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Dietary patterns and health and nutrition outcomes in men living with HIV infection[1,2,3]

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Abstract

Background—Nutritional status is an important determinant of HIV outcomes.

Objective—We assessed the association between dietary patterns identified by cluster analysis and change in body mass index (BMI; in kg/m^2), CD4 count, and viral load (VL).

Design—HIV-positive adult male subjects (n = 348) with a BMI ≥ 20.5 were evaluated by biochemical, body composition, and dietary data. Cluster analysis was performed on 41 designated food groups derived from 3-d food records. Dietary clusters were compared for sociodemographic, nutrient intake, and clinical outcomes. Multivariate linear regression assessed associations between dietary clusters and change in BMI, CD4 count, and VL.

Results—We observed 3 dietary patterns: juice and soda; fast food and fruit drinks; and fruit, vegetable, and low-fat dairy. Subjects in the fast food and fruit drinks pattern had the lowest fiber intake, highest VL, and lowest CD4 count and had a lower income than did subjects in the other 2 clusters. Subjects in the fruit, vegetable, and low-fat dairy diet pattern had higher intakes of protein, fiber, and micronutrients and the highest BMI and CD4 count. Subjects in the juice and soda pattern had higher energy intakes and lowest BMI. On average, the fast food and fruit drinks cluster and fruit, vegetable, and low-fat dairy cluster gained 0.33 (P = 0.06) and 0.42 (P = 0.02), respectively, more in BMI than the juice and soda cluster across the study interval in a multivariate model.

Conclusions—In a cohort of HIV-positive men, we identified 3 distinct dietary patterns; each pattern was associated with specific nutrition, demographic, and HIV-related variables.

INTRODUCTION

Research evaluating the role of nutrition in HIV infection focused initially on loss of weight or lean body mass (LBM) and wasting (1,2).Each of these variables was found to be associated with increased risk of opportunistic infections and death (3). Even in the era of highly active antiretroviral therapy(HAART), unintentional weight loss is associated with increased risk of mortality (4). However, the issue is complex, because HAART has improved life expectancy, changed the nutrition profile, and presented new challenges for persons living with HIV

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infection (5–7). Indeed, dyslipidemia, insulin resistance, metabolic syndrome, and obesity are now frequently seen among persons living with HIV (8–14). Although risk of coronary heart disease is associated with metabolic and body composition alterations in the general population, the underlying mechanisms remain unclear in persons living with HIV infection (9,15,16). Thus, nutrition priorities vary, and dietary recommendations may be less straightforward as HIV treatment and outcomes continue to evolve.

Although body composition and biochemical measures of metabolic risk were extensively investigated in HIV, the role of diet has received less attention. Traditional dietary analysis was used to describe nutrient deficiencies and to examine outcomes in relation to dietary intake of individual macronutrients or micronutrients (17,18). Although important, the association of individual nutrient intakes with disease outcomes can be difficult to detect, because nutrients are not consumed in isolation and act synergistically in the body (19,20).

To address the limitations of studying individual nutrient intakes, dietary pattern analysis has emerged as a method of assessing total food consumption (19,21–23). Such analysis allows for the examination of the effects of many dietary components, considered in aggregate, on the outcome of interest (20). Although the use of patterning methods to analyze dietary data is still being refined, there is a considerable body of literature on the topic (24–30). A common approach is cluster analysis, which groups persons into mutually exclusive groups based on differences in mean intakes of foods (20). Inherent subjectivity occurs throughout the pattern analysis because investigators must decide how to collapse the data (typically into food groups) and how to quantify the variables (as weight, frequency, or percentage of energy) (20). Finally, naming the derived patterns involves subjectivity, which may be described quantitatively based on the predominate food group consumed (fruit, vegetable) or qualitatively (healthy pattern) (20). Cluster analysis was used to characterize dietary patterns that were associated with obesity, cardiovascular disease, and metabolic syndrome in the general population (22,27, 31–33).

In this study we used cluster analysis to derive dietary patterns in a sample of 348 HIV-positive men. We then examined prospectively how these patterns were associated with change in body mass index (BMI; in kg/m^2), CD4 count, or viral load (VL) over an interval of ≈8 mo. To our knowledge, this is the first study that has used cluster analysis to examine dietary patterns in an HIV-positive population.

SUBJECTS AND METHODS

Nutrition for Healthy Living (NFHL), a longitudinal cohort study examining the nutritional and metabolic consequences of HIV infection, was conducted in Massachusetts and Rhode Island from February 1995 to June 2005. Inclusion criteria were documented HIV infection and age ≥ 18 y. Exclusion criteria for NFHL were pregnancy, thyroid disease, diabetes, malignancies other than Kaposi sarcoma, or inadequate fluency in English. The Tufts-New England Medical Center Institutional Review Board reviewed the study, and participant confidentiality was ensured (2).

Visits occurred biannually; information on sociodemographic characteristics, clinical status, quality of life, use of recreational drugs, and use of HIV-related medications were obtained at each visit. Fasting blood at each visit was measured for immunologic, biochemical, and nutrition markers. For this study, data from the most recent 2 consecutive visits of male participants with complete and reliable 3-d food records, as determined by a trained nutritionist, were used. To exclude wasting, only subjects with a BMI ≥ 20.5 were included.

Body composition was assessed by anthropometry and bioelectrical impedance analysis. Weight, height, skinfold thickness, and waist and hip circumferences were collected following the standardized methods of Lohman et al (34). BMI was calculated. Bioelectrical impedance analysis was performed with the use of a Quantum hand-held analyzer (RJL Systems, Clinton Township, MI) to measure resistance and reactance. LBM and fat estimates were derived with the use of the equation of Lukaski et al (35). Resting energy expenditure (REE) was measured with the use of indirect calorimetry by measuring oxygen and carbon dioxide exchange with the use of a VMax Series 29n calorimeter (Sensor Medics Corporation, Yorba Linda, CA) and calculated with the use of the Weir equation (36). Subjects were studied recumbent in a quiet, dimly lit room.

Dietary intake was obtained by collecting 3-d food records. A trained nutritionist followed a standardized procedure at the baseline visit in the NFHL study. Participants were instructed on how to keep a 3-d food record and were given a food scale (Sunbeam Corporation, Mississauga, Canada) and a ruler to estimate portion size. One week before each biannual visit, the participants were mailed a 3-d food record. Completed food records were reviewed by the nutritionist with the patient. Dietary intake data were analyzed with the use of the NUTRITION DATA SYSTEM FOR RESEARCH (NDS-R) software developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN, using the version concordant with the time of data collection (37,38). Food insecurity was assessed with the use of validated hunger and food insecurity items (39).

We categorized all foods in NDS-R and new foods consumed by our study participants into food groups, as previously described, mainly according to macronutrient composition or primary ingredient (32). Approximately 30 000 foods were previously classified by NDS-R; 5023 foods were either reclassified or new foods. We determined the commonly consumed foods and beverages in our population and created 41 food groups (see Appendix A). Vitamin and mineral supplements, nonnutritive over-the-counter medications, and fiber supplements were not included in the cluster analysis (although were included in the nutrient analysis); any food group that was not recorded by ≥10% of the study sample was also excluded. High-fiber cereals (≥2.5 g/serving) were separated from low-fiber cereals (<2.5 g/serving). Similarly, high-fat dairy products (whole or 2% fat milk) had its own group, whereas those low in fat (skim or 1% fat milk) comprised a separate group. For cluster analysis, food group intake may be measured in absolute weight (in grams), percentage of energy, or frequency (number of servings) (20). Although each method has limitations, percentage of energy does not consider certain foods that may affect health (such as water, diet soda, tea) and serving size of foods are not consistent. Because these foods are commonly consumed in our population and help define dietary patterns, we chose to quantify food group intake with the use of absolute weight in grams per day. This approach has been used successfully in other studies, leading to interpretable patterns that were associated with meaningful health outcomes (40–43).

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CD4 cells were counted with the use of a fluorescent monoclonal antibody-labeled cell sorter. HIV RNA VLs were determined with the use of Roche Amplicor Monitor reverse transcriptase polymerase chain reaction assay (Roche Molecular Systems, Somerville, NJ). The lower detection limit was 400 copies/mL (2.6 $\log_{10}$ copies/mL).HAART was defined as receipt of any of the following regimens: 2 protease inhibitors, 1 protease inhibitor and 2 nucleotide reverse transcriptase inhibitors, or 1 non-nucleotide reverse transcriptase inhibitors and 2 nucleotide reverse transcriptase inhibitors.

Statistical analyses

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All statistical analyses were performed with the use of SAS statistical software (version 9.1; SAS Institute, Cary, NC). We conducted analyses with data from a single visit and change across the study interval. All change values for VL, CD4 count, BMI, REE per kilogram, and energy intake per kilogram were computed by subtracting the measurement at the beginning of the time interval from the end of the time interval. All other data presented were collected at the beginning of the study interval. The main predictors of interest were the dietary pattern clusters, derived with the use of cluster analysis; the main outcome was change in BMI across the study interval. VL and food group measurements were log transformed for the analysis.

Cluster analysis was performed with the use of PROC FAST-CLUS on 41 food groups that had ≥10%of participants reporting they had consumed that food group. Food group quantities were logged before cluster analysis procedures. We used PROC CLUSTER procedure in SAS (SAS Inc) to determine the number of clusters to be used in the analysis. We performed 2–8 cluster solutions and examined and compared the solutions and their respective cubic clustering criterion statistic to evaluate which set of clusters best delineated the dietary patterns while preserving adequate statistical power in each group to detect effects. On the basis of these criteria, the optimal set of clusters was a 3-cluster solution.

We compared dietary intakes (food group, total energy, nutrients) across the 3 clusters, as well as sociodemographic and clinical characteristics. We used PROC ANOVA to compare food group intake measurements across clusters. PROC GLM was used to adjust comparisons across clusters for *1*) age and race for energy intake, REE, and nutrition status measurements and *2*) age, race, and energy intake for individual nutrients and micronutrients intake measurements. Bonferroni correction was used for multiple pair-wise comparisons.

We performed multivariate linear regression to estimate the association between dietary patterns and change in BMI, CD4 count, and VL across the study interval. Potential confounders were selected based on their individual relations with clusters and change in BMI, CD4 count, and VL. We specifically sought to include both sociodemographic and clinical factors and explored interactions between clusters and HAART use.

RESULTS

The average age of the study sample was 45 y, 34% were non-white, a majority (87%) had graduated from high school, 28% met the criteria for AIDS diagnosis, and 77% were on HAART regimens (Table 1). No subject had wasting. Mean (±SD) weight was 78.4 ± 13.7 kg and mean BMI was 25.4 ± 4.0. The mean VL was 3.2 $\log_{10}$ VL copies/mL and the mean CD4 count was 444 cells/μL.

Three dietary pattern clusters were derived, which we descriptively labeled *1*) juice and soda, *2*) fast food and fruit drinks, and *3*) fruit, vegetable, and low-fat dairy dietary patterns, based on the food groups that were predominant in that cluster (Table 2). The juice and soda cluster had significantly higher mean intakes of juice and soda than did the other 2 clusters and significantly higher mean intake of potatoes than did the fast food and fruit drink cluster. The fruit, vegetable, and low-fat dairy cluster had significantly higher mean intakes of fruit, low-fat dairy, diet beverage, and water than did the other 2 clusters. This group had significantly higher mean intakes of whole grains and nuts than did the fast food and fruit drinks cluster. Both the fruit, vegetable, and low-fat dairy cluster and the juice and soda cluster had higher intakes of vegetables, vegetable oil, poultry, nonwhite breads, low-fat dairy, fruit, full fat baked goods, and seafood than did the fast food and fruit drink cluster. The fast food and fruit drinks dietary cluster had significantly higher intakes of fast food than did the other 2 clusters and significantly higher mean intakes of fruit drinks than did the fruit, vegetable, and low-fat dairy cluster.

The juice and soda cluster had significantly higher mean intakes of energy per kilogram of body weight than did the other 2 clusters. This cluster had higher intakes of energy, fiber, and vitamin B-6 than did the fast food and fruit drink cluster and higher REE per kilogram than did the fruit, vegetable, and low-fat dairy cluster. The fruit, vegetable, and low-fat dairy cluster had significantly higher mean intakes of protein, fiber, and vitamin B-6 from food alone than did the other 2 clusters. The fruit, vegetable, and low-fat dairy cluster and the juice and soda cluster had significantly greater intakes of carbohydrate, sucrose, vitamin A, thiamine, vitamin C, vitamin E, calcium, and folate from food alone than did the fast food and fruit drinks cluster. The energy, macronutrient, and micronutrient intakes from food alone and food plus vitamin and mineral supplements across dietary pattern clusters is shown in Table 3. Subjects in the fast food and fruit drinks dietary cluster were significantly more likely to be non-white, meet the federal poverty level, be food insecure, and be exposed to HIV through heterosexual contact or injection drug use (IDU) than were subjects in the other 2 clusters. This group was more likely to have a diagnosis of AIDS than were subjects in the juice and soda cluster. Subjects in this cluster had significantly higher mean VL than did subjects in the juice and soda cluster (Table 4). Subjects in the fruit, vegetable, and low-fat dairy cluster were significantly more likely to be white, have at least a high school education, and be exposed to HIV through transmission of men having sex with men. Subjects in this cluster had significantly higher mean weight and BMI than did subjects in the juice and soda cluster and significantly greater LBM than did subjects in the fast food and fruit drink cluster. No differences were observed between clusters in change in BMI or clinical variables across the study interval.

On average, the fast food and fruit drinks and the fruit, vegetable, and low-fat dairy clusters gained 0.33 ($P = 0.06$) and 0.42 ($P = 0.02$) more in BMI than did the juice and soda cluster across the study interval in a multivariate model adjusted for age, race, HAART use, BMI, energy intake per kilogram, and REE per kilogram at the start of the study interval and the duration of the study interval (Table 5). Interactions that were explored between dietary patterns and HAART use were nonsignificant ($P > 0.40$; data not shown). The association between dietary patterns and change in VL and CD4 count across the study interval was not significant.

DISCUSSION

In this analysis of food intake in a relatively healthy outpatient cohort of HIV-positive men, we identified 3 distinct dietary patterns; each pattern was associated with specific nutrition, demographic, and HIV-related variables. Subjects in the fruit, vegetable, and low-fat dairy dietary pattern had the lowest risk of poverty or food insecurity but were most likely to have transmission by men having sex with men. Protein, fiber, and micronutrient intakes were highest in this group, reflecting their more nutritious food choices; LBM and CD4 count were highest in this group. Subjects in the fast food and fruit drinks dietary pattern were more likely to live in poverty, be food insecure or IDU, and have diets of lower nutrient density. Subjects in this group had poorer HIV measures with the highest mean VL, lowest mean CD4 count, and they were more likely to carry an AIDS diagnosis. Subjects in the juice and soda dietary pattern had the lowest mean BMI and highest mean calorie intake, possibly indicating a compensatory attempt to consume more energy to prevent weight loss.

In asymptomatic HIV-positive persons, REE increases an estimated 10% (44). Compared with an average intake of 2590 calories for healthy men in this age group (NHANES 1999–2000), energy intake for the juice and soda cluster was 12% higher and the fruit, vegetable, and low-fat dairy cluster was 7% higher, whereas energy intake in the fast food and fruit drinks cluster was similar to NHANES (45).

In all 3 dietary patterns, mean micronutrient intakes from food alone were adequate compared with the dietary reference intakes (DRIs), except for vitamin E in the fast food and fruit drinks cluster (46–48). When vitamin and mineral supplements were included, mean intakes of all micronutrients were above the DRIs. This does not preclude individual dietary deficiencies, however. Previous reports from this cohort have reported mean intakes from diet alone to be at or near adequacy, yet dietary inadequacy of vitamin A, vitamin E, folate, zinc, and calcium were observed in >30%of the men (49–51). Subjects in the fruit, vegetable, and low-fat dairy pattern had an energy intake between the other clusters, but they had the highest mean intake of 6 of 7 nutrients assessed, indicating higher nutrient density than the other 2 diet patterns (52,53). All micronutrient intakes, except iron, were lowest among subjects in the fast food and fruit drinks pattern. This may reflect the poor nutrient density of these foods and low consumption of fruit, vegetables, and whole grains in this cluster (52–55). The low nutrient density of food choices by subjects in the fast food and fruit drink dietary pattern may be affected by food insecurity and poverty (56–58). Indeed, energy-dense diets high in fast foods are associated with lower dietary quality and lower diet costs (52,54,59) and food insecurity, IDU, homelessness, and no primary caregiver found to influence nutrient intakes in HIV (56, 60).

In our study, mean intakes were above current recommendations of 25–35% of calories from fat, 10% of calories from saturated fat, and 300 mg cholesterol/d (61–64); differences were not significant across dietary patterns. Subjects in all 3 clusters consumed a greater percentage of calories from fat and saturated fat than the NHANES average for men in this age group of 33.4% kcal daily from fat and 11.1% kcal from saturated fat (45).

Protein intake was high in all clusters (> 100 g/d). Protein-rich foods naturally provide some lipids and may raise total and saturated fat intakes. The fruit, vegetable, and low-fat dairy dietary pattern had the highest total and percentage of calories from protein but the lowest percentage of calories from saturated fat; they were more likely to consume low-fat dairy products, nuts, seeds, poultry, seafood, and vegetable oil. The fast food and fruit drinks dietary pattern had the lowest mean protein intake but the highest percentage of saturated fat and cholesterol, possibly influenced by a high intake of fast food and pizza.

The mean fiber intake of each cluster was below the DRI of 38 g/d for men, although intake was significantly higher in the fruit, vegetable, and low-fat dairy cluster (24.2 ± 11.4 g) than in the other 2 clusters (65). These men consumed more fruit, vegetables, beans and legumes, and whole-grain breads. The fast food and fruit drinks cluster consumed significantly lower total fiber (14.5 ± 8.2 g/d) and significantly lower gram intakes of each of these food groups.

Men in the juice and soda cluster had mean fiber and micronutrient intakes that were intermediate, despite having the highest energy intake. This is consistent with consumption of some high-energy and nutrient-poor foods, such as nondiet soda and alcohol. In addition, men in this cluster consumed higher-fat dairy, fruit juice, meat, potatoes, and starchy vegetables. This cluster had the highest REE per kilogram and, despite the highest total energy intake and kilocalorie per kilogram, had the lowest mean weight, BMI, triceps skinfold thickness, and waist circumference. Wasting has known mortality risks and may be seen as a threat by subjects living with HIV infection. This may lead to increased intake of easily consumed “empty” calories as well as full-fat and higher calorie foods in an attempt to maintain weight, although this cannot be confirmed as the reason for these dietary choices. Although change in VL and CD4 count were not significant in this analysis, the negative effect of unintentional weight loss on HIV outcomes is well documented (1–4). The focus of the current analysis was on weight gain and quality of diet in a relatively healthy group of HIV-positive men (mean BMI: 25.4; mean CD4 count: 444 cells/μL).

The strengths of this study include the use of cluster analysis as a data-reduction method to identify dietary intake patterns that were then investigated in a relatively large sample of patients. To our knowledge, this approach has not been used in an HIV-positive population and provides meaningful information on the dietary patterns in this group, who have special needs. In this study, almost all the food consumed by the participants was considered in the analysis, capturing total diet. In addition, we used 3-d records instead of 24-h recall or food frequency for the food records, which provides a more precise measure of dietary intake.

Finally, we performed a longitudinal analysis; thus, we were able to evaluate changes over time in our multivariate regression models.

A potential limitation of the study is that we chose to compare food group intake in grams per day, and clusters may have been different when compared as a percentage of energy contribution (25). However, we feel our interpretation of the differences by cluster as reported are valid, because relevant outcomes were adjusted for total energy intake and mean weights were relatively stable over the interval. Another limitation of this study is the exclusion of women. This was primarily because of insufficient number of female participants with valid 3-d records. Further research in HIV-infected women is therefore needed, and a dietary pattern approach may be useful.

As HIV infection becomes a more chronic disease and the management of HIV becomes increasingly sophisticated, the ability to ensure HIV-infected persons have access to high-quality, nutritious food choices that promote optimal dietary patterns, rather than just sufficient quantities of food, will also be increasingly important (6,65). Further research on the effect of dietary patterns on metabolic outcomes is warranted.

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REFERENCES

1. Kotler DP, Wang J, Pierson RN Jr. Body composition studies in patients ith the acquired immunodeficiency syndrome. Am J Clin Nutr 1985;42:1255–1265. [PubMed: 3865530]
2. Forrester JE, Spiegelman D, Tchetgen E, Knox TA, Gorbach SL. Weight loss and body-composition changes in men and women infected with HIV. Am J Clin Nutr 2002;76:1428–1434. [PubMed: 12450913]
3. Kotler DP, Tierney AR, Wang J, Pierson RN Jr. Magnitude of body-cell mass depletion and the timing of death from wasting in AIDS. Am J Clin Nutr 1989;50:444–447. [PubMed: 2773823]
4. Tang AM, Forrester JE, Spiegelman D, Knox TA, Tchetgen E, Gorbach SL. Weight loss and survival in HIV-positive patients in the era of highly active antiretroviral therapy. J Acquir Immune Defic Syndr 2002;31:230–236. [PubMed: 12394802]
5. Faintuch J, Soeters PB, Osmo HG. Nutritional and metabolic abnormalities in pre-AIDS HIV infection. Nutrition 2006;22:683–690. [PubMed: 16704957]
6. Fields-Gardner C, Fergusson P. ADA reports: position of the American Dietetic Association and Dietitians of Canada: nutrition intervention in the care of persons with human immunodeficiency virus infection. J Am Diet Assoc 2004;104:1425–1441. [PubMed: 15354161]
7. Sutinen J, Yki-Jarvinen H. Increased resting energy expenditure, fat oxidation, and food intake in patients with highly active antiretroviral therapy-associated lipodystrophy. Am J Physiol Endocrinol Metab 2007;292:E687–E692. [PubMed: 17062843]
8. Mangili A, Jacobson DL, Gerrior J, Polak JF, Gorbach SL, Wanke CA. Metabolic syndrome with subclinical atherosclerosis in patients infected with HIV. Clin Infect Dis 2007;44:1368–1374. [PubMed: 17443477]
9. Mangili A, Gerrior J, Tang AM, et al. Risk of cardiovascular disease in a cohort of HIV-infected adults: a study using carotid intima-media thickness and coronary artery calcium score. Clin Infect Dis 2006;43:1482–1489. [PubMed: 17083026]

10. Jones CY, Hogan JW, Snyder B, et al. Overweight and human immunodeficiency virus (HIV) progression in women: associations HIV disease progression and changes in body mass index in women in the HIV Epidemiology Research Study Cohort. Clin Infect Dis 2003;37:S69–S80. [PubMed: 12942377]
11. Jacobson DL, Tang AM, Spiegelman D, et al. Incidence of metabolic syndrome in a cohort of HIV-infected adults and prevalence relative to the US population (National Health and Nutrition Examination Survey). J Acquir Immune Defic Syndr 2006;43:458–466. [PubMed: 16980905]
12. Jones CY, Wilson IB, Greenberg AS, et al. Insulin resistance in HIV-infected men and women in the Nutrition for Healthy Living Cohort. J Acquir Immune Defic Syndr 2005;40:202–211. [PubMed: 16186739]
13. Schambelan M, Benson CA, Carr A, et al. Management of metabolic complications associated with antiretroviral therapy for HIV-1 infection: recommendations of an International AIDS Society-USA panel. J Acquir Immune Defic Syndr 2002;31:257–275. [PubMed: 12439201]
14. Hadigan C, Meigs JB, Corcoran C, et al. Metabolic abnormalities and cardiovascular disease risk factors in adults with human immunodeficiency virus infection and lipodystrophy. Clin Infect Dis 2001;32:130–139. [PubMed: 11118392]
15. Grunfeld C, Tien P. Difficulties in understanding the metabolic complications of acquired immune deficiency syndrome. Clin Infect Dis 2003;37:S43–S46. [PubMed: 12942373]
16. Wohl DA, McComsey G, Tebas P, et al. Current concepts in the diagnosis and management of metabolic complications of HIV infection and its therapy. Clin Infect Dis 2006;43:645–653. [PubMed: 16886161]
17. Gibson, RS. Principles of nutritional assessment. Vol. 2nd ed.. New York, NY: Oxford University Press; 2005.
18. Thompson FE, Byers T. Dietary assessment resource manual. J Nutr 1994;124:2245S–2317S. [PubMed: 7965210]
19. Kant AK. Dietary patterns and health outcomes. J Am Diet Assoc 2004;104:615–635. [PubMed: 15054348]
20. Newby PK, Tucker KL. Empirically derived eating patterns using factor or cluster analysis: a review. Nutr Rev 2004;62:177–203. [PubMed: 15212319]
21. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol 2002;13:3–9. [PubMed: 11790957]
22. Newby PK, Muller D, Tucker KL. Associations of empirically derived eating patterns with plasma lipid biomarkers: a comparison of factor and cluster analysis methods. Am J Clin Nutr 2004;80:759–767. [PubMed: 15321819]
23. Panagiotakos DB, Pitsavos C, Skoumas Y, Stefanadis C. The association between food patterns and the metabolic syndrome using principal components analysis: the ATTICA Study. J Am Diet Assoc 2007;107:979–987. [PubMed: 17524719]
24. Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Dietary patterns, insulin resistance, and prevalence of the metabolic syndrome in women. Am J Clin Nutr 2007;85:910–918. [PubMed: 17344515]
25. Bailey RL, Gutschall MD, Mitchell DC, Miller CK, Lawrence FR, Smiciklas-Wright H. Comparative strategies for using cluster analysis to assess dietary patterns. J Am Diet Assoc 2006;106:1194–1200. [PubMed: 16863714]
26. Nettleton JA, Streffen LM, Schulze MB, et al. Associations between markers of subclinical atherosclerosis and dietary patterns derived by principal components analysis and reduced rank regression in the Multi-Ethnic Study of Atherosclerosis (MESA). Am J Clin Nutr 2007;85:1615–1625. [PubMed: 17556701]
27. Kerver JM, Yang EJ, Bianchi L, Song WO. Dietary patterns associated with risk factors for cardiovascular disease in healthy US adults. Am J Clin Nutr 2003;78:1103–1110. [PubMed: 14668271]
28. Lee S, Harnack L, Jacobs DR, Steffen LM, Luepker RV, Arnett DK. Trends in diet quality for coronary heart disease prevention between 1980–1982 and 2000–2002: the Minnesota Heart Survey. J Am Diet Assoc 2007;107:213–222. [PubMed: 17258957]

29. Tseng M, DeVellis RF. Fundamental dietary patterns and their correlates among US Whites. J Am Diet Assoc 2001;101:929–932. [PubMed: 11501872]
30. van Dam RM, Grievink L, Ocke MC, Feskens EJM. Patterns of food consumption and risk factors for cardiovascular disease in general Dutch population. Am J Clin Nutr 2003;77:1156–1163. [PubMed: 12716666]
31. Millen BE, Quatromoni PA, Pencina M, et al. Unique dietary patterns and chronic disease risk profiles of adult men: the Framingham Nutrition Studies. J Am Diet Assoc 2005;105:1723–1734. [PubMed: 16256756]
32. Newby PK, Muller D, Hallfrisch J, Qiao N, Andres R, Tucker KL. Dietary patterns and changes in body mass index and waist circumference in adults. Am J Clin Nutr 2003;77:1417–1425. [PubMed: 12791618]
33. Wirfalt AKE, Jeffery RW. Using cluster analysis to examine dietary patterns: nutrient intakes, gender, and weight status differ across food pattern clusters. J Am Diet Assoc 1997;97:272–279. [PubMed: 9060944]
34. Lohman, TG.; Roche, AF.; Martdroll, R. Anthropometrics standardization reference manual. Champaign, IL: Human Kinetics Books; 1988.
35. Lukaski HC, Bolonchik WW, Hall CB, Siders WA. Validation of tetrapolar bioelectrical impedance method to assess human body composition. J Appl Physiol 1986;60:1327–1332. [PubMed: 3700310]
36. Weir JB. New method for calculating metabolic rate with special reference to protein metabolism. J Physiol 1949;109:1–9. [PubMed: 15394301]
37. Feskanich D, Seilaff BH, Chong K, Buzzard IM. Computerized collection and analysis of dietary intake information. Comput Methods Programs Biomed 1989;30:47–57. [PubMed: 2582746]
38. Schakel SF, Sievert YA, Buzzard IM. Sources of data for developing and maintaining a nutrient database. J Am Diet Assoc 1988;88:1268–1271. [PubMed: 3171020]
39. Radimer KL, Olson CM, Campbell CC. Development of indicators to assess hunger. J Nutr 1990;120:1544–1548. [PubMed: 2243303]
40. Millen BE, Quatromoni PA, Nam BH, O'Horo CE, Polak JF, D'Agostino RB. Dietary patterns and the odds of carotid atherosclerosis in women: the Framingham Nutrition Studies. Prev Med 2002;35:540–547. [PubMed: 12460521]
41. Tucker KL, Dallal GE, Rush D. Dietary patterns of elderly Boston-area residents defined by cluster analysis. J Am Diet Assoc 1992;92:1487–1491. [PubMed: 1452962]
42. Quatromoni PA, Copenhafer DL, Demissie S, et al. The Framingham Nutrition Studies. The internal validity of a dietary pattern analysis. J Epidemiol Community Health 2002;56:381–188. [PubMed: 11964437]
43. Millen BE, Quatromoni PA, Nam BH, et al. Dietary patterns, smoking, and subclinical heart disease in women: opportunities for primary prevention from the Framingham Nutrition Studies. J Am Diet Assoc 2004;104:208–214. [PubMed: 14760568]
44. World Health Organization. Executive Summary of a Scientific Review: Consultation on Nutrition and HIV/AIDS in Africa: Evidence, Lessons, and Recommendations for Action. Oct 4. 2005
45. Massachusetts Medical Society. Trends in Intake of Energy and Macronutrients—United States, 1971–2000. MMWR Morb Mortal Wkly Rep 2004;53:80–82. [PubMed: 14762332]
46. Food and Nutrition Board. Dietary reference intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin, and choline. Washington, DC: National Academic Press; 1998.
47. Food and Nutrition Board. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington, DC: National Academic Press; 2000.
48. Food and Nutrition Board. Dietary Reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, DC: National Academic Press; 2001.
49. Woods MN, Spiegelman D, Knox TA, et al. Nutrient intake and body weight in a large HIV cohort that includes women and minorities. J Am Diet Assoc 2002;102:203–211. [PubMed: 11846114]
50. Hendricks KM, Tang AM, Spiegelman D, Skinner SC, Woods MN. Dietary intake in human immunodeficiency virus-infected adults: a comparison of dietary assessment methods. J Am Diet Assoc 2005;105:532–540. [PubMed: 15800553]

51. Hendricks KM, Sansevero MR, Houser R, Tang AM, Wanke CA. Dietary supplement use and nutrient intake in HIV-infected persons. AIDS Reader 2007;17:211–216. [PubMed: 17479507]
52. Kant AK. Consumption of energy-dense, nutrient-poor foods by adult Americans: nutritional and health implications. The Third National Health and Nutrition Examination Survey, 1988–1994. Am J Clin Nutr 2000;72:929–936. [PubMed: 11010933]
53. Ledikwe JH, Blanck HM, Kettel-Khan L, et al. Low-energy-density diets are associated with high diet quality in adults in the United States. J Am Diet Assoc 2006;106:1172–1180. [PubMed: 16863711]
54. Drewnowski A, Monsivais P, Maillot M, Darmon N. Low-energy-density diets are associated with higher diet quality and higher diet costs in French adults. J Am Diet Assoc 2007;107:1028–1032. [PubMed: 17524726]
55. Kant AK, Graubard BI. Energy density of diets reported by American adults: association with food group intake, nutrient intake, and body weight. Int J Obes 2005;29:950–956.
56. Campa A, Yang Z, Lai S, et al. HIV-related wasting in HIV-infected drug users in the era of highly active antiretroviral therapy. Clin Infect Dis 2005;41:1179–1185. [PubMed: 16163638]
57. Normen L, Chan K, Breslow RA, et al. Food insecurity and hunger are prevalent among HIV-positive individuals in British Columbia, Canada. J Nutr 2005;135:820–825. [PubMed: 15795441]
58. Smit E, Graham NMH, Tang AM, Flynn C, Solomon L, Vlahov D. Dietary intake of community-based HIV-1 seropositive and seronegative injecting drug users. Nutrition 1996;12:496–501. [PubMed: 8878141]
59. Newby PK. Examining energy density: comments on diet quality, dietary advice, and the cost of healthful eating. J Am Diet Assoc 2006;106:1166–1169. [PubMed: 16863710]
60. Kim JH, Spiegelman D, Rimm E, Gorbach SL. The correlates of dietary intake among HIV-positive adults. Am J Clin Nutr 2001;74:852–861. [PubMed: 11722969]
61. Dube MP, Stein JH, Aberg JA, et al. Guidelines for the evaluation and management of dyslipidemia in human immunodeficiency virus-infected adults receiving antiretroviral therapy: recommendations of the HIV Medicine Association of the Infectious Disease Society of America and the Adult AIDS Clinical Trials Group. Clin Infect Dis 2003;37:613–627. [PubMed: 12942391]
62. US Department of Health and Human Services and US Department of Agriculture. The dietary guidelines for Americans, 2005. 6th ed.Washington, DC: US Government Printing Office; 2005.
63. National Institutes of Health: National Heart, Lung, and Blood Institute. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) Final Report. JAMA 2001;285:2486–2497. [PubMed: 11368702]
64. Institute of Medicine of the National Academies. Dietary reference intakes for energy, carbohydrates, fiber, fat, protein, a nd amino acids (macronutrients). Washington, DC: National Academies Press; 2005.
65. Freeland-Graves J, Nitzke S. Position of the American Dietetic Association: total diet approach to communicating food and nutrition information. J Am Diet Assoc 2002;102:98–108.

Appendix

Appendix

APPENDIX A

Forty-one food groups used in the cluster analysis

Food group		Food(s)
1	High-fat dairy	Whole or 2% milk (white or chocolate), cream (heavy, light, or half and half), hard cheese, yogurt, butter, sour cream, cream cheese
2	Reduced-fat dairy	Skim or 1% milk (white or chocolate), reduced fat dairy products (butter, cheese, yogurt, sour cream, cream cheese, cottage cheese)
3	High-fat dairy desserts	Pudding, cheesecake, custard, ice cream
4	Low-fat dairy desserts	Pudding, ice milk, frozen yogurt, sherbet
5	Margarine	All full- and reduced-fat hard margarine, shortening
6	Vegetable oils	Salad dressing, mayonnaise, vegetable and nut oils, spray oils or margarines, liquid margarines
7	Miscellaneous fats	Gravy, lard, salt pork, nondairy creamer, fats from meats, nondairy dairy items (eg, nondairy sour cream)
8	Fruit	Orange, grapefruit, lemon, lime, banana, mango, dried fruit, apple, pear, melons, berries, tropical fruits, kiwi, fruit salad
9	Fruit juices	Orange, grapefruit, apple juice, other 100% fruit juices, nectars
10	Fruit drinks	Sweetened fruit drinks (not 100% fruit)
11	Vegetables	Winter squash, carrot, broccoli, brussels sprouts, leafy greens (mustard, turnip, spinach, other), cauliflower, tomato, tomato or vegetable juice, tomato products (salsa, sauce), all lettuces (leafy green, romaine, iceberg), okra, sweet peas, green or red pepper, onion, shallot, leek, string bean, green bean, avocado, coleslaw, radish, mixed vegetables, mixed vegetable dishes
12	Potatoes	Potato, all preparations
13	Starchy vegetables	Green banana, plantains, sweet potato, corn, other root crops
14	Beans and legumes	Beans, hard peas, legumes, baked beans and pork, cowpeas, mixed dishes with beans or legumes, soybeans, tofu, meat substitutes made from soy products, soy nuts, soymilk, vegetable protein products
15	Eggs	Eggs, all preparations, including egg salad and egg substitutes
16	Poultry	Chicken or turkey, with or without skin, all preparations
17	Meat	Steak, ground beef, mixed dishes with beef, lamb, veal, game, whole or ground pork, venison, mixed dishes with these meats, pork turnovers, dumplings, eggrolls, neck bones
18	Processed meat	Processed lunch meats (including lean and fat-free), sausage, hot dog, bacon, breakfast sausage
19	Seafood	Whole fish, all kinds, sardines, tuna fish, shellfish, tuna fish salad sandwich, other fish, mixed dishes with fish
20	Sweet baked goods, full fat	Cake, cookies, quick bread, donut, sweet roll, granola bar, muffin, sweet potato pie, crisp, cobbler
21	Sweet baked goods, reduced fat	All of the above, reduced-fat versions
22	Low-fiber cereals[1]	Low-fiber cereals (fortified and nonfortified, hot or cold)
23	High-fiber cereals[1]	High-fiber cereals (fortified and nonfortified, hot or cold)
24	White bread and refined grains	White bread (including light), roll, stuffing, cracker, biscuit, bagel, pancake, waffle, white flour, corn meal, corn bread, hush puppies, grits, cracked wheat bread, croutons, pretzels
25	Rice, pasta, or mixed dishes with rice or pasta	White rice, steamed or fried, mixed dishes with rice, rice and beans, pasta with vegetables, macaroni and cheese, mixed pasta dishes without beef, wheat pasta
26	Nonwhite breads	Whole-wheat bread, rye bread, other multigrain and whole-grain breads (including light), wheat cracker, whole-wheat flour
27	Whole grains	Barley, quinoa, bulgur, kasha, couscous, wheat germ, processed bran, oats or oat bran, other grains, brown rice, popcorn
28	Salty snacks	Potato chips, corn chips, Chex mix, corn nuts, tortilla chips, pretzels, other salty snacks
29	Nondiet soda	Cola or noncola, with or without caffeine

Food group		Food(s)
30	Alcohol	Red or white wine, beer (regular or lite), liquor
31	Nuts or seeds	Almonds, peanuts, walnuts, seeds, other nuts or seeds, peanut butter, tahini (sesame butter), coconut
32	Pizza	Pizza (plain or with toppings)
33	Miscellaneous sugary foods	Syrup, jam, table sugar, hard candy (including light and fat-free versions), Popsicles, Jell-O, sorbet
34	Chocolate	Chocolate, candy bars with chocolate
35	Soups, broth or bouillon	Noncream, broth-based soups
36	Chowders, cream-based soups	Cream soups, chowders
37	Fast food	Any food from a fast-food restaurant (hamburgers, chicken, fish, French fries, breakfast sandwiches, milkshakes, pancakes, eggs, etc)
38	Coffee	Coffee, all preparations
39	Tea	Tea, all preparations
40	Diet beverages	All no- or low-calorie beverages (eg, diet soda)
41	Water	Water

[1]Foods that provide ≥10% of the daily value for fiber, or ≥2.5 g/serving, are considered a “good source of fiber” and are in the high-fiber cereal group. Cereals providing <2.5 g/serving fiber are in the low-fiber cereal group.

TABLE 1

Sociodemographic, nutrition status, energy intake and expenditure, and clinical characteristics among 348 men participating in the Nutrition for Healthy Living Study[1]

	Values
Age (y)	45.6 ± 7.8[2]
Non-white [*n* (%)]	120 (34)
High school education [*n* (%)]	303 (87)
Meet poverty definition [*n* (%)]	115 (34)
Food insecure [*n* (%)]	78 (22)
HIV transmission risk [*n* (%)]	
Men having sex with men	259 (75)
Heterosexual contact	66 (19)
Intravenous injection	73 (21)
AIDS diagnosis [*n* (%)]	99 (28)
HAART use [*n* (%)]	266 (77)
Body weight (kg)	78.4 ± 13.7
BMI (kg/m^2)	25.4 ± 4.0
Daily energy intake (kcal/kg)	37.7 ± 14.0
Daily REE (kcal/kg)	25.4 ± 3.5
Log_{10} viral load (copies/mL)	3.2 ± 1.1
CD4 count (cells/μL)	444 ± 283

[1] HAART, highly active antiretroviral therapy, REE, resting energy expenditure.

[2] $\bar{x}$ ± SD (all such values).

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TABLE 2

Food patterns showing intake of food groups (g/d) across the 3 clusters among 348 adult men participating in the Nutrition for Healthy Living Study

	Cluster 1 (*n* = 119)[1]	Cluster 2 (*n* = 115)[2]	Cluster 3 (*n* = 114)[3]	Global *P*[4]	Pairwise *P*[5]: Cluster 1 compared with cluster 2	Pairwise *P*[5]: Cluster 1 compared with cluster 3	Pairwise *P*[5]: Cluster 2 compared with cluster 3
High-fat dairy	211.1 ± 263.5	190.9 ± 192.2	149.4 ± 254.9	0.14	—	—	—
Reduced-fat dairy	67.3 ± 131.1	11.7 ± 47.3[6]	166.8 ± 230.3[7]	<0.001	<0.001	<0.001	178>
High-fat dairy desserts	36.9 ± 65.4	17.8 ± 59.5[6]	39.7 ± 82.8[7]	0.04	—	—	—
Low-fat dairy desserts	6.0 ± 21.0	1.7 ± 11.7	5.0 ± 20.2	0.18	—	—	—
Margarine	2.4 ± 5.3	1.8 ± 5.0	3.1 ± 7.5	0.28	—		—
Vegetable oils	16.6 ± 18.9	4.6 ± 10.2[6]	19.0 ± 24.5[7]	<0.001	<0.001	—	<0.001
Miscellaneous fats	7.7 ± 17.1	3.6 ± 16.0	7.4 ± 18.3	0.13	—	—	—
Fruits	109.4 ± 117.5	24.5 ± 62.9[6]	152.9 ± 143.1[7]	<0.001	<0.001	0.011	<0.001
Fruit juices	182.3 ± 202.9[7]	107.1 ± 165.2[6]	116.0 ± 172.9	<0.001	0.002	0.008	—
Fruit drinks	118.1 ± 193.4	156.7 ± 237.6[7]	77.3 ± 181.4[6]	<0.001	—	—	0.005
Vegetables	163.5 ± 113.8	67.5 ± 90.7[6]	196.4 ± 136.8[7]	<0.001	<0.001	—	<0.001
Potatoes	60.7 ± 57.1[7]	35.6 ± 52.0[6]	46.7 ± 56.2	<0.001	<0.001	—	—
Starchy vegetables	17.5 ± 33.1	9.0 ± 25.0	14.0 ± 31.7	0.10	—	—	—
Beans and legumes	26.6 ± 54.6	19.2 ± 47.8	29.5 ± 59.1	0.33	—	—	—
Eggs	32.5 ± 39.1	35.3 ± 43.8	32.7 ± 42.6	0.85	—	—	—
Poultry	69.8 ± 77.1	44.6 ± 57.1[6]	81.6 ± 71.2[7]	<0.001	0.005	—	<0.001
Meat	113.3 ± 109.1	107.4 ± 106.8	86.4 ± 98.7	0.13	—	—	—
Processed meat	33.7 ± 40.0	33.2 ± 41.7	31.4 ± 45.6	0.92	—	—	—
Seafood	44.3 ± 54.4	24.6 ± 49.8[6]	56.0 ± 69.0[7]	<0.001	0.004	—	0.007
Sweet baked goods, full fat	54.4 ± 61.4[7]	26.4 ± 40.5[6]	41.8 ± 51.7	<0.001	<0.001	—	0.005
Sweet baked goods, reduced fat	1.4 ± 5.9	0.3 ± 3.5	1.0 ± 5.7	0.27	—	—	—
Low-fiber cereals	9.9 ± 22.6	6.1 ± 15.1[6]	16.4 ± 37.1[7]	0.01	—	—	—
High-fiber cereals	8.4 ± 20.8	5.7 ± 16.6[6]	14.2 ± 27.6[7]	0.01	—	—	—
White bread, refined grains	72.0 ± 57.0	72.4 ± 66.8	61.7 ± 63.8	0.34	—	—	—

	Cluster 1 (n = 119)[1]	Cluster 2 (n = 115)[2]	Cluster 3 (n = 114)[3]	Global P[4]	Pairwise P[5]		
					Cluster 1 compared with cluster 2	Cluster 1 compared with cluster 3	Cluster 2 compared with cluster 3
Rice, pasta, mixed rice pasta	100.5 ± 106.3	100.7 ± 116.3	87.5 ± 102.0	0.57	—	—	—
Nonwhite breads	22.7 ± 33.7	5.9 ± 17.8[6]	26.4 ± 39.3[7]	<0.001	<0.001	—	<0.001
Whole grains	23.9 ± 60.0	18.3 ± 62.7[6]	49.3 ± 103.2[7]	0.01	—	—	0.006
Salty snacks	9.1 ± 16.8	5.2 ± 12.0	9.2 ± 18.5	0.10	—	—	—
Nondiet soda	349.4 ± 280.3[7]	242.8 ± 280.6	5.1 ± 25.3[6]	<0.001	0.004	<0.001	<0.001
Alcohol	95.4 ± 188.3[7]	44.7 ± 162.6[6]	57.2 ± 128.9	0.05	—	—	—
Nuts and seeds	8.9 ± 19.5	4.1 ± 14.7[6]	12.1 ± 24.4[7]	0.01	—	—	0.003
Pizza	25.9 ± 51.2	27.2 ± 52.1	14.4 ± 41.8	0.09	—	—	—
Miscellaneous sugary foods	25.2 ± 30.6	23.4 ± 41.0	18.3 ± 28.1	0.27	—	—	—
Chocolate	7.3 ± 19.2	2.9 ± 10.4	6.9 ± 17.5	0.07	—	—	—
Soups, broth or bouillon	56.2 ± 98.4	34.3 ± 90.3	48.5 ± 90.1	0.19	—	—	—
Chowders, cream-based soups	11.9 ± 40.3	3.3 ± 19.4	9.8 ± 35.0	0.12	—	—	—
Fast food	39.3 ± 87.7[6]	137.0 ± 174.1[7]	65.5 ± 129.6	<0.001	<0.001	—	<0.001
Coffee	233.9 ± 289.1	202.2 ± 259.3	287.4 ± 324.8	0.08	—	—	—
Tea	122.1 ± 199.6	66.8 ± 155.0	90.0 ± 199.1	0.07	—	—	—
Diet beverages	15.3 ± 80.0[6]	45.4 ± 190.9	202.3 ± 369.6[7]	<0.001	—	0.002	<0.001
Water	85.7 ± 238.5	35.1 ± 145.9[6]	227.4 ± 420.4[7]	<0.001	—	0.002	<0.001

[1] Food pattern of juice and soda.

[2] >Food pattern of fast food and fruit drinks.

[3] Food pattern of fruit, vegetables, and low-fat dairy.

[4] Determined by ANOVA.

[5] Determined by *t* test (significant values $P < 0.017$, Bonferroni adjustment for multiple comparisons).

[6] Food or food group contributed the relatively lowest mean intake across the 3 clusters.

[7] Food or food group contributed the relatively highest mean intake across the 3 clusters.

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TABLE 3

Demographic and clinical indicators by the 3 clusters at among 348 adult men participating in the Nutrition for Healthy Living Study[1]

	Cluster 1 (*n* = 119)	Cluster 2 (*n* = 115)	Cluster 3 (*n* = 114)	Global *P*	Pairwise *P*[2]		
					Cluster 1 compared with cluster 2	Cluster 1 compared with cluster 3	Cluster 2 compared with cluster 3
Sample characteristics							
Age (y)	45.6±7.8[3]	44.9±8.2	46.3±7.5	0.37	—	—	—
Non-white [*n* (%)]	37 (31)	58 (50)[4]	25 (22)[5]	<0.001	0.003	—	178 > 0.001
High school education [*n* (%)]	108 (90)	85 (74)[5]	110 (96)[4]	<0.001	<0.001	—	<0.001
Meet poverty definition [*n* (%)]	34 (29)	63 (55)[4]	18 (14)[5]	<0.001	<0.001	0.016	<0.001
Food insecure [*n* (%)]	20 (17)	44 (38)[4]	14 (12)[5]	<0.001	<0.001	—	<0.001
HIV transmission risk [*n* (%)]							
Men having sex with men	98 (82)	61 (55)[5]	100 (88)[4]	<0.001	<0.001	—	<0.001
Heterosexual contact	17 (14)	39 (35)[4]	10 (9)[5]	<0.001	<0.001	—	<0.001
Intravenous injection	22 (18)	41 (37)[4]	10 (9)[5]	<0.001	0.002	—	<0.001
AIDS diagnosis	27 (23)[5]	43 (37)[4]	29 (25)[5]	0.03	0.014	—	—
HAART use	97 (81)	85 (75)	84 (74)	0.36	—	—	—
Energy and micronutrient intake							
Daily energy total intake (kcal)	2893±809[4]	2518±926[5]	2767±926	0.004[6]	0.005[6]	—	—
Daily energy intake (kcal/kg)	39.1±12.4[4]	33.1±13.1[5]	35.4±13.0	0.001[6]	0.001[6]	0.015[6]	—
Daily total REE (kcal)	1926.7±256.9	1903.9±255.7	1935.8±243.9	0.64[6]	—	—	—
Daily REE (kcal/kg)	25.8±3.5[4]	25.0±3.6	24.6±3.1[5]	0.03[6]	—	0.003[6]	—
Nutrition intake (g/d)							
Carbohydrates	354.9±113.8[4]	290.3±101.0[5]	320.9±116.4	<0.001[7]	<0.001	—	0.005
Protein	110.5±33.3	100.5±45.8[5]	121.3±50.5[4]	<0.001[7]	—	<0.001	0.008
Saturated fats	41.1±16.5	37.8±19.0	38.7±19.1	0.24[7]	—	—	—

	Cluster 1 (*n* = 119)	Cluster 2 (*n* = 115)	Cluster 3 (*n* = 114)	Global *P*	Pairwise *P*[2]		
					Cluster 1 compared with cluster 2	Cluster 1 compared with cluster 3	Cluster 2 compared with cluster 3
Total fats	114.7±40.9[4]	102.7±47.5[5]	112.1±47.6	0.05[7]	—	—	—
Cholesterol	425.2±198.5	433.8±256.0	417.0±225.5	0.84[7]	—	—	—
Energy (% of daily intake)							
Carbohydrates	49.2±7.2	47.2±8.9	46.8±9.2	0.08[7]	—	—	—
Protein	15.8±4.2[5]	16.1±3.9	17.9±4.8[4]	<0.001[7]	—	0.003	0.008
Saturated fats	12.7±3.5	13.2±4.0	12.2±3.4	0.07[7]	—	—	—
Total fats	35.1±6.8	36.0±7.7	35.6±7.5	0.68[7]	—	—	—
Sucrose (g)	68.9±40.5[4]	53.3±36.3[5]	61.4±36.7	<0.001[7]	<0.001	—	—
Starch (g)	140.4±55.3[4]	124.9±50.0[5]	136.7±53.1	0.03[7]	—	—	—
Fiber (g)	21.8±9.1	14.5±8.2[5]	24.2±11.4[4]	<0.001[7]	<0.001	0.005	<0.001
Vitamin and micronutrient intake							
Vitamin A	1626.8±1103.1	1147.2±1462.5[5]	1705.7±1149.9[4]	<0.001[7]	0.004	—	<0.001
Thiamine	2.4±1.0	2.1±0.9	2.3±0.9	0.19[7]	—	—	—
Vitamin B-6	2.6±1.2	2.1±1.3[5]	2.9±1.3[4]	<0.001[7]	—	<0.001	<0.001
Vitamin B-12	8.9±11.0	8.7±17.6	9.8±10.4	0.80[7]	—	—	—
Vitamin C	154.5±92.9	107.0±90.1[5]	161.6±132.5[4]	<0.001[7]	0.003	—	0.001
Vitamin E	16.0±12.0	11.2±10.0[5]	16.4±11.5[4]	<0.001[7]	—	—	0.006
Folate	521.3±260.3	423.8±209.0[5]	523.7±220.7[4]	<0.001[7]	—	—	0.002
Iron	27.2±13.5	29.1±19.1	32.6±20.7	0.75[7]	—	—	—
Calcium	1319±769	1019±622[5]	1367±721[4]	<0.001[7]	<0.001	—	<0.001
Vitamin and micronutrient intake from food and supplements							
Vitamin A	3019.1±2601.0	1790.9±1875.1[5]	3220.2±2366.2[4]	<0.001[7]	0.004	—	<0.001
Thiamine	18.1±31.9	8.0±20.1[5]	27.4±44.8[4]	<0.001[7]	—	—	<0.001
Vitamin B-6	19.3±33.5	7.1±18.2[5]	27.4±44.9[4]	<0.001[7]	0.016	—	0.002

	Cluster 1 (*n* = 119)	Cluster 2 (*n* = 115)	Cluster 3 (*n* = 114)	Global *P*	Pairwise P^2: Cluster 1 compared with cluster 2	Pairwise P^2: Cluster 1 compared with cluster 3	Pairwise P^2: Cluster 2 compared with cluster 3
Vitamin B-12	2569.0±27497.8	20.8±63.3	76.5±155.1	0.38[7]	—	—	—
Vitamin C	521.99±650.8	264.2±547.0[5]	647.5±902.4[4]	<0.001[7]	—	—	<0.001
Vitamin E	127.4±193.8	49.6±113.6[5]	171.0±245.7[4]	<0.001[7]	0.004	—	0.002
Folate	791.9±439.5	595.1±376.2[5]	887.1±451.5[4]	<0.001[7]	—	—	<0.001

[1] HAART, highly active antiretroviral therapy, REE, resting energy expenditure. Food patterns for clusters are described in footnotes 1–3 of Table 2.

[2] Determined by *t* test (significant values *P* ± 0.017, Bonferroni adjustment for multiple comparisons).

[3] $\bar{x}$ ± SD (all such values).

[4] Food or food group contributed the relatively highest mean intake across the 3 clusters.

[5] Food or food group contributed the relatively lowest mean intake across the 3 clusters.

[6] Adjusted for age and race by using generalized linear modeling.

[7] Adjusted for age, race, and energy intake per kilogram with generalized linear modeling.

TABLE 4

Nutrition status and daily nutrient intake across the 3 clusters among 348 male adults participating in the Nutrition for Healthy Living Study[1]

	Cluster 1 (*n* = 119)	Cluster 2 (*n* = 115)	Cluster 3 (*n* = 114)	Global*P*	Pairwise *P*[2]		
					Cluster 1 comared With cluster 2	Cluster 1 compared With cluster 3	Cluster 2 compared with cluster 3
Body weight (kg)	75.9 ± 12.4[3,4]	78.9 ± 14.7	80.5 ± 13.6[5]	0.03[6]	—	0.006	—
BMI (kg/m²)	24.6 ± 3.5[4]	25.8 ± 4.3	26.0 ± 4.1[5]	0.01[6]	—	0.002	—
Triceps skin fold thickness (cm)	8.4 ± 5.8[4]	10.3 ± 6.3[5]	8.4 ± 6.7	0.03[6]	—	—	—
Hip circumference (cm)	94.6 ± 7.5[4]	96.8 ± 8.3[5]	96.2 ± 8.4	0.12[6]	—	—	—
Waist circumference (cm)	89.5 ± 9.5[4]	92.8 ± 11.8	93.0 ± 10.8[5]	0.04[6]	0.013	—	—
Lean body mass (kg)	58.5 ± 7.6	58.0 ± 7.6[4]	60.6 ± 7.0[5]	0.02[6]	—	—	0.008
Lean body mass (%)	77.9 ± 6.4[5]	75.8 ± 6.8[4]	76.7 ± 6.6	0.06[6]	—	—	—
Log_{10} viral load (copies/mL)	3.0 ± 1.1[4]	3.4 ± 1.1[5]	3.1 ± 1.1	0.02	0.008	—	—
CD4 count (cells/μL)	468.8 ± 270.0	413.8 ± 275.6[4]	501.3 ± 345.6[5]	0.09	—	—	—
Changes across study interval							
Change in log_{10} viral load (copies/mL)	−0.1 ± 0.7[4]	0.1 ± 1.1[5]	−0.0 ± 0.8	0.18	—	—	—
Change in CD4 count (cells/μL)	13.1 ± 155.2	2.6 ± 146.5[4]	30.5 ± 168.9[5]	0.42	—	—	—
Change in BMI	−0.1 ± 0.9[4]	0.1 ± 1.7	0.2 ± 1.4[5]	0.22[6]	—	—	—
Change in energy intake (kcal/kg)	−1.5 ± 10.8	−3.6 ± 13.7[4]	−0.8 ± 10.2[5]	0.31[6]	—	—	—
Change in REE (kcal/kg)	0.1 ± 3.3[5]	−0.4 ± 3.0	−0.7 ± 2.5[4]	0.12[6]	—	—	—
Average duration across interval (mo)	7.8 ± 7.2[4]	8.2 ± 7.6	8.3 ± 8.2[5]	0.88	—	—	—

[1] REE, resting energy expenditure. Food patterns for clusters are described in footnotes 1–3 of Table 2.

[2] Determined with *t* test (significant values $P < 0.017$, Bonferroni adjustment for multiple comparisons).

[3] $\bar{x}$ ± SD (all such values).

[4] Food or food group contributed the relatively lowest mean intake across the 3 clusters.

[5]Food or food group contributed the relatively highest mean intake across the 3 clusters.

[6]Adjusted for age and race by using generalized linear modeling.

TABLE 5

Multivariate linear regression model showing adjusted associations between food pattern clusters and change in BMI Among 348 adult men participating in the Nutrition for Healthy Living Study[1]

Cofactors	**β-Coefficient**	**SE**	***P***
Intercept	3.8	1.2	0.01
Fast food and fruit drinks diet[2]	0.33	0.18	0.06
Fruit, vegetable, low-fat dairy[2]	0.42	0.18	0.02
Age (y)	−0.02	0.009	0.06
Non-white	−0.27	0.16	0.09
BMI at start of interval	−0.09	0.02	<0.001

[1] Regression models were also adjusted for highly active antiretroviral therapy use, energy intake per kilogram, and resting energy expenditure per kilogram at start of study interval (R^2: 1.02).

[2] In comparison to cluster 1 (juice and soda).

APPENDIX A

Forty-one food groups used in the cluster analysis

Food group		Food(s)
1	High-fat dairy	Whole or 2% milk (white or chocolate), cream (heavy, light, or half and half), hard cheese, yogurt, butter, sour cream, cream cheese
2	Reduced-fat dairy	Skim or 1% milk (white or chocolate), reduced fat dairy products (butter, cheese, yogurt, sour cream, cream cheese, cottage cheese)
3	High-fat dairy desserts	Pudding, cheesecake, custard, ice cream
4	Low-fat dairy desserts	Pudding, ice milk, frozen yogurt, sherbet
5	Margarine	All full- and reduced-fat hard margarine, shortening
6	Vegetable oils	Salad dressing, mayonnaise, vegetable and nut oils, spray oils or margarines, liquid margarines
7	Miscellaneous fats	Gravy, lard, salt pork, nondairy creamer, fats from meats, nondairy dairy items (eg, nondairy sour cream)
8	Fruit	Orange, grapefruit, lemon, lime, banana, mango, dried fruit, apple, pear, melons, berries, tropical fruits, kiwi, fruit salad
9	Fruit juices	Orange, grapefruit, apple juice, other 100% fruit juices, nectars
10	Fruit drinks	Sweetened fruit drinks (not 100% fruit)
11	Vegetables	Winter squash, carrot, broccoli, brussels sprouts, leafy greens (mustard, turnip, spinach, other), cauliflower, tomato, tomato or vegetable juice, tomato products (salsa, sauce), all lettuces (leafy green, romaine, iceberg), okra, sweet peas, green or red pepper, onion, shallot, leek, string bean, green bean, avocado, coleslaw, radish, mixed vegetables, mixed vegetable dishes
12	Potatoes	Potato, all preparations
13	Starchy vegetables	Green banana, plantains, sweet potato, corn, other root crops
14	Beans and legumes	Beans, hard peas, legumes, baked beans and pork, cowpeas, mixed dishes with beans or legumes, soybeans, tofu, meat substitutes made from soy products, soy nuts, soymilk, vegetable protein products
15	Eggs	Eggs, all preparations, including egg salad and egg substitutes
16	Poultry	Chicken or turkey, with or without skin, all preparations
17	Meat	Steak, ground beef, mixed dishes with beef, lamb, veal, game, whole or ground pork, venison, mixed dishes with these meats, pork turnovers, dumplings, eggrolls, neck bones
18	Processed meat	Processed lunch meats (including lean and fat-free), sausage, hot dog, bacon, breakfast sausage
19	Seafood	Whole fish, all kinds, sardines, tuna fish, shellfish, tuna fish salad sandwich, other fish, mixed dishes with fish
20	Sweet baked goods, full fat	Cake, cookies, quick bread, donut, sweet roll, granola bar, muffin, sweet potato pie, crisp, cobbler
21	Sweet baked goods, reduced fat	All of the above, reduced-fat versions
22	Low-fiber cereals[1]	Low-fiber cereals (fortified and nonfortified, hot or cold)
23	High-fiber cereals[1]	High-fiber cereals (fortified and nonfortified, hot or cold)
24	White bread and refined grains	White bread (including light), roll, stuffing, cracker, biscuit, bagel, pancake, waffle, white flour, corn meal, corn bread, hush puppies, grits, cracked wheat bread, croutons, pretzels
25	Rice, pasta, or mixed dishes with rice or pasta	White rice, steamed or fried, mixed dishes with rice, rice and beans, pasta with vegetables, macaroni and cheese, mixed pasta dishes without beef, wheat pasta
26	Nonwhite breads	Whole-wheat bread, rye bread, other multigrain and whole-grain breads (including light), wheat cracker, whole-wheat flour
27	Whole grains	Barley, quinoa, bulgur, kasha, couscous, wheat germ, processed bran, oats or oat bran, other grains, brown rice, popcorn
28	Salty snacks	Potato chips, corn chips, Chex mix, corn nuts, tortilla chips, pretzels, other salty snacks

Food group		Food(s)
29	Nondiet soda	Cola or noncola, with or without caffeine
30	Alcohol	Red or white wine, beer (regular or lite), liquor
31	Nuts or seeds	Almonds, peanuts, walnuts, seeds, other nuts or seeds, peanut butter, tahini (sesame butter), coconut
32	Pizza	Pizza (plain or with toppings)
33	Miscellaneous sugary foods	Syrup, jam, table sugar, hard candy (including light and fat-free versions), Popsicles, Jell-O, sorbet
34	Chocolate	Chocolate, candy bars with chocolate
35	Soups, broth or bouillon	Noncream, broth-based soups
36	Chowders, cream-based soups	Cream soups, chowders
37	Fast food	Any food from a fast-food restaurant (hamburgers, chicken, fish, French fries, breakfast sandwiches, milkshakes, pancakes, eggs, etc)
38	Coffee	Coffee, all preparations
39	Tea	Tea, all preparations
40	Diet beverages	All no- or low-calorie beverages (eg, diet soda)
41	Water	Water

[1] Foods that provide ≥10% of the daily value for fiber, or ≥2.5 g/serving, are considered a “good source of fiber” and are in the high-fiber cereal group. Cereals providing <2.5 g/serving fiber are in the low-fiber cereal group.