,10,15} Although many studies have linked HIV lipodystrophy to dyslipidemia, most have used a clinical definition of lipodystrophy, with varying inclusion of lipoatrophy and lipohypertrophy. It is now recognized that lipoatrophy and lipohypertrophy are not part of the same disorder.^{16–19} Similar to HIV-infected men, lipoatrophy is the predominant syndrome in HIV-infected women.^{16,19}

Few studies, however, have examined the relation between regional body fat measurements and lipid levels in HIV-infected women in comparison with controls. A primary aim of the Fat Redistribution and Metabolic Changes in HIV Infection (FRAM) study was to define the association between magnetic resonance imaging (MRI)–measured regional adipose tissue volume and fasting measurements of triglycerides, HDL-C, and directly measured LDL-C in HIV-infected women compared with control women, also taking into account the contribution of HIV-related factors to triglycerides, HDL-C, and LDL-C in HIV-infected women.

METHODS

Study Population

The FRAM study enrolled 350 HIV-infected women and 142 control women between June and September 2002. HIV-infected participants enrolled in the FRAM Study were selected from coded lists of patients seen in 16 HIV or infectious disease clinics or cohorts in the United States and were representative of HIV-infected participants living in the United States.^{20,21} Control subjects were recruited from 2 centers of the Coronary Artery Risk Development in Young Adults (CARDIA) study.^{22,23} CARDIA study subjects were originally recruited as a sample of healthy 18- to 30-year-old white and African American men and women from 4 cities in 1985 to 1986 for a longitudinal study of cardiovascular risk factors, with population-based recruitment in 3 cities and recruitment from the membership of a prepaid health care program in the fourth city. Participants in the CARDIA study were stratified to have equal numbers of the 2 races and genders.

Details of the recruitment and data collection procedures for FRAM study HIV-infected and control participants have been described elsewhere.²¹ Institutional review boards at all participating sites approved the study protocol and consent process.

Study Procedures

FRAM study participants were asked about their physical activity, alcohol intake, smoking, illicit drug use, and adequacy of food intake using standardized instruments.^{22,24–26} Medical history was also assessed. Women who reported at least 12 months of amenorrhea attributable to natural menopause or a history of bilateral oophorectomy were categorized as being menopausal. Research associates interviewed HIV-infected participants and reviewed medical charts to determine the dates of use of individual antiretroviral medications.

Blood was drawn after a 12-hour overnight fast and sent to Covance central laboratory (Indianapolis, IN) for determination of TC, HDL-C, triglycerides, and direct LDL-C. Direct LDL-C was measured using the LDL-C Plus assay (Roche Diagnostics, Indianapolis, IN). CD4 T-lymphocyte counts were determined by flow cytometry (Becton Dickinson, Franklin Lakes, NJ), and HIV RNA levels were determined by the Amplicor HIV-1 MONITOR test (Roche Diagnostics, Branchburg, NJ), with a linear range from 400 to 750,000 copies/mL.

Weight and height were determined using standard methods. Whole-body MRI was performed to quantify body composition using a standard protocol,²⁷ as described previously.¹⁷ MRI scans were segmented using image analysis software (Tomovision Inc., Montreal, Quebec, Canada). Volume of each tissue for the space between 2 consecutive slices was calculated by means of a mathematic algorithm.²⁸ Using these methods, we quantified adipose tissue volume in the following sites: leg, lower trunk (abdomen and back), upper trunk (chest and back), arm, total subcutaneous adipose tissue (SAT), visceral adipose tissue (VAT), and total adipose tissue.

Statistical Methods

Of the 492 women in the FRAM study, 284 HIV-infected and 129 control women were included in the analysis. Among the HIV-infected women, 66 women were excluded because of missing lipid or MRI data ($n = 56$) and having a recent opportunistic infection (OI; $n = 10$), and among the control women, 13 were excluded because of missing lipid or MRI data. For comparisons of HIV and control characteristics, 157 (of the 284) HIV-infected women of similar age to control women were included. For numeric values, data are presented as median values and 95% confidence intervals (CIs), with distribution-free CIs constructed for the median and P values calculated using the Mann-Whitney U test. The Fisher exact test was used for categorical values.

To assess the independent associations of body fat depots and other factors with lipids, we performed multivariable regression analysis in separate models for control and HIV-infected subjects. Separate analyses were performed for each of the following lipids: triglycerides, direct LDL-C, and HDL-C. In this first analysis, factors related to HIV infection were excluded so as to assess the association of adipose tissue using an equivalent model in control subjects and in HIV-infected subjects. The primary predictors were trichotomized amounts of adipose tissue volume from anatomic sites measured by MRI: upper trunk, lower trunk, arm, leg, total SAT, VAT, and total fat. Trichotomized versions of the anatomic site measurements were created using tertile cutoffs from the control group of women to facilitate comparison of similar quantities of adipose tissue. Demographic predictors unrelated to HIV infection, such as age and ethnicity, were also included. The effect of age was modeled linearly but with potentially different slopes in the ranges 18 to 40, 40 to 50, and 50+ years old. Other predictors included as candidates in the modeling were level of physical activity, current smoking status, current illicit drug use (marijuana, crack, cocaine, and combination use of crack and cocaine), food consumption (adequate [defined as self-report of having enough food to eat and the kinds of food wanted] vs. inadequate), and alcohol drinks used in the past year.

Multivariable linear regression models were built using stepwise regression, with $P = 0.05$ for entry and retention, testing for interactions of HIV and ethnicity with other factors at each step; age and ethnicity were forced to be included in every model. A fat depot was included in the model if testing showed statistical significance at the 0.05 level. We tested for collinearity among fat depots and found it was not substantial. We performed stepwise regression by evaluating possible models individually rather than with an automated stepwise procedure so as to avoid exclusion of observations that had missing data only on unselected candidate variables. Because of their skewed distribution, the lipids were log-transformed in all linear regression analyses; results were back-transformed to produce estimated percentage effects of each factor. Adjusted geometric mean lipid levels were obtained from the same models using the LSMEANS statement in SAS Proc Mixed (Cary, NC) for each tertiled level of fat.

In a further stepwise multivariable analysis, we tested whether the addition of factors related to HIV infection affected the association of adipose tissue volumes with the lipids, using the complete HIV-infected cohort. HIV-related factors screened in the model were CD4 cell count, HIV RNA level, history of AIDS by OI, and current antiretroviral therapy in models similar to those previously presented,^{16,17} with current CD4 cell counts and HIV RNA levels forced to be included in the model.

Another objective was to compare lipid levels among HIV-infected and control women after adjusting for the common predictors measured in both groups. We used a stepwise multivariable analysis similar to the first one but with HIV versus control added as a factor. For this analysis, 137 HIV-infected and 129 control women were included in the analysis after age was restricted to 33 to 45 years and only data from whites and African Americans were used to match the demographics of the controls.

RESULTS

Demographic and clinical characteristics of HIV-infected and control women are presented in Table 1. Compared with control women in the same age range, HIV-infected women were younger, more likely to smoke, and more likely to report inadequate food intake and current use of crack or cocaine. The proportions of African Americans and whites were similar in the HIV-infected and control groups. Body mass index (BMI) was similar between HIV-infected and control women, but HIV-infected women had less SAT in the leg, lower trunk, and arm and a trend toward more VAT.

Among the HIV-infected women, African Americans had lower median CD4 cell counts than whites (324 vs. 417 cells/ μ L; $P = 0.039$), but HIV RNA levels and use of specific antiretroviral drugs were similar between African Americans and whites (data not shown). There were significant differences in body composition between African American and white women. Among HIV-infected women, African Americans had less VAT (median: 1.10 vs. 1.62 L; $P = 0.004$) than whites. Among controls, African Americans had more VAT (median: 1.28 vs. 0.62 L; $P = 0.017$) than white controls. Regardless of HIV status, African Americans had a higher median BMI and more subcutaneous fat in all depots (data not shown).

Compared with controls, HIV-infected women had a higher median triglyceride level (127 vs. 79 mg/dL; $P < 0.001$) and lower HDL-C (49 vs. 54 mg/dL; $P = 0.006$) (Fig. 1A). LDL-C was lower in similar aged HIV-infected women compared with control women (103 vs. 115 mg/dL; $P = 0.009$), and levels of total cholesterol were similar (188 mg/dL in HIV-infected women vs. 192 mg/dL in controls; $P = 0.22$).

When stratified by race, HIV-infected African American women had higher triglycerides (116 vs. 83 mg/dL; $P < 0.001$) compared with control African American women but had similar HDL-C (52 vs. 50 mg/dL; $P = 0.60$) and lower LDL-C (99 vs. 118 mg/dL; $P = 0.008$) (see Fig.

1B). In contrast, although HIV-infected white women also had higher triglycerides (141 vs. 78 mg/dL; $P < 0.001$), they had lower HDL-C (46 vs. 57 mg/dL; $P < 0.001$) and only slightly lower LDL-C (100 vs. 107 mg/dL; $P = 0.059$) compared with controls (see Fig. 1C). Among all HIV-infected women, African Americans had lower triglycerides and higher HDL when compared with HIV-infected whites (115 vs. 146 mg/dL; $P = 0.001$ and 52 vs. 47 mg/dL; $P = 0.009$, respectively).

The proportion of HIV-infected women with triglycerides > 150 mg/dL was higher compared with controls for African Americans (35% vs. 8%; $P < 0.001$) and whites (43% vs. 11%; $P < 0.001$). The proportion of HIV-infected women with HDL-C < 50 mg/dL was higher for whites compared with controls (61% vs. 23%; $P < 0.001$) but similar to controls for African Americans (47% vs. 48%; $P > 0.99$). The proportion of HIV-infected women with LDL-C > 130 mg/dL was slightly lower than in controls for African Americans (27% vs. 33%; $P = 0.46$) and whites (26% vs. 35%; $P = 0.33$). The proportion of all HIV-infected women with triglycerides > 150 mg/dL was lower in African Americans compared with whites, and there was a trend for HIV-infected African American women to have a lower proportion with HDL < 50 mg/dL (33% vs. 49%; $P = 0.012$ and 46% vs. 57%; $P = 0.094$, respectively).

Among whites, HIV-infected women were more likely to be on lipid-lowering therapy than controls (Table 2). The rate of lipid-lowering therapy use was similar among HIV-infected and control African American women.

Regional Adipose Tissue Volume and Triglycerides, HDL-C, and LDL-C

After adjustment for demographic and lifestyle factors, higher amounts of VAT and lower amounts of leg SAT were associated with higher triglycerides in HIV-infected women (Fig. 2). In control women, higher amounts of upper trunk SAT and lower amounts of leg SAT were associated with higher triglycerides; VAT seemed to be associated with higher triglycerides, but the magnitude of the association was less than what was seen in the HIV group (34% higher triglycerides in controls vs. 85% in HIV-infected women for subjects in the third tertile) and did not reach statistical significance.

Higher amounts of VAT were associated with lower levels of HDL-C in HIV-infected and control women. No statistically significant association between any regional adipose tissue depot and LDL-C was observed, although VAT and upper trunk SAT seemed to be weakly associated with higher levels of LDL-C in the HIV-infected women and more leg SAT seemed to be weakly associated with higher levels of LDL-C in controls.

HIV and Triglycerides, HDL-C, and LDL-C

After adjustment for demographic and HIV-unrelated factors, including adipose tissue volume, HIV infection in women was associated with higher triglycerides and lower LDL-C compared with controls; the effect of HIV on HDL-C was not statistically significant (Table 3). An interaction of HIV by ethnicity was identified ($P = 0.009$) for HDL-C, however. HIV infection in African American women was associated with 8% higher HDL-C (95% CI: -2 to 19 ; $P = 0.13$), whereas HIV infection in white women was associated with 21% lower HDL-C (95% CI: -29 to -12 ; $P < 0.001$). No statistically significant interactions of HIV by ethnicity were identified for triglycerides or LDL-C.

Among HIV-infected women, when HIV-related factors were included in the multivariable model, little change was seen in the association with adipose tissue depots (data not shown). Higher current HIV viral load was associated with higher triglycerides, lower HDL-C, and lower LDL-C (Table 4). A higher CD4 cell count also seemed to be associated with higher triglycerides. Because African Americans had lower CD4 cell counts than whites, we tested

for an ethnicity by CD4 interaction with triglycerides, which was not significant ($P = 0.62$). Being on any PI or efavirenz was independently associated with higher triglycerides, whereas current stavudine seemed to be associated with lower triglycerides. Being on nevirapine was associated with higher HDL. Being on ritonavir was associated with higher LDL-C. Tenofovir use was associated with higher triglycerides, lower HDL-C, and lower LDL-C. We did not observe any statistically significant interactions of ethnicity with the antiretroviral drugs (data not shown).

DISCUSSION

Using direct measures of regional adipose tissue in our large cohort of HIV-infected and control women, we observed that more VAT and upper trunk SAT but less leg SAT were associated with higher triglycerides; more VAT was associated with lower HDL. After adjustment for adipose tissue volumes as well as demographic and other non-HIV-related factors, HIV infection was associated with 40% higher triglycerides, whereas the association between HIV infection and HDL-C was no longer statistically significant. A prior study in HIV-infected and uninfected women observed independent effects of HIV and waist-to-hip ratio on triglycerides and HDL-C but did not distinguish the separate effects of central versus peripheral fat.²⁹

We found some important ethnic differences between HIV-infected African American and white women, which few studies have described. Both HIV-infected groups had higher triglycerides. In white women, HIV infection was associated with 21% lower HDL-C, and in African American women, HIV infection was associated with 8% higher HDL-C after adjustment. Furthermore, although HIV-infected African American women had lower LDL-C, the decrease in HIV-infected white women compared with controls was smaller. As a consequence, white women may be at more risk of cardiovascular disease. Another recent study of women with and at risk for HIV infection also found that white women had a more atherogenic lipid profile when compared with African American and Hispanic women.³⁰

In our study, the differences observed in the HIV effect on HDL by ethnicity may be partly attributed to the unexpected finding that among control women, whites had higher HDL than African Americans. Interestingly, white controls also had lower VAT than African American controls. Among the HIV-infected women, African Americans had less VAT than whites; after controlling for VAT, being African American remained independently associated with higher HDL, suggesting that the higher HDL in African Americans compared with whites is not attributable to the difference in VAT. Being African American also remained independently associated with lower triglycerides and higher HDL, after controlling for CD4 cell count, HIV RNA level, and anti-retroviral drug use.

Few, if any, studies in HIV have demonstrated an association between less leg SAT (the fat depot most affected in HIV-infected men and women) and hypertriglyceridemia. In HIV-uninfected patients, studies of familial and acquired lipodystrophy syndromes have shown a link between lipoatrophy and hypertriglyceridemia.³¹ Another study in elderly HIV-uninfected participants found an association between lower thigh subcutaneous fat and higher triglycerides, independent of abdominal fat.³²

Although more VAT has been shown to be associated with unfavorable lipid profiles in the general population, we found that higher amounts of VAT in HIV-infected women trended toward a stronger association with higher triglycerides than in control women. It is unclear whether VAT in HIV-infected women behaves differently metabolically. We previously observed that there may be some HIV-infected women who have more VAT than control women.

Among HIV-infected women, we demonstrated that higher plasma HIV RNA levels were associated with higher triglycerides, lower HDL-C, and lower LDL-C. The association between HIV infection and higher triglycerides, lower HDL-C, and lower LDL-C has previously been observed in men in the era before highly active antiretroviral therapy (HAART).¹⁻⁴ Our findings suggest that uncontrolled viral replication in HIV-infected women in the HAART era is associated with these same outcomes, supporting a possible association between chronic inflammation and alterations in lipid metabolism in HIV infection.

It is important to note that the median lipid and lipoprotein levels in our cohort of women between 33 and 45 years of age remained in the normal ranges. More HIV-infected women (especially white women) were on lipid-lowering agents. Approximately one third to one half of HIV-infected women still had lipid and lipoprotein values higher than the standard cutoffs at which behavioral or lipid-lowering therapy should be considered, however. Yet, <10% of HIV-infected women were on lipid-lowering therapy.

In contrast to the association of HIV RNA levels with triglycerides, LDL-C, and HDL-C, we found differential associations of specific antiretroviral drugs and PIs on the individual lipoproteins. The association of antiretroviral drugs with lipid parameters may be confounded by other factors, however. For instance, participants may have been removed from an antiretroviral drug because of a metabolic effect or not prescribed an antiretroviral drug because of known metabolic abnormalities, thus decreasing or even reversing the association. Nevertheless, similar to other studies,³³⁻³⁶ we found that being on a PI or the nonnucleoside reverse transcriptase inhibitor (NNRTI) efavirenz was associated with increased triglycerides and that use of nevirapine was associated with increased HDL-C. In contrast to other studies,^{15,37} we observed that being on stavudine was associated with lower rather than higher triglycerides. Because we analyzed current use of an antiretroviral drug (because of the reported acute effect of antiretroviral drugs on lipid outcomes) and adjusted for adipose tissue volume, we may not have observed the cumulative drug effects that may occur. We also observed that tenofovir use was associated with higher triglycerides, lower HDL-C, and lower LDL-C. It is unclear if our findings represent a direct effect of tenofovir, prescriber bias (in which patients with known metabolic abnormalities were specifically started on tenofovir because of the minimal effect of tenofovir on lipids), or, rather, are suggestive of patients with advanced disease being on tenofovir. Subjects on tenofovir at the time of our study had lower CD4 cell counts and slightly higher HIV RNA levels, and the prevalence of tenofovir use was low, making adjustment difficult.

The limitations of our study include its cross-sectional design, which limited the ability to determine how changes in body fat and antiretroviral drugs affect lipid and lipoprotein levels. Likewise, it is difficult to make causal inferences regarding changes in HIV disease status; therefore, our findings that a higher plasma HIV viral load, and thus uncontrolled viral replication, was associated with higher triglycerides, lower HDL, and lower LDL should be interpreted with caution. The risks identified may also not extrapolate to cardiovascular risk in all settings. Other unmeasured factors such as inflammation, diet, and additional lipid parameters may alter cardiovascular risk. The ability to adjust for regional adipose tissue depot volumes provides important information on the link between those depots and HIV effects, however.

In summary, HIV-infected women have higher triglycerides, lower HDL-C, and lower LDL-C than control women. HIV-infected white women have a more proatherogenic lipid profile despite having a higher prevalence of taking lipid-lowering medication. Less leg SAT and more VAT are important risk factors for adverse lipid profiles in women. HIV-infected women may be at particular risk of developing a proatherogenic lipid profile, because leg SAT is the fat depot most affected in HIV infection and HIV-infected women often have high amounts of

VAT. The effect of HIV infection on HDL-C is reduced after adjusting for total adipose tissue, however. Given the association of lipid abnormalities with HIV viral load, maintaining effective antiretroviral therapy (with minimal direct effects on lipid levels) to control HIV replication may be important in minimizing adverse lipid profiles, and thus cardiovascular disease risk.

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APPENDIX

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FIGURE 1.

A, Lipid and lipoprotein levels stratified by HIV status. B, Lipid and lipoprotein levels in African American women stratified by HIV status. C, Lipid and lipoprotein levels in white women stratified by HIV status.

(Triglycerides): Multivariable association of regional adipose tissue with lipid and lipoprotein levels in HIV-infected and Control women (not age restricted)

FIGURE 2.

Multivariable association of regional adipose tissue with lipid and lipoprotein levels in HIV-infected and control women (not age-restricted). Triglycerides (A), LDL-C (B), and HDL-C (C). Analyses also control for demographic and lifestyle factors and include all HIV-infected women. Italicized depots did not reach statistical significance and were not included in the model but are shown to facilitate comparison. Levels are in mg/dL. ◇ corresponds to the first tertile or lowest amount of fat; ■ corresponds to the second tertile; ▲ corresponds to the third tertile or highest amount of fat. Asterisks denote comparison with first tertile: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

TABLE 1

Demographic and Clinical Characteristics of HIV-Infected and Control Women

	Age-Restricted		<i>P</i> [*]	All
	Control	HIV-Infected		HIV-Infected
n	129	157		284
Age (y), median (IQR)	42.0 (38.0 to 44.0)	39.0 (36.0 to 42.0)	<0.0001	41.0 (36.0 to 47.0)
Race				
White	51%	34%	0.065 [†]	35%
African American	49%	53%		52%
Hispanic	0	11%		10%
Other	0	2%		3.5%
Physical activity				
First quartile	25%	38%	0.070	37%
Second quartile	25%	22%		23%
Third quartile	24%	22%		24%
Fourth quartile	26%	17%		16%
Inadequate food	11%	36%	<0.0001	38%
Current smoker	11%	48%	<0.0001	45%
Alcohol				
None	28%	38%	0.026	37%
<1/wk	31%	38%		34%
1 to 7/wk	33%	18%		20%
>7/wk	8%	6%		8%
Current marijuana	9%	14%	0.35	15%
Current crack/cocaine	1%	8%	0.004	8%
Menopausal status [‡]	7%	7%	>0.999	24%
BMI (kg/m ²), median (IQR)	27.6 (22.9 to 32.9)	26.1 (22.1 to 31.6)	0.20	25.9 (22.2 to 30.7)
VAT (L), median (IQR)	1.1 (0.44 to 1.9)	1.3 (0.6 to 2.3)	0.065	1.4 (0.62 to 2.4)
Leg SAT (L), median (IQR)	10.3 (7.3 to 13.6)	7.3 (5.1 to 10.8)	<0.0001	7.6 (5.1 to 11.0)
Lower trunk SAT (L), median (IQR)	10.9 (6.9 to 15.0)	9.5 (5.5 to 13.3)	0.024	9.3 (5.7 to 13.3)
Upper trunk SAT (L), median (IQR)	5.0 (2.8 to 8.1)	5.9 (3.2 to 8.8)	0.19	5.8 (3.4 to 8.2)
Arm SAT (L), median (IQR)	2.2 (1.4 to 2.9)	1.8 (1.2 to 2.5)	0.005	1.8 (1.2 to 2.5)
HIV risk factors				
Heterosexual		59%		56%
IDU		26%		28%
Other		15%		17%
Duration HIV (y), median (IQR)		8.5 (6.0 to 10.9)		8.2 (5.9 to 10.9)
HIV RNA level (1000 copies/mL), median (IQR)		0.8 (0.4 to 16.5)		0.4 (0.4 to 14.2)
CD4 count (cells/μL), median (IQR)		359 (185 to 567)		355 (198 to 557)
Current HAART		73%		71%
Ritonavir dose				
>400 mg/d		8%		5%
≤400 mg/d		22%		21%
None		71%		74%

Adipose tissue measures are height-normalized and back-transformed.

* *P* value from Mann-Whitney *U* test or Fisher exact test, excluding all participants with recent OI.

[†] Race comparison is proportion of whites versus African Americans.

[‡] Defined as self-report of amenorrhea for at least 12 months (not attributable to surgery) or history of bilateral oophorectomy.

IDU indicates injection drug use; IQR, interquartile range.

TABLE 2

Proportion of HIV-Infected and Control Women on Lipid-Lowering Therapy

	All Races		White		African American		P
	HIV ⁺	Control	P	HIV ⁺	Control	P	
Any lipid-lowering therapy	7.7%	1.6%	0.025	11.1%	0.0%	0.007	0.70
Statin	5.8%	0.8%	0.025	7.4%	0.0%	0.039	0.63
Fibrate	1.9%	0.0%	0.25	3.7%	0.0%	0.20	>0.99
Other	0.0%	0.8%	0.45	0%	0%	0%	0.44

Analysis is age-restricted and OI-excluded.

TABLE 3

Multivariable Association of HIV Infection With Lipid and Lipoprotein Levels* (Age-Restricted and OI-Excluded African American and White Women)

	HIV-Infected vs. Control	
	% Effect95% CI	<i>P</i>
Triglycerides	40(21 to 63)	<0.0001
HDL	-3(-10 to 5)	0.45
LDL	-17(-26 to -8)	0.001

* Multivariable linear regression of combined HIV and control populations, controlling for demographics, lifestyle factors, and regional adipose tissue volume.

TABLE 4

Multivariable Linear Regression Analysis of HIV-Related Factors Associated With Lipid and Lipoprotein Levels In HIV-Positive Women*

	Triglycerides (n = 271) [†]		HDL-C (n = 275) [†]		LDL-C (n = 316) [†]	
	% Effect(95% CI)	P	% Effect(95% CI)	P	% Effect(95% CI)	P
African American vs. white	-19(-30 to -6)	0.005	13(4 to 22)	0.003	-2(-12 to 9)	0.67
Hispanic vs. white	-2(-23 to 25)	0.87	14(-1 to 30)	0.062	3(-14 to 23)	0.74
Other vs. white	-30(-51 to 1)	0.058	0(-19 to 23)	0.98	-15(-36 to 12)	0.24
Current CD4 cell count (log ₂)	7(0 to 15)	0.050	-1(-5 to 3)	0.54	3(-2 to 8)	0.27
Current HIV viral load (log ₁₀)	12(3 to 22)	0.009	-11(-15 to -7)	<0.0001	-13(-18 to -7)	<0.0001
Currently on PI class	47(27 to 69)	<0.0001				
Currently on efavirenz	46(21 to 75)	0.0001				
Currently on stavudine	-14(-26 to 0)	0.044				
Currently on nevirapine			24(12 to 37)	<0.0001	14(1 to 29)	0.036
Currently on ritonavir			-24(-37 to -9)	0.003	-40(-53 to -24)	<0.0001
Currently on tenofovir	46(5 to 103)	0.023				

Model also controls for demographic and lifestyle factors as well as regional adipose tissue volumes.

* Not age-restricted.

[†] n differs for the different lipid and lipoprotein levels because of missing fasting lipid data.