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Dietary inadequacies in HIV-infected and uninfected school-aged children in Johannesburg, South Africa

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Abstract

Objectives—The World Health Organization (WHO) recommends that HIV-infected children increase energy intake and maintain a balanced macronutrient distribution for optimal growth and nutrition. Few studies have evaluated dietary intake of HIV-infected children in resource-limited settings.

Methods—We conducted a cross-sectional analysis of the dietary intake of 220 perinatally HIV-infected children and 220 HIV-uninfected controls ages 5–9 years in Johannesburg, South Africa. A standardized 24-hour recall questionnaire and software developed specifically for the South African population was used to estimate intake of energy, macronutrients, and micronutrients. Intake was categorized based on recommendations by the WHO and Acceptable Macronutrient Distribution Ranges (AMDRs) established by the Institute of Medicine (IOM).

Results—The overall mean age was 6.7 years and 51.8% were boys. Total energy intake was higher in HIV-infected than HIV-uninfected children (1341 vs. 1196 kcal/day, p=0.002), but proportions below the recommended energy requirement were similar in the two groups (82.5 vs. 85.2%, p=0.45). Overall, 51.8% of the macronutrient energy intake was from carbohydrates,

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The study was designed by AC, MTY, LK, and SMA. Data was collected by RS, FP, and AC. SS, AW, SK analyzed the data under the supervision of SMA. SS, AW, and SMA drafted the manuscript. All authors critically reviewed and edited the manuscript, and approved the final version for submission (SS, AW, RS, FP, AC, SK, SB, MTY, LK, SMA).

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The authors have no conflicts of interest to declare.

13.2% from protein, and 30.8% from fat. The HIV-infected group had a higher percentage of their energy intake from carbohydrates and lower percentage from protein compared to the HIV-uninfected group. Intakes of folate, vitamin A, vitamin D, calcium, iodine, and selenium were suboptimal for both groups.

Conclusions—Our findings suggest that the typical diet of HIV-infected children as well as uninfected children in Johannesburg, South Africa does not meet energy or micronutrient requirements. There appear to be opportunities for interventions to improve dietary intake for both groups.

Introduction

HIV infection is commonly accompanied by poor growth during childhood and various forms of malnutrition due to reduced dietary intake, poor nutrient absorption, excessive nutrient losses, as well as increased energy utilization (1). Dietary inadequacies are of particular concern for children with HIV, as malnutrition can further contribute to immune dysfunction and potentially accelerate disease progression (2).

Recognition of the importance of nutritional considerations in the care of children with HIV led to the development of the World Health Organization (WHO) Guidelines for an Integrated Approach to the Nutritional Care of HIV-Infected Children (3). These nutritional guidelines recommend increases in energy intake for HIV-infected children above those of the general population, even for those who are growing well and are asymptomatic or only mildly symptomatic, while maintaining a balanced age-appropriate macronutrient distribution of carbohydrates, protein, and, fat. In addition, adequate micronutrient intake is essential, as micronutrient deficiency and HIV both impact immune function.

Diet may also be important with respect to a number of metabolic alterations, including dyslipidemias and alterations in glucose-insulin homeostasis, that are prevalent in children with HIV who are receiving antiretroviral therapy (ART), and are known to elevate long term risk for cardiovascular disease (4, 5).

In many sub-Saharan African communities where >90% of the estimated 1.8 million children living with HIV now reside, childhood malnutrition, including protein energy malnutrition and micronutrient deficiencies, are common, with a prevalence close to 20% (6–8). However, few recent studies have assessed the dietary patterns of ART-treated HIV-infected sub-Saharan African children. The aim of this study is to assess the dietary intake of a group of school-aged perinatally HIV-infected children with well-controlled disease who started ART early. Infected children are compared to a control group of HIV-uninfected children of a similar age from the same communities. Dietary intake was evaluated based on the WHO nutritional guidelines as well as macronutrient distribution ranges and micronutrient requirements recommended by the Institute of Medicine (IOM) (9).

Methods

Study population

This cross-sectional study uses dietary intake data collected from all children at the baseline visit of the CHANGES Bone Study, an observational cohort study of HIV-infected and uninfected children ages 5–9 years, conducted at Empilweni Service and Research Unit (ESRU) at Rahima Moosa Mother and Child Hospital in Johannesburg, South Africa (10, 11). This analysis includes 220 perinatally HIV-infected children who started ART at a mean age of 9 months and a control group of 220 healthy HIV-uninfected children, comprised of sibling/household members of the HIV-infected subjects and otherwise healthy children attending hospital clinics for non-acute routine health services. Children with current corticosteroid or anticonvulsant drug use, known bone, renal, or liver disease, malabsorption syndrome, or inflammatory bowel disease, were excluded from enrollment.

Measurements

Demographic information was collected using a questionnaire. Weight in kilograms (kg) was measured by a digital scale (Micro Electronic Platform Scale T3, ScaleRite, Gauteng, South Africa) and height in centimeters (cm) by a wall-mounted stadiometer (Seca 216, Seca, Chino, CA, USA). Body mass index (BMI) was calculated as kg/m^2. Weight-for-age (WAZ), height-for-age (HAZ), and BMI-for-age (BAZ) Z-scores were calculated using WHO Child Growth Standards (12). Underweight was defined as WAZ <-2 and stunted was defined as HAZ <-2. Mid upper arm circumference (MUAC) was measured with a fiberglass tape measure with compression spring (Gulick II, Country Technology, Gays Mills, WI, USA). For HIV-infected children, CD4 percentage and HIV-1 RNA quantity were measured (Roche COBAS INTEGRA 400 system, Switzerland).

Dietary intake was evaluated by two methods: a single 24-Hour Recall (24H Recall) diet questionnaire and a quantitative Food Frequency Questionnaire (FFQ) (13). While the 24H Recall provides information on specific foods and amounts consumed within the past 24 hours, the FFQ provides information on the average long-term diet (past 6 months). Both have been used and validated for this age group in the South African National Food Consumption Survey (14). Trained study interviewers administered the questionnaires to the caregivers of the study participants at ESRU, engaging both the caregiver and the child in the recall of his/her food and beverage intake using food flash cards and a food photo manual (Dietary Assessment and Education Kit, South Africa Medical Research Council, Tygerberg, South Africa) (15).

Diet assessment

The questionnaire results were converted to nutritional information using Food Finder 3, a dietary assessment software program that includes a comprehensive list of commonly consumed foods in South Africa. This program was developed by the Nutritional Intervention Research Unit and the Biomedical Informatics Research Division of the South African Council in collaboration with WAMTechnology CC (Stellenbosch, South Africa).

First, the average daily intake of energy, macronutrients, and micronutrients was calculated by using the collected data from the 24H Recall questionnaire (16). Total energy intakes (kcals/day) for HIV-infected subjects were compared to energy requirements recommended by the WHO for children ages 6–9 years: 1650 kcal/day for HIV-uninfected children and 10% additional (1815 kcal/day) for HIV-infected children (3, 17). Evaluated micronutrients included in the study were folate, vitamin A, vitamin B6, vitamin B12, vitamin C, vitamin D, calcium, iodine, iron, magnesium, phosphorus, selenium, and zinc.

Intakes of total carbohydrates, total fat, and total protein, expressed as percentages of total energy intake, were calculated and evaluated against the Acceptable Macronutrient Distribution Range (AMDR), the percentage of total calorie intake that is recommended for a particular macronutrient (9). For 4–8 year olds the AMDR is as follows: 45–65% for total carbohydrates, 25–35% for total fat, and 10–30% for total protein. The prevalence of adequate, high, and low macronutrient intake was determined.

In addition, consumption of added sugars in g/day expressed as a percentage of total carbohydrates as well as total energy was calculated and compared to the WHO recommendation (limit to no more than 10% of total energy intake) (18). Polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), saturated fat, and trans fat were calculated as a percentage of total fat intake; plant protein and animal protein were calculated as a percentage of total protein intake. Total fiber (g/day) was evaluated against the recommended dietary allowance (RDA) for 4–8 year olds: 25 g/day of total fiber. Cholesterol intake was reported as mg/day.

We estimated the prevalence of adequate and inadequate micronutrient intake using the IOM Estimated Average Requirement (EAR) thresholds for vitamin A, vitamin B6, vitamin B12, vitamin C, vitamin D, calcium, iodine, iron, magnesium, phosphorous, selenium, and zinc (9). Micronutrients of concern were defined as those for which greater than 50% of the group (HIV-infected or HIV-uninfected) had inadequate intake.

Based on results from the FFQ, we calculated the percentage that each food item contributed to energy, carbohydrates, protein, fat, cholesterol, and fiber intake on average in the combined group of children (HIV-infected and uninfected). We identified the ten most frequently reported sources of energy, carbohydrates, protein, fat, cholesterol, and fiber by ranking food items in descending order of this percentage. Food items were defined as not only single food items (e.g. pear) but also as mixed dishes (e.g. sardines in tomato sauce). Results were also stratified by HIV status.

In addition, using data from the 24H Recall questionnaire, a diet diversity score was calculated as an additional measure of micronutrient adequacy (19–21). Diet diversity is defined as the number of different food groups consumed over a given reference period, in this instance it was the past day. A single point was assigned for consumption in the past day of each of the following 9 food groups in the child's diet and the diet diversity score was calculated as the sum: (i) cereals; (ii) roots; (iii) vegetables; (iv) fruit; (v) meat, poultry, and fish; (vi) eggs; (vii) legumes; (viii) dairy products; and (ix) fats or oils. Each group was counted only once. A diet diversity score value <4 was considered low (20).

Signed informed consent was provided by each child's parent/guardian and children provided assent if they were at least 7 years old and able to understand. The study was approved by the Institutional Review Boards of Columbia University (New York, New York) and the University of the Witwatersrand (Johannesburg, South Africa).

Statistical analysis

Comparisons between HIV-infected children and those in the HIV-uninfected group were conducted using t-tests for continuous variables and χ^2 tests or Fisher's exact tests for categorical variables. Analyses of energy intake, macronutrients, and micronutrients were repeated stratified by sex. All p-values are 2-tailed and p-values <0.05 were considered statistically significant. Data analysis was performed using SAS version 9.4 (Cary, NC).

Results

Characteristics

Demographic characteristics of the study participants are presented in Table 1. There were 228 males (51.8%), and the mean±SD age was 6.7±1.4 years. The HIV-infected group was younger (6.4 years vs. 7.0 years, p<0.0001). The mean WAZ and HAZ of both the HIV-infected group (−0.83±0.9 and −1.4±0.9, respectively) and HIV-uninfected group (−0.29±1.1 and −0.82±0.9, respectively) fell below the reference norm and both parameters were significantly lower in the HIV-infected compared to the HIV-uninfected group (p<0.0001). In addition, a greater proportion of HIV-infected children were underweight and stunted compared to HIV-uninfected participants. The HIV-infected children had been on ART for a mean of 5.7±1.1 years, with 93.6% virally suppressed (HIV RNA quantity <400 copies/ml) and a mean CD4 percentage of 37.3±7.1%, which is normal for children of this age. There were no significant differences in household characteristics between the groups (data not shown). All but 7 (98%) of the 24H Recall questionnaires were completed, and 100% of the FFQs were completed. In all cases of missing data, the caregiver who brought the child to the clinic did not know what the child had eaten on the day prior to the visit.

Total energy and macronutrients

The average daily intakes of energy and macronutrients, as well as the proportion of children meeting and not meeting recommended intakes are reported in Table 2. Although the reported total energy intake was approximately 12% greater in HIV-infected than HIV-uninfected children (1341 vs. 1196 kcal/day, p=0.002), similar proportions of both groups fell below their respective recommended dietary energy intake. Among the HIV-uninfected children, 85.2% fell below the recommended intake of 1650 kcal/day for HIV-uninfected children ages 6–9 and 82.5% of the HIV-infected children fell below the recommended intake of 1815 kcal/day (10% higher) for HIV-infected children of the same age (3). Differences in total energy intake between groups remained after adjustment for weight.

Overall 51.8% of the macronutrient energy intake was from carbohydrates, 13.2% from protein, and 30.8% from fat, on average. Small but significant differences in macronutrient distribution were observed between the groups. The diet of HIV-infected children consisted of a higher mean percentage of energy intake from carbohydrates (53.0±9.2 vs 50.6±10.7%, p=0.012) and slightly lower mean percentage of energy intake from fat (29.8±9.6 vs 31.8±11.4%, p=0.043) and protein (12.9±4.3 vs. 13.5±4.0%, p=0.13). In addition, HIV-infected children had a higher mean percentage of fat intake from saturated fat (33.0±7.9 vs. 30.8±6.6%, p=0.002) compared to HIV-uninfected children, and higher mean percentage of fat intake from trans fat (2.7±2.4 vs. 2.3±1.9%, p=0.048). HIV-uninfected children had a higher mean percentage carbohydrates coming from added sugars compared to the HIV-infected children (p= 0.017). A third of children in both groups exceeded the WHO recommendation to limit added sugars to less than 10% of total energy intake.

Seventy-one percent of HIV-infected children met the AMDR for percentage of energy intake coming from carbohydrates, 10.6% consumed more, and 18.4% consumed less. For percentage of energy intake coming from fat and protein, no HIV-infected children fell above the AMDR, but 31.8% consumed less than the AMDR for fat and 27.7% consumed less than the AMDR for protein. Patterns were similar for the HIV-uninfected group, although more of the HIV-uninfected group met the AMDR for the percentage of energy intake coming from protein compared to the HIV-infected group (81.5 vs. 72.4%, p=0.022). Almost all the children in both groups fell below the RDA for total fiber (95.9% of HIV-infected group and 98.2% of HIV-uninfected group). There were no differences in mean cholesterol (mg/day) intake between groups.

Micronutrients

Table 3 (included Supplementary Digital Content 1) shows the average intakes for micronutrients in HIV-infected and uninfected-children, as well as prevalence of adequate and inadequate micronutrient intake. Folate, vitamin A, vitamin D, calcium, iodine, and selenium were all micronutrients of concern (more than 50% of the group failed to meet the EAR for these) for both HIV-infected and HIV-uninfected groups. In addition, vitamin C was a micronutrient of concern for the HIV-uninfected group, with 56% of the group failing to meet the EAR.

Sex-stratified analyses

Sex-stratified analyses of total energy and macronutrients are presented in Table 4 (included as Supplementary Digital Content 2). Differences in total energy and macronutrient distribution between HIV-infected and HIV-uninfected children appear to be more pronounced in boys. In particular, only 67.3% of the HIV-infected boys met the AMDR for total protein compared to 82.4% of the HIV-uninfected boys (p=0.009). All of the micronutrients of concern identified in the combined analysis remain micronutrients of concern within all strata (e.g. HIV-infected boys, HIV-uninfected boys, HIV-infected girls, HIV-uninfected girls; data not shown).

Food sources and diet diversity score

The food items that provided the greatest contribution to energy, carbohydrates, protein, fat, cholesterol, and fiber intake are presented in Table 5 (included as Supplementary Digital Content 3). Top food items were similar in both HIV-infected and uninfected children. In an analysis of the ten leading sources of total energy intake, half of the items were either refined grains or fats/oils and sweets (i.e. food items with high concentration of added sugars). The food items that contributed the highest (greatest percentage) to total energy intake were sunflower oil (7.3%), savory snacks (6.2%), and bread (4.5%).

Food sources that contributed to total protein intake were varied. The leading contributors to animal protein were chicken with skin (8.7%), sardines in tomato sauce (8.7%), and ground beef (6.8%). The top contributor to plant protein was brown bread (12.7%), followed by white bread (8.7%), egg noodles (7.1%), maize porridge (7.1%), and savory snacks (6.6%). Savory snacks were the highest source of saturated fat, trans fat, and mono-unsaturated fat; they were the second highest source of total fat, contributing 9.0% of the total fat intake. Sunflower oil contributed to 18.1% of the total fat intake for the sample and savory snacks contributed to nearly half (48%) of the reported trans fat intake. The leading contributors to total carbohydrate intake were brown bread (6.6%), maize porridge (6.3%), savory snacks (5.2%), and white bread (5%). Carbonated cold drinks were the overall highest source of added sugars (19%; data not shown). The top three sources of cholesterol were dishes in which eggs were the main ingredient (egg fried in sunflower oil, egg in chicken, and egg noodles). The most commonly reported source of fiber for the sample was brown bread (12.0%), followed by oranges (6.7%) and Granny Smith apples (6.5%). The mean diet diversity score was 4.2; this was similar between HIV-infected and HIV-uninfected groups. Approximately one third of the children (31.2%) had a diet diversity score <4.

Discussion

In this study of dietary intake of school-aged children in Johannesburg, South Africa, we observed inadequacies in dietary energy intake and in numerous micronutrients in both HIV-infected and uninfected children. In addition, a substantial portion of both groups consumed a diet comprised of lower than recommended amounts of protein and an excess of added sugars. The reported energy intake of HIV-infected children exceeded that of the HIV-uninfected children by approximately 10%. However, neither group met the recommended daily energy intake with the majority (>80%) of children with and without HIV failing to achieve even energy recommendations (3). These findings are in contrast to prior studies of energy intake among HIV-infected children conducted in other settings. In two studies from the United States using 24H Recall questionnaires, reported mean caloric intakes of HIV-infected children and adolescents exceeded energy recommendations (22, 23). Similarly, a study in Brazil of HIV-infected children and adolescents, aged 7–17 years, also found an average energy intake that far exceeded energy requirements recommended by the WHO, but this study used a FFQ to assess dietary intake which may have overestimated daily energy intake (24). The observed shortcomings in energy intake in our cohort indicate a potential threat to long term growth and development.

For all participants, approximately half of the macronutrient energy intake was from carbohydrates, 14% from protein, and 30.8% from fat. A higher percentage of energy intake came from carbohydrates and lower percentage of energy intake came from protein for the HIV-infected group compared to the HIV-uninfected group. Although the reported macronutrient composition fell within the AMDRs for more than half of the sample, many children in both groups fell below the recommended ranges for carbohydrates, protein, or fat. In comparison to a study of South African children ages 1–8 years, our estimate of protein as a percentage of energy was similar, but we observed a lower percentage of energy intake from carbohydrates and higher percentage of energy intake from fat (25). For the HIV-infected group, we found a lower percentage of energy intake coming from protein and carbohydrate, but a higher percentage of energy intake from fat as compared to Brazilian HIV-infected adolescents (24). Of interest, our results are confirmatory of secular trends of increasing fat intake among South African children. Steyn *et al.* reported that the percentage of daily energy intake coming from fat among schoolchildren in urban areas of Gauteng, South Africa increased from 17% in 1962 to 26% in 1999 (26). Intake of trans fats, largely from snack foods, is not ideal, particularly for children with HIV in whom elevated cholesterol and low density lipoproteins are commonly encountered directly due to HIV and long term exposure to ART, and who face an increased lifetime risk of cardiovascular disease (4, 27–30). Added sugars were 8% of total energy intake in the HIV-infected group and 9.1% of total energy in the HIV-uninfected group; this was similar to the 9% reported in the study by Maudner *et al.* and just below the new WHO guidelines which recommend a maximum of 10% energy from free sugars (25). However, a third of the children overall exceeded the 10% recommendation.

More than 50% of the children failed to meet recommended thresholds for a number of micronutrients from food sources, including several that are essential to maintenance of normal immune function: folate, vitamin A, vitamin D, calcium, iodine, and selenium. In addition, the low mean diet diversity score similar to other studies of South African Children (20, 25) further suggests an increased risk for nutritional deficiencies. As recommended, a large proportion of the HIV-infected group was taking multivitamins but the micronutrient composition of the multivitamins was unknown and we were unable to factor this into the analysis (31). Avoiding additional sources of immune dysfunction due to nutritional deficiencies is particularly important, however research is limited with respect to micronutrient supplementation for children with HIV (32).

The results of our study suggest a possible role for dietary interventions to optimize a number of outcomes, including overall growth and cardiometabolic health, in this cohort of HIV-infected children with well-controlled disease. While prior studies of increased caloric intake among children with HIV failed to observe reversal of height deficits, these were undertaken prior to the availability of potent ART in children with advanced disease (33, 34). Improvements in diet, particularly during critical periods of growth, might also prove beneficial to HIV-uninfected South African children who, despite economic growth, continue to suffer from a high prevalence of stunting (35). Potential interventions for both groups may include increases in total daily energy intake with an expansion of protein, a reduction in foods high in trans fat and saturated fat (e.g. savory snacks) by replacement with locally available sources of PUFA and MUFA, as well as a reduction in the amount of added sugars in the diet. Increasing frequency of meals and snacks with nutrient-dense foods may be a helpful strategy (31).

Our study has several limitations. First, the dietary questionnaires relied on self-report, and because the 24H Recall asks the participants to recall dietary intake during a school day, the data may not reflect home diversity or represent true mean dietary intake values. Due to logistical reasons, we were only able to obtain a 1-day 24H Recall as opposed to the preferred 3-day 24H Recall. We used several reference ranges for children ages 4–8, as there are no reference ranges tailored directly to our study sample (ages 5–9 years), which may affect the accuracy of our results. In addition, we did not conduct laboratory measurements of trace elements and micronutrients, nor did we have measures of nutrient absorption or energy utilization (e.g. basal metabolic rates). Future studies can use more rigorous dietary assessment methods (e.g. 3-day 24H Recall), as well as biochemical tests of nutrients.

In our study of HIV-infected children in Johannesburg, South Africa who were initiated early on ART and have well-controlled disease but high rates of stunting, the typical diet does not meet energy or micronutrient requirements. There appear to be opportunities for interventions to improve dietary intake for both the HIV-infected and HIV-uninfected groups.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What is Known

- The World Health Organization (WHO) recommends that HIV-infected children increase energy intake and maintain a balanced macronutrient distribution for optimal growth and nutrition.
- Few studies have evaluated dietary intake of HIV-infected children in resource-limited settings.

What is New

- Total energy intake was higher in HIV-infected than HIV-uninfected children, but proportions below the recommended energy requirement were similar in the two groups.
- Our findings suggest that the typical diet of HIV-infected children as well as uninfected children in Johannesburg, South Africa does not meet energy or micronutrient requirements.

Table 1

Characteristics of 220 HIV-infected and 220 HIV-uninfected children ages 5–9 years in Johannesburg, South Africa

Characteristic	HIV-infected (N=220)	HIV-uninfected (N=220)	P
Sex, N (%)			0.25
Male	108 (49.1)	120 (54.5)	
Female	112 (50.9)	100 (45.5)	
Age (years), Mean (SD)	6.4 (1.3)	7.0 (1.5)	<0.0001
Weight-for-Age Z-score (WAZ), Mean (SD)	−0.83 (0.9)	−0.29 (1.1)	<0.0001
Underweight (WAZ<−2), N (%)	24 (10.9)	6 (2.7)	0.0007
Height-for-Age Z-score (HAZ), Mean (SD)	−1.4 (0.9)	−0.82 (0.9)	<0.0001
Stunted (HAZ<−2), N (%)	61 (27.7)	19 (8.6)	<0.0001
BMI-for-Age Z-score, Mean (SD)	0.08 (1.0)	0.28 (1.1)	0.047
Overweight (BAZ>1), N (%)	36 (16.4)	53 (24.1)	0.044
Mid upper arm circumference (cm), Mean (SD)	16.1 (1.7)	17.2 (2.1)	<0.0001
24H Recall performed, N (%)	217 (98.6)	216 (98.2)	1.0
Food frequency questionnaire performed, N (%)	220 (100)	220 (100)	1.0
Reports consumption of multivitamin supplements in past 6 months, N (%)	148 (67.3)	58 (26.4)	<0.0001

Table 2

Average daily intakes of energy and macronutrients, and number and percentage of children meeting and not meeting recommended intakes, stratified by HIV group

Variable		HIV-infected (N=217)	HIV-uninfected (N=216)	P
Total energy (kcal/day)	Mean (SD)	1341 (529)	1196 (442)	0.002
Not meeting energy requirement[1]	N (%)	179 (82.5)	184 (85.2)	0.45
Total carbohydrate (% energy)	Mean (SD)	53.0 (9.2)	50.6 (10.7)	0.012
<45% 45–65% (AMDR) ≥65%	N (%)	40 (18.4) 154 (71.0) 23 (10.6)	60 (27.8) 138 (63.9) 18 (8.3)	0.064
Added sugars (g)	Mean (SD)	26.8 (26.9)	26.3 (20.2)	0.81
Added sugars (% carbohydrates)	Mean (SD)	14.6 (11.8)	17.3 (11.3)	0.017
Added sugars (% energy)	Mean (SD)	8.0 (7.0)	9.0 (6.7)	0.11
<10% (WHO) ≥10%		147 (67.7) 70 (32.3)	139 (64.4) 77 (35.7)	0.46
Total fat (% energy)	Mean (SD)	29.8 (9.6)	31.8 (11.4)	0.043
<25% 25–35% (AMDR) ≥35%	N (%)	69 (31.8) 148 (68.2) 0 (0.0)	61 (28.2) 155 (71.8) 0 (0.0)	0.42
PUFA (% fat)	Mean (SD)	23.4 (10.7)	24.9 (8.9)	0.11
MUFA (% fat)	Mean (SD)	34.0 (5.9)	35.0 (5.4)	0.07
Saturated fat (% fat)	Mean (SD)	33.0 (7.9)	30.8 (6.6)	0.002
Trans (% fat)	Mean (SD)	2.7 (2.4)	2.3 (1.9)	0.048
Total protein (% energy)	Mean (SD)	12.9 (4.3)	13.5 (4.0)	0.13
<10% 10–30% (AMDR) ≥30%	N (%)	60 (27.7) 157 (72.4) 0 (0.0)	39 (18.1) 176 (81.5) 1 (0.5)	0.022
Plant (% protein)	Mean (SD)	50.0 (19.2)	46.8 (19.2)	0.084
Animal (% protein)	Mean (SD)	48.6 (19.4)	50.5 (20.6)	0.33
Total fiber (g/day)	Mean (SD)	12.4 (6.7)	10.5 (5.5)	0.0009
<25 ≥25 (RDA)	N (%)	208 (95.9) 9 (4.2)	212 (98.2) 4 (1.9)	0.16
Cholesterol (mg/day)	Mean (SD)	136 (117)	151 (134)	0.20

Abbreviations: RDA – Recommended Dietary Allowance; AMDR – Acceptable Macronutrient Distribution Range; PUFA – polyunsaturated fatty acids; MUFA – monounsaturated fatty acids; WHO – World Health Organization

[1]Energy requirement recommendations by the World Health Organization for children ages 6–9 years: 1650 kcal/day for HIV-uninfected children and 10% additional (1815 kcal/day) for HIV-infected children