Dyslipidemia, Diet and Physical Exercise in Children on Treatment With Antiretroviral Medication in El Salvador: A Cross-sectional Study

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Background: Dyslipidemias are common in HIV-infected children, especially if treated with protease inhibitors, but there are few data on how to treat dyslipidemias in this population. We estimated the dyslipidemia prevalence and its association with treatment, diet and physical exercise in children on antiretroviral treatment at the El Salvador reference center for pediatric HIV care (CENID).

Methods: Information was gathered regarding socio-demographic characteristics, treatment, diet and physical activity of 173 children aged 5–18 years and receiving antiretroviral therapy. Triglycerides, total cholesterol, low-density lipoprotein (LDL-C), high-density lipoprotein (HDL-C), viral load and CD4 T-lymphocytes were measured. Abnormal concentrations were defined as triglycerides ≥130 mg/dL in 10- to 18-year olds and ≥100 mg/dL in <10-year olds; total cholesterol ≥200 mg/dL; LDL-C ≥130 mg/dL and HDL-C ≤35 mg/dL. We adjusted 4 different multivariate models to assess the independent association of each type of dyslipidemia with protease inhibitors, diet and physical exercise.

Results: Of the 173 children, 83 (48%) had hypertriglyceridemia and 25 (14.5%) hypercholesterolemia. High LDL-C concentrations were observed in 17 children (9.8%) and low HDL-C in 38 (22%). Treatment with protease inhibitors was significantly associated with hypertriglyceridemia [prevalence ratio (PR) 2.8; 95% confidence interval (CI): 2.0–3.8] and hypercholesterolemia (PR 9.0; 95% CI: 3.6–22.2). Higher adherence to a "high fat/sugar diet" was associated with hypercholesterolemia (PR 1.6; 95% CI: 1.1–2.3) and high LDL-C (PR 1.7; 95% CI: 1.0–2.9). Compared with those exercising <3 times/week, children exercising ≥7 times were less likely to have low HDL-C (PR = 0.4; 95% CI: 0.2–0.7).

Conclusions: These results suggest that a healthy diet and exercise habits can contribute to controlling some aspects of the lipid profile in this population.

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Dyslipidemia is frequent in HIV-infected children, as it has been reported in studies from North America,[1,2] South America,[3] Europe,[4] Asia[5] and Africa.[6] Dyslipidemia has been observed even in the absence of any HIV treatment,[5,6] but usually worsens with antiretroviral drugs (ART),[5,7,8] especially if protease inhibitors (PIs) are used.[9,10] To the best of our knowledge, there is no published study reporting on the prevalence of dyslipidemia and its association with PI among HIV-infected children in Central America.

The presence of cardiovascular risk factors (such as dyslipidemia) in childhood is related to atherosclerotic vascular changes in adulthood.[11,12] In HIV-infected children premature cardiovascular complications have been documented, such as arterial stiffness and biomarkers of vascular dysfunction in childhood[13,14]; increased risk score for atherosclerotic cardiovascular disease in adolescence[15] and increased thickness of the carotid intima media in adolescents and young adults.[16]

Genetic factors can partly explain the differences in the susceptibility to ART-related dyslipidemia among patients,[17] and genetics will probably help in the future to shape individualized treatments. In resource poor countries, only few options are available to prevent and treat lipid abnormalities in HIV-infected children, because the use of statins is recommended only for specific cases[18] and the switch from PIs to more lipid-favorable drugs[19] may not always be possible. A recent review suggests that dietary counseling and physical exercise can improve metabolic abnormalities in adults with HIV/AIDS,[20] but little information is available for children.[21,22]

The objectives of this study were to estimate the prevalence of dyslipidemia in children on ART in El Salvador and to study the independent association between dyslipidemia and ARV treatment, diet and physical exercise.

El Salvador is a low-middle income country of Central America. It has about 6 million inhabitants, 34.5% of whom live below the poverty line.[23] According to the most recent estimates, the prevalence of HIV among adults and adolescents aged 15–49 years is 0.6%.[24] No specific estimates are currently available in children.

MATERIALS AND METHODS

Data Collection

Between December 2010 and December 2011 a cross-sectional survey was performed at the "Centro de Excelencia para Niños con Inmunodeficiencias" (CENID) of the Benjamin Bloom Children Hospital in San Salvador, the institution through which all children diagnosed with HIV resident in El Salvador are receiving medical care and follow-up.

We focused on the children on antiretroviral treatment, aged 5–18 years at the time of the survey. Data collection took place throughout the year during their follow-up visit, after the informed consent was obtained from parents or guardians.

Information on socio-demographic characteristics and current treatment were extracted from individual medical and social records. A structured questionnaire was administered to the children and their caretakers (only to caretakers in the case of children below 10 years), that included a 24-hour dietary recall; a weekly food frequency questionnaire (FFQ) and a section on the types and frequency of physical activities.

At the time of the survey, the children were weighed and measured with a combined weighting scale and stadiometer (DETECTO, model 43).

Triglycerides (TG), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C-C) and high-density lipoprotein cholesterol (HDL-C-C) were measured after 12 hours of fasting, using the Beckman-Coulter Synchron CX TGB and CHOL. The manual Beckman-Coulter CD4 count kit was used for the CD4 counting, and the Roche PCR AmpliPrep Taq-Man96 for viral load measurement (PCR).

Variables Definitions

Abnormal lipid concentrations were defined as TC ≥200 mg/dL, LDL-C ≥130 mg/dL and HDL-C ≤35 mg/dL. TG was considered abnormal if ≥130 mg/dL in children aged 10–18 years and ≥100 mg/dL in children aged <10 years.[18,25,26]

The dietary habits were assessed through an FFQ based upon the standardized FFQ used in the 2006 Spanish National Health Survey.[27] The food list was adapted to the El Salvador context, grounded on the consultation of bibliography, input by local nutrition experts and the results of 24-hour recalls conducted previously in the population of study.

The frequency of food intake was measured across 5 categories ranging from "Rarely or never" to "Daily." The reference period was an average 7-day week over the last month. No information on the portion size of foods consumed was obtained.

The FFQ results were used to identify dietary patterns by principal component analysis. This is a statistical technique that aggregates the data on specific foods items into patterns on the basis of their correlation with one another. A summary score is then derived for each pattern and can be used in further analysis to explore the association between dietary patterns and the selected outcome.[28]

In this population, 3 main patterns were identified, which we classified as: "healthy diet," "poor diet" and "high fat/sugar diet." The "high fat/sugar diet" pattern, consisting of a diet poor in fruits and vegetables and rich in sweets, sugary drinks, fat processed foods, eggs and meat or fish, was used in the analysis as a proxy for unhealthy diet. An index of adherence to the "high fat/sugar diet" was created and subsequently divided in tertiles. The highest tertile was considered as "high adherence" to the pattern and the 2 lowest tertiles as "low adherence."

Questions on physical activity were based on the SIVFRENT-J, the standardized questionnaire of the "Surveillance System for Risk Factors associated with Non-Transmissible Diseases in Youth" of the Madrid Region (Spain),[29] adapted to local activities preferences.

Physical activity was determined by asking whether, during an average 7-day week over the last month, the child engaged in any of the activities from a list read by the interviewer (including soccer, commuting to and from school, biking, basketball, running and physical education at school, among others). There was also the possibility for the child or the caregiver to report on activities not included in the list. The number of times per week the child engaged in each of the reported activities was registered, but not the length or intensity of the exercise. Considering all the activities performed, we calculated the average number of times per week the child engaged in exercising, and created 3 categories: (1) exercise less than 3 times a week; (2) 3–6 times a week; (3) 7 or more times a week.

The adjustment variables were: duration of treatment; HIV viral load (under or above 50 copies/mL); CD4 cell count; age; sex; body mass index (BMI)-for-age Z score, calculated from height, weight and date of birth as for the WHO 2007 references[30]; residence (rural or urban) and socioeconomic status. All children admitted at the CENID were classified by the social worker, according to their socioeconomic conditions, in one of these 6 categories: (1) extremely poor; (2) poor; (3) low class; (4) medium class; (5) high class or (6) living in institution. However, as there were no children classified as high class, the fifth category was deleted, and the low and middle income categories were collapsed in one because of the low number of children ranked in each of them. Therefore, the final socioeconomic variable contained only 4 categories: (1) extremely poor; (2) poor; (3) low-middle class and (4) "institution."

Statistical Analysis

Statistical analysis was performed using the STATA statistical software package, version 12. We described the characteristics of the children disaggregated by sex, as recommended to avoid gender bias.[31]

The prevalence of elevated TG, TC and LDL-C levels, and low HDL-C levels were calculated for each category of the independent variables. Differences were tested for continuous and categorical variables through *t* test and χ^2 test, respectively.

Crude and adjusted prevalence ratios (PRs) and their 95% confidence interval (CI) were calculated using the Poisson regression analysis with a robust variance estimator.[32] Four multivariate models (one for each type of dyslipidemia) were created, adjusted for all the variables listed above.

The possible interactions between sex and the independent variables were explored, as well as the interactions between use of PI and adherence to the "high fat/sugar diet" or physical exercise.

P values <0.05 were considered statistically significant in all the analyses.

Ethical Approval

The study was approved by the Clinical Research Ethical Committee (Comité de Etica en Investigacion Clinica) of the Hospital Nacional de Niños Benjamín Bloom in El Salvador and by the Research Ethical Committee (Comité de Ética de la Investigación y Bienestar Animal) of the Instituto de Salud Carlos III in Spain.

RESULTS

Characteristics of the Sample

At the time of the survey 312 children were in medical care at the CENID; 270 of them were aged 5–18 years and were taking ART. Because of shortage in laboratory reagents, for 95 children (35%) LDL-C and/or HDL-C could not be measured. Two other children had missing data on diet and duration of treatment, respectively; thus, 173 children with complete data (64% of the eligible) were finally included into the analysis.

Children with complete lipid data did not show significant differences as compared with children with missing values (see Table, Supplemental Digital Content 1, http://links.lww.com/INF/C501).

In nearly all the children (170/173) vertical transmission of HIV-1 was documented; in the remaining 3, the mode of transmission was unknown.

Twenty children (11.6%) were institutionalized. Of the rest, 86.3% were living in poverty or extreme poverty. Mean age at the survey was 10.2 years (standard deviation 3.0), with 69% of the children under 12 years of age. Sixty percent of the children had been on treatment for more than 5 years, and the majority had undetectable viral load (77.5%) and showed no immunosuppression (89.0%).

The only statistical differences found between girls and boys (see Table, Supplemental Digital Content 2, http://links.lww.com/INF/C502) were the residence in rural areas (higher in boys, $P = 0.008$), and the physical activity [42.5% of girls versus 17.2% of boys practiced exercise less than 3 times a week, while only 37.5% of girls practiced 7 times a week or more, compared with 52.7% of boys ($P = 0.001$)].

At the time of the survey, 49 children (28.3%) were receiving PI, in most cases (91.8%) in combination with 2 nucleoside reverse transcriptase inhibitors; the remaining 124 children were on a combination including 2 nucleoside reverse transcriptase inhibitors and 1 nonnucleoside reverse transcriptase inhibitor.

One hundred and four children presented with at least one type of dyslipidemia, accounting for an overall prevalence of 60.1% (95% CI: 52.7–67.5). Elevated TG was the most common (48%) lipid abnormality, followed by low HDL-C levels (21%). TC and LDL-C cholesterol were elevated in 14.5% and 9.8% of the children, respectively. The mean values (±standard deviation) for TG, TC, LDL-C and HDL-C were 132 (±80) mg/dL, 161 (±38) mg/dL, 88 (±30) mg/dL and 45 (±12) mg/dL, respectively. No significant differences were found between boys and girls.

Bivariate Analysis

The results of the bivariate analysis are presented in Tables 1 and 2.

Children on PI medication were significantly more likely, compared with those not receiving PIs, to have elevated TG levels (86% versus 33%; $P < 0.001$) and elevated TC levels (37% vs. 6%; $P < 0.001$).

The prevalence of low HDL-C was 36% in children exercising less than 3 times per week, 20% in those exercising 3–6 times and 14% in children exercising more than 7 times per week ($P = 0.012$; P for trend = 0.004).

BMI Z score was significantly associated with elevated TG and LDL-C, whilst time on therapy was inversely associated with low HDL-C.

Multivariate Analysis

The results of the multivariate analysis are presented in Table 3. Children on a regimen containing PI were significantly more likely to have high TG (PR 2.6; 95% CI: 2.0−3.8; $P < 0.001$) and high TC (PR 9.0; 95% CI: 3.6−22.2; $P < 0.001$).

After adjustment, children with high adherence to the "high fat/sugar diet" were more likely to have high TC (PR 1.6; 95% CI: 1.1−2.3; $P = 0.019$) and high LDL-C (PR 1.7; 95% CI: 1.0−2.9; $P = 0.052$).

The probability of having low HDL-C decreased as the frequency of physical activity increased: compared with children practicing exercise less than 3 times a week, the PR for low HLD levels was 0.5 (95% CI: 0.3−1.1; $P = 0.107$) for children practicing 3–6 times per week, and 0.4 (95% CI: 0.2−0.7; $P = 0.005$) for those practicing 7 times per week or more.

TABLE 1. Association of Independent Variables With High TG and High TC: Bivariate Analysis

Variables	Categories	Total N	Triglycerides High TG n (%)	Triglycerides Crude PR (95% CI)	Cholesterol High TC n (%)	Cholesterol Crude PR (95% CI)
Total sample		173	83 (48.0)		36 (13.3)	
Protease inhibitors in current regimen	No	124	41 (33.1)	Ref	7 (5.6)	Ref
	Yes	49	42 (85.7)	2.59 (1.97–3.41)*	18 (36.7)	6.51 (2.89–14.63)*
High fat/sugar diet	Low adherence	111	54 (48.6)	Ref	13 (11.7)	Ref
	High adherence	62	29 (46.8)	0.98 (0.83–1.15)	12 (19.3)	1.28 (0.90–1.84)
Physical activity (times/week)	<3	50	22 (44.0)	Ref	5 (10.0)	Ref
	3–6	44	22 (50.0)	1.14 (0.74–1.75)	8 (18.2)	1.82 (0.64–5.17)
	≥7	79	39 (49.4)	1.12 (0.76–1.65)	12(15.2)	1.52 (0.57–4.06)
Residence	Urban	126	64 (50.8)	Ref	17 (13.5)	Ref
	Rural	47	19 (40.4)	0.80 (0.54–1.17)	8 (17.0)	1.26 (0.58–2.73)
Socioeconomic status	Extreme	52	24 (46.1)	Ref	6 (11.5)	Ref
	Poverty	80	38 (47.5)	1.03 (0.71–1.45)	12 (15.0)	1.30 (0.61–3.26)
	Medium-low	21	9 (42.9)	0.93 (0.52–1.65)	5 (23.8)	2.06 (0.70–6.05)
	Institution	20	12 (60.0)	1.30 (0.82–2.0.7)	2 (10.0)	0.87 (0.19–3.95)
Sex	Female	80	36 (45.0)	Ref	8 (10.0)	Ref
	Male	93	47 (50.5)	1.12 (0.82–1.54)	17 (18.3)	1.83 (0.83–4.02)
Age in yrs (continuous)				0.99 (0.94–1.05)		1.03 (0.92–1.17)
BMI-for-age Z score†				1.21 (1.04–1.39)*		1.23 (0.92–1.67)
Age at diagnosis (yrs)				0.97 (0.92–1.03)		1.02 (0.90–1.15)
Years on treatment				1.02 (0.95–1.10)		1.11 (0.92–1.34)
CD4‡				1.02 (0.97–1.06)		1.03 (0.96–1.11)
Viral load (copies/mL)	<50	134	65 (48.5)	Ref	20 (14.9)	Ref
	≥50	39	18 (46.1)	0.95 (0.65–1.39)	5 (12.8)	0.86 (0.34–2.15)

N = 173.
*$P < 0.05$.
†PR increase per 1 standard deviation.
‡PR increase per 100 cell/mm^3.

TABLE 2. Association of Independent Variables With High LDL and Low HDL: Bivariate Analysis

			LDL Cholesterol		HDL Cholesterol	
		Total	High LDL		Low HDL	
Variables	Categories	N	n (%)	Crude PR (95% CI)	n (%)	Crude PR (95% CI)
Total sample		173	17 (9.8)		39 (21.3)	
Protease inhibitors in current regimen	No	124	9 (7.3)	Ref	31 (25.0)	Ref
	Yes	49	8 (16.3)	2.25 (0.92–5.51)	7 (14.3)	0.57 (0.27–1.21)
High fat/sugar diet	Low adherence	111	8 (7.2)	Ref	25 (22.5)	Ref
	High adherence	62	9 (14.5)	1.42 (0.90–2.23)	13 (21.0)	0.96 (0.72–1.30)
Physical activity (times/week)	<3	50	4 (8.0)	Ref	18 (36.0)	Ref
	3–6	44	4 (9.1)	1.14 (0.30–4.29)	9 (20.4)	0.54 (0.27–1.09)
	≥7	79	9 (11.4)	1.42 (0.46–4.39)	11 (13.9)	0.40 (0.20–0.73)*
Residence	Urban	126	9 (7.1)	Ref	28 (22.2)	Ref
	Rural	47	8 (17.1)	2.38 (0.97–5.83)	10 (21.3	0.96 (0.50–1.82)
Socioeconomic status	Extreme poverty	52	5 (9.6)	Ref	15 (28.8)	Ref
	Poverty	80	7 (8.7)	0.91 (0.30–2.72)	18 (22.5)	0.78 (0.43–1.41)
	Medium-low	21	4 (19.0)	1.98 (0.59–6.69)	1 (4.5)	0.16 (0.02–1.18)
	Institution	20	1 (5.0)	0.52 (0.06–4.20)	4 (20.0)	0.69 (0.26–1.84)
Sex	Female	80	5 (6.2)	Ref	16 (20.0)	Ref
	Male	93	12 (12.9)	2.06 (0.76–5.63)	22 (23.7)	1.18 (0.67–2.10)
Age in yrs (continuous)				0.92 (0.78–1.09)		0.95 (0.86–1.05)
BMI-for-age Z score†				1.60 (1.12–2.27)*		0.94 (0.71–1.23)
Age at diagnosis (yrs)				0.91 (0.79–1.05)		1.03 (0.94–1.12)
Years on treatment				1.04 (0.85–1.26)		0.84 (0.74–0.94)*
CD4‡				1.01 (0.91–1.12)		0.99 (0.90–1.08)
Viral load (copies/mL)	<50	134	14 (10.4)	Ref	28 (20.9)	Ref
	≥50	39	3 (7.7)	0.74 (0.22–2.44)	10 (25.6)	1.23 (0.65–2.30)

N = 173.
*$P < 0.05$.
†PR increase per 1 standard deviation.
‡PR increase per 100 cell/mm^3.

After adjustment, boys were nearly twice more likely to have low HDL-C than girls (PR 1.9; 95% CI: 1.1–3.4; $P = 0.025$).

BMI Z score was directly associated with high TG and LDL-C. For each year of ART treatment, the PR for low HDL-C was reduced by 16%.

No interaction was found between sex and use of PI, "high fat/sugar diet" or physical exercise, nor between the use of PI and "high fat/sugar diet" or physical exercise.

DISCUSSION

This study shows that dyslipidemia is a common disorder in the children with HIV treated at the CENID in El Salvador. Therapy including PI is associated with elevated TG and TC. Furthermore, high adherence to a "high fat/sugar diet" is associated with elevated TC and LDL-C, whilst increased physical activity is associated with healthier HDL-C levels.

The finding of a high prevalence of dyslipidemia in this population is consistent with other studies,[33–38] and the lipid mean

TABLE 3. Association of Independent Variables With Abnormal Lipid Levels: Multivariate Models

		Triglycerides	Cholesterol	High LDL	Low HDL
Variables	Categories	PR (95% CI)†	PR (95% CI)†	PR (95% CI)†	PR (95% CI)†
Protease inhibitors in current regimen	No	Ref	Ref	Ref	Ref
	Yes	2.79 (2.04–3.80)*	9.00 (3.65–22.22)*	2.57 (0.92–7.17)	0.55 (0.25–1.24)
High fat/sugar diet	Low adherence	Ref	Ref	Ref	Ref
	High adherence	1.07 (0.91–1.25)	1.59 (1.08–2.33)*	1.69 (1.00–2.87)	0.93 (0.69–1.25)
Physical activity (times/week)	<3	Ref	Ref	Ref	Ref
	3–6	0.90 (0.60–1.36)	1.27 (0.44–3.62)	1.06 (0.24–4.73)	0.55 (0.27–1.14)
	≥7	0.95 (0.65–1.38)	0.99 (0.39–2.53)	1.03 (0.33–3.27)	0.38 (0.19–0.74)*
Sex	Female	Ref	Ref	Ref	Ref
	Male	1.08 (0.80–1.44)	1.71 (0.74–3.98)	1.77 (0.57–5.52)	1.94 (1.09–3.45)*
BMI-for-age Z scores (continuous)‡		1.22 (1.04–1.45)*	1.13 (0.82–1.56)	1.54 (1.05–2.27)*	1.10 (0.83–1.44)
Years of treatment (continuous)		0.96 (0.90–1.03)	0.96 (0.84–1.10)	1.01 (0.84–1.22)	0.84 (0.74–0.96)*

*$P < 0.05$.
†Models also adjusted for residence (rural/urban), socioeconomic status, age, CD4 count and viral load (all nonsignificant).
‡PR increase per 1 standard deviation.

values encountered are close to those of other samples of HIV-infected children in Mexico,[39] Brazil,[40] Spain[4] and US.[41]

Our population has a mean level of TG that is 20–60 mg/dL higher than that of the general population of children from Brazil,[42] Costa Rica[43] and Mexico[44] (there are no available data on healthy Salvadorian children). This is consistent with studies comparing HIV-infected children with children from the general population.[1,41] These studies, however, also find lower levels of HDL-C in HIV-infected children, whilst our comparison with neighboring populations shows similar or higher HDL-C levels.[42–44]

The finding of a strong association between PI treatment and elevated TG and TC is in line with the existing literature.[3,6,33] Although LDL-C and HDL-C are less extensively studied, the higher likelihood of elevated LDL-C and low HDL-C found in this study is confirmed also by some other reports.[6,41]

The association between a "high fat/sugar diet" pattern and elevated TC and LDL-C has been widely described in healthy children[45,46] and adults,[47] but scarcely documented in HIV-infected children. Our results are among the first to document such an association, which may have important implications for policies and future studies.

Another finding of this study is the strong association found between physical activity and better HDL-C profiles. Although similar associations have been reported for HIV-infected adults,[48,49] and for healthy[50] and overweight[51,52] children, results in HIV-infected children are limited and not consistent. Two studies did not show association between exercise and blood lipid levels in HIV-infected children,[21,22] but they cannot be compared directly with our results, as in one of them dyslipidemia was analyzed in conjunction with lipodystrophy,[21] and in the other one only 10 subjects were evaluated.[22]

In our study boys are nearly twice more likely to have low HDL-C than girls, in consistency with the reported higher risk of coronary disease in perinatally infected male adolescents.[15] Moreover, difference by sex is evident for physical activity, with girls exercising less than boys. Similar results have been reported for the general Latin-American population.[53] Furthermore, most children in our sample exercised less than 7 times a week, which is far from the WHO recommendations of at least 60 minutes of daily physical activity for 5- to 17-year olds.[54]

Strengths and Limitations

To the best of our knowledge, this is the first study to be published on dyslipidemia in HIV-infected children in El Salvador and, as far as we know, in Central America. The study tries to avoid gender bias, by describing the characteristics of the population disaggregated by sex and exploring if sex is a modifier in the association between the main independent variables and dyslipidemia. Furthermore, it is among the first studies to analyze the association of diet and physical exercise with dyslipidemia in children with HIV.

There was a participation rate of 100%, but 36% of children, because of lack of reagents, had missing values on the LDL-C and HDL-C measurements and could not be analyzed. However, no differences were found between children with and without missing values, therefore the results can be probably generalized to all the children diagnosed with HIV infection living in El Salvador.

The study has the limitations inherent to a cross-sectional design, including difficulty in establishing a temporal relationship between risk factors and outcomes. Another limitation is the lack of ART-naïve or HIV-negative controls, which would have helped to better understand what risk factors for dyslipidemia are specific to the population of HIV-infected children on ART.

CONCLUSIONS

This study shows that HIV-infected children on ART treatment in El Salvador are a population at high risk for dyslipidemia, especially high TG and low HDL-C.

The results suggest that avoiding an unhealthy diet and practicing physical activity can improve the lipid levels also in HIV-infected children on ART treatment. Moreover, our study shows that the PI use does not modify the effect of diet and physical exercise on lipids in this population, suggesting that patients taking PI and patients not taking PI can equally benefit from a healthy diet and exercise practice. Physical activity should be encouraged in boys, who are at higher risk for low HDL-C, and in girls, who have less physical activity with respect to boys.

Large cohort studies are needed to confirm these findings in the pediatric HIV population, while intervention trials may clarify the benefit of different prevention and treatment strategies. While awaiting for more evidence, diet and exercise advice are likely to be useful, especially in low and medium income countries, where routine measurement of lipids are not always available and where the choice of antiretroviral drugs is often limited.

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