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Effect of HIV Infection on Body Composition and Fat Distribution in Rwandan Women

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Abstract

Objective—To assess the association of HIV infection with body weight and composition in Rwandan women.

Design—Body weight and composition, the latter determined by bioelectrical impedance analysis (BIA) and by anthropometry, were compared in 620 HIV-positive and 211 HIV-negative participants. Associations of HIV with body composition were assessed, and t tests compared the groups.

Results—HIV-positive women were younger (−7.0 years, P < .001) and shorter (− 2.1 cm, P < .001). Mean body weight, body mass index (BMI), total body fat, and waist-to-hip ratio (WHR) were similar. Mean fat-free mass was 2.5% greater in HIV-negative participants, and 19% of HIV-positive group had BMI <18.5 kg/m^2 versus 26% of the HIV-negative group ($P < .05$). CD4 counts and body composition were not associated.

Conclusions—Malnutrition was common in this cohort of Rwandan women. However, HIV infection was not associated with nutritional status. Factors other than malnutrition may influence quality-of-life outcomes in HIV-infected Rwandan women. Initiatives to improve nutritional status should be population-wide and not restricted to the HIV-infected population.

Keywords

HIV; malnutrition; body composition; Rwanda; women; fat distribution

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Declaration of Conflicting Interests
The author(s) declared no conflicts of interest with respect to the authorship and/or publication of this article.

Introduction

Malnutrition is associated with untreated HIV infection in the developed and in the developing countries and includes depletion of both body fat and fat-free mass.[1,2] Many factors affect nutritional status, including genetic and environmental influences, as well as the effects of acute and chronic illnesses. Malnutrition in HIV infection has been associated with adverse outcomes, including shortened survival and decreased quality of life.[1] In HIV-negative persons, severe malnutrition impairs immunity as measured by CD4 lymphocytes[2] and is a major predictor of mortality in HIV-infected patients starting antiretroviral therapy (ART).[3]

However, malnutrition is common in many developing countries, especially in sub-Saharan Africa, regardless of whether HIV is present.[4] Studies from Africa have shown lower physical activity and prolonged illness in patients with lower body mass index (BMI), irrespective of HIV infection.[5] One study compared body composition changes in HIV-positive and HIV-negative lactating South African women,[6] but there are few studies in developing countries comparing nutritional status in HIV-positive and HIV-negative individuals in the general population. The interactions between malnutrition and HIV infection are not well described particularly in sub-Saharan Africans, for whom both HIV infection and malnutrition are the most prevalent worldwide.

Our primary aim was to assess the association of HIV infection with body composition and fat distribution in HIV-negative and antiretroviral (ARV)-naive HIV-positive Rwandan women. Although nutritional status includes both macro- and micronutrition, our study focused on macronutritional body composition measurements. We compared the results using bioelectrical impedance analysis (BIA) and anthropometric measurements. Although criterion measures of body composition in HIV-infected and uninfected Rwandan women were not available for this field study, we felt that the results of measurements of the same body compartments by 2 completely independent methods, if consistent, would strengthen our conclusions.

Participants and Methods

Participants

This is a cross-sectional analysis of enrollment data from the Rwanda Women's Interassociation Study and Assessment (RWISA), an observational prospective cohort study investigating the effectiveness and toxicity of ART in HIV-infected Rwandan women. The HIV-infected patients were treatment-naive at the time these measurements were made. A total of 936 (710 HIV-infected and 226 HIV-uninfected) individuals were enrolled between May 15 and November 15, 2005. Informed consent was obtained in accordance with protocols approved by the Rwandan National Ethics Committee and the Institutional Review Board (IRB) of Montefiore Medical Center, Bronx, New York. Inclusion criteria included age >25 years, willingness to be HIV tested and return for follow-up, presence in Rwanda in 1994, and for HIV-infected women naïveté to ART, except exposure to single-dose nevirapine (NVP). At study entry, participants provided historical information including medical history, demographic parameters, psychosocial history, experience of trauma during the 1994 Rwandan genocide, and symptoms of depression and posttraumatic stress. A physical examination was performed and specimens were taken for CD4 count, full blood count, and other laboratory studies.

Body Composition Measurements

Anthropometric measurements and BIA were performed. Nurses who performed the evaluations were trained on proper anthropometry with anatomic placement of the tape measure and location of skin folds by trained clinicians in the Women's Interagency HIV Study (WIHS), a US cohort study. Anthropo-metric measurements were performed in duplicate, with provisions for a third measurement in the case of discrepancy. Standing height and weight were measured while the participant was wearing light clothing and no shoes, whereas hip and waist circumferences were taken without clothing. Waist circumference was measured 2 cm above the posterior iliac crest. Hip circumference was measured at the level of anterior superior iliac spine or at the broadest circumference below the waist. Two measurements were taken; if they differed by ≥2 cm, a third measurement was taken, and the mean of the closest 2 was used to calculate waist-to-hip ratio (WHR). Three measurements of skin folds at mid triceps, front thigh, subscapular, and suprailiac were taken, read to the nearest 0.2 mm, and an average obtained for each site.[7] The results of triceps and subscapular skinfold measurements were used to estimate body fat and fat-free mass. Impedance measurements were taken using a standard tetrapolar electrode placement on the hand and foot. Total body fat and fat-free mass were calculated from resistance and reactance using standard formulae.[8] Body mass index was calculated as weight in kg/(height in meters)^2.

Race has an important influence on the estimation of body composition, especially using anthropometry.[9] However, most of the commonly used anthropometric equations were derived using results from Caucasians. For this reason, we derived the equation used in this study from results of anthropometric measurements and dual energy x-ray absorptiometry (DEXA) studies obtained in 102 African-American women studied at St Luke's-Roosevelt Hospital Center, after informed consent, in IRB-approved studies. The technique compared the log sum of skinfolds to body fat percentage, as determined by a criterion method, similar to the method of Durnin and Womersley.[10,11] In this study, only the triceps and subscapular skin fold results were included in the model to narrow the resulting confidence intervals associated with including multiple measurements. The sum of the logs of triceps and subscapular skinfolds were strongly associated with body fat content as determined by DEXA scanning ($r^2 = .80$; Figure 1). The estimating equation for body fat percentage was then applied in this study.

Statistical Analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 10.7. The means and standard deviations of the study parameters were calculated for HIV-positive group and controls. Waist and hip circumferences and WHR were used to assess body fat distribution. Effects of HIV infection on body composition and fat distribution were assessed both in unadjusted and in age- and height-adjusted analyses.

Groups were compared by t test. To further determine the possible effects of immune deficiency on body composition, CD4 counts were plotted as a function of fat-free mass.

Results

The analysis included 831 women (620 HIV-positive and 211 HIV-negative) who had complete data for anthropometric measures and BIA. HIV-infected women were younger (−7.0 years, $P < .001$) and slightly but significantly shorter (−2.1 cm, $P < .001$) than HIV-negative women (Table 1). In contrast, mean body weight, BMI, total body fat by BIA, and WHRs were similar in the 2 groups, both in unadjusted and in age- and height-adjusted results. The distribution of BMI in the 2 groups was similar and skewed toward lower values (Figure 2). Nineteen percent of the HIV-positive group had values of BMI below 18.5 kg/m^2, compared to 26% of the HIV-negative group ($P < .05$). Mean fat-free mass by BIA was 2.5% greater in controls than in HIV-positive women (Table 1), and mean body fat content by anthropometry was lower in HIV-positive women than in controls, but there were no statistically significant differences after age and height adjustment.

The results of these studies show no significant differences in mean body composition in the HIV-positive and control groups by either BIA or anthropometry. Figure 3A shows the regression line comparing unadjusted total body fat calculated by BIA and by the anthropometric equation. There is close correlation between the results ($r^2 = .48$; $P <.001$). Bland Altman analysis suggests the presence of a systematic error, with higher values for BIA at low body fat contents and higher values for anthropometry at higher body fat contents (Figure 3B).

Mean CD4 lymphocyte count was significantly lower in HIV-positive women than HIV-negative women (280±161 vs 897 ± 344 cells/mm^3, $P < .0001$). However, there were no significant associations between CD4 counts and body composition in either group (data not shown).

Discussion

We found that body fat and fat-free mass were similar in untreated, HIV-infected, and uninfected Rwandan women in this cohort, which is in contrast to the results of many prior studies.[12,13] These findings were similar whether the body composition data were calculated from BIA or from anthropo-metric measurements, after adjustment for differences in age and height. In addition, HIV infection was not associated with differences in body fat distribution, as estimated by WHR. Others have reported that HIV infection results in considerable loss of body weight and changes in body fat distribution.[14,15] Both HIV-positive and HIV-negative women in our study demonstrated characteristics of poor nutrition, but an association of AIDS with body composition was not noted. However, the clinical course of HIV disease may affect longevity and well-being of Rwandan women, as others have found that nutritional deficiencies are more likely to occur in HIV-positive people.[16] Although characteristics of malnutrition were evident in both groups, our findings of body composition measures attributable to malnutrition were quantitatively similar to others' findings.[14] Because inclusion in this study was limited to clinically stable people, it is possible that HIV-infected individuals with more advanced immunosuppression, or clinical instability due to superimposed opportunistic disease, were not represented in this cohort.

Both study groups contained substantial numbers of mal-nourished participants. In 1995, an expert committee of the World Health Organization (WHO) published a report categorizing different populations' nutritional status, with malnutrition defined as BMI less than 18.5 kg/m^2.[17] They considered 20% to 39% to be high prevalence of malnutrition. In our study, the proportion of women with BMI less than 18.5 kg/m^2 was 19% in the HIV-positive group and 26% in HIV-negative group, indicating a moderate-to-high population prevalence of malnutrition, irrespective of HIV infection. The BMI distributions among the 2 groups were also similar (Figure 2). Our findings are supported by a prior Rwandan study performed from 1988 to 1992, which demonstrated similar mean BMI (22.6 and 22.8 kg/m^2) in HIV-infected and uninfected women, respectively.[18] Lower dietary intake demonstrated by undernutrition in this study is a common social and economic reality for women of childbearing age in other sub-Saharan African countries, irrespective of HIV infection.[19] In Rwanda, it was estimated in 2005 that nutritional animal product consumption, which is of higher quality, was only 3% of total energy intake (7% of proteins and 38% of fat), which increases the potential for deficiency of essential amino and fatty acids.[20] Low body weight is commonly compounded by asymptomatic endemic maladies associated with reduction in nutrient absorption and utilization or anemia that may hasten malnutrition. As in other war-torn countries, it is evident that the legacy and manifestations of social disruption and deprivation related to food scarcity appear to affect this community even several years postwar and -conflict.[21] In addition to food scarcity, other sequelae of the conflict such as depression or posttraumatic stress could affect nutritional status.

We interpret these findings in the context and circumstances of a post-conflict milieu but with great optimism that the socioeconomic well-being and nutritional status of the Rwandan inhabitants will be achieved. There has been a marked shift from emergency relief programs to curb widespread malnutrition following the 1994 war period,[22] with greater emphasis on economic development and poverty reduction strategies. Rwanda's development initiatives through its Economic Development and Poverty Reduction Strategy (EDPRS), such as the "one cow per family" program, to improve animal and crop production, promoting chains of agribusiness and building technical capacity have been initiated.[23,24] It would be useful to examine the impact of such initiatives on the temporal trends in overall nutritional status for vulnerable populations, both HIV infected and uninfected. Additionally, although malnutrition adversely affects total lymphocyte and CD4 counts resulting in decreased survival mainly in highly active antiretroviral therapy (HAART)-naive HIV-positive patients, we did not observe such a relationship in this study.[25,26] Perhaps, further effects of malnutrition on total lymphocyte and CD4 counts in this cohort will be evident from longitudinal analysis including HIV clinical stage, HAART initiation, virologic outcomes, and immune reconstitution.

Our findings are comparable to a Malawian cross-sectional study of HIV-positive and HIV-negative adults with pulmonary tuberculosis, in which the majority of the patients were mal-nourished (59% had BMI less than 18.5 kg/m^2) and BMI was similar in HIV-negative compared with HIV-positive individuals in the lowest tertile of viral load.[27] A high prevalence of malnutrition and HIV seropositivity were observed in a study on nutritional status of in-patient adults in Burundi.[27] After stratification into different nutritional groups, mean BMI was not significantly different between HIV-positive and HIV-negative patients.[28] Our findings are particularly important as women comprise 52% of African inhabitants and are more likely than men to be HIV infected in all age groups. Women account for over 60% of all HIV-infected adults in most sub-Saharan African countries.

The strengths of this study include the large sample size, relevant HIV-negative controls, inclusion of participants with a wide range of CD4 lymphocyte counts, and the use of 2 independent methods for estimating body composition. This study is limited by its cross-sectional design and lack of data on caloric intake. Another limitation is in the diagnosis of malnutrition, based on weight and body composition alone. Anthropometry may be the most feasible field technique available to the study population, and it has proved sensitive and useful in assessing body composition changes in other studies of HIV-positive adults.[29,30] However, this study suffers from the lack of an anthropometric equation that has been properly cross-validated with a criterion, that is, a gold standard method for use in Rwandan women. While the approach taken in this study, deriving an anthropometric equation using data from African-American women, avoids some of the limitations of other methods, it is not ideal. For example, African and African-American adults have, on average, a higher bone density than do Caucasians, and this difference affects the accuracy of anthropometric calculations.[31] However, the genetic comparability of the Africans and African Americans may be questioned because the groups may have originated from different geographic areas in Africa. Rwanda is located in Central Africa and most African Americans are believed to have originated from equatorial West Africa. It also is possible that the predictive equations and the results are influenced by racial admixture in African Americans. Published estimates of European racial admixture in African Americans range from 15% to 25% in different areas of the United States.[32] Future studies would be improved by the application of more precise fat quantification methods, such as DEXA, which was not available in Rwanda at the time of the study.

In conclusion, malnutrition is common in Rwandan women, independent of HIV serostatus. HIV has long been considered an important factor affecting nutritional status of the patients in the previous studies.[12-14] The fact that both ART naive HIV-positive and HIV-negative women in our study showed moderate-to-high prevalence of malnutrition likely reflected the low food availability and poverty in this community at the time this study was performed. Current measures to improve general nutritional status for HIV-infected and -uninfected adults may need to consider the cultural setting, as in some communities the fear of developing too much appetite but not having enough to eat could be a unique and potentially major obstacle to adherence to ART in Rwanda.[33] As factors other than malnutrition may influence quality-of-life outcome in HIV-infected Rwandan women, studies on determinants of nutritional status and longitudinal relationships between nutrition and HIV disease progression are warranted. The influence of malnutrition on the response to ART, both efficacy and toxicity remains an important question. However, initiatives to improve nutritional status should be population-wide and not restricted to the HIV-infected population.

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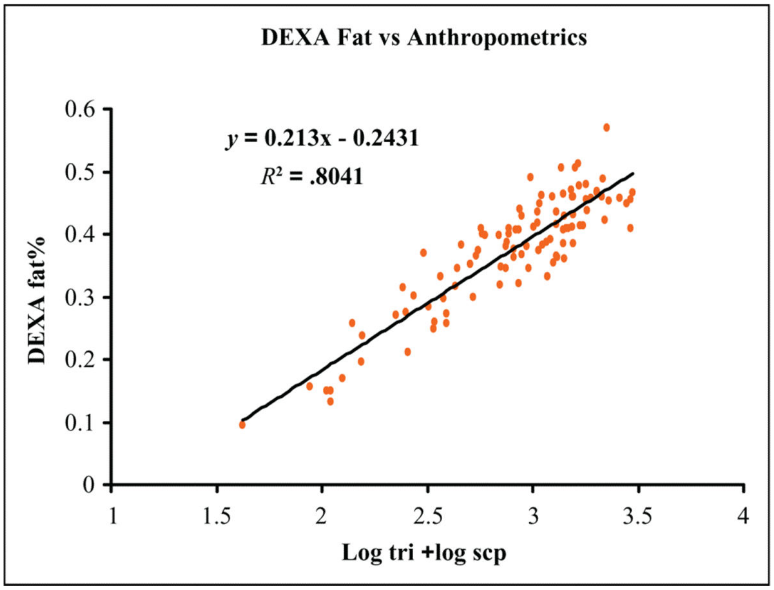

Figure 1.
Dual energy x-ray absorptiometry (DEXA) versus anthropometrics in 102 African-American women.

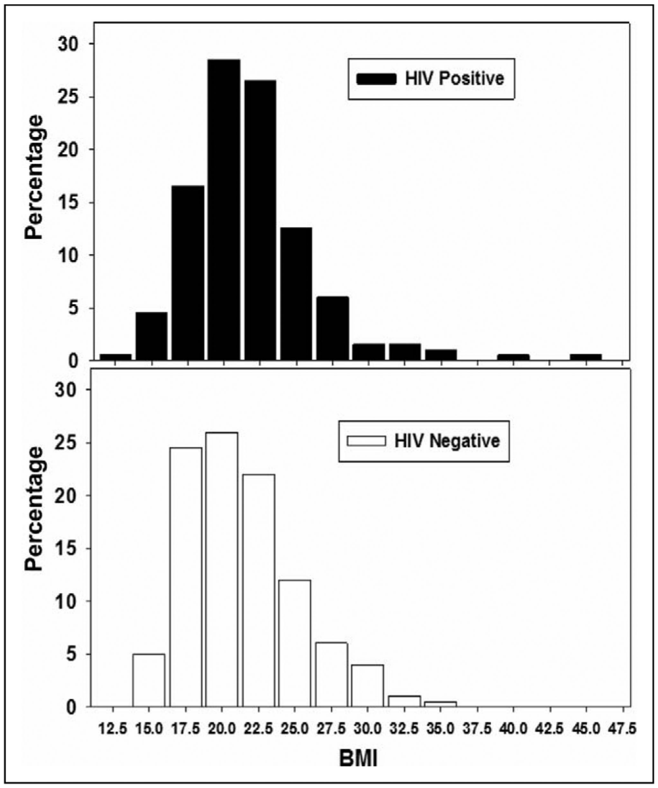

Figure 2.

Body mass index distribution in HIV-infected and uninfected women.

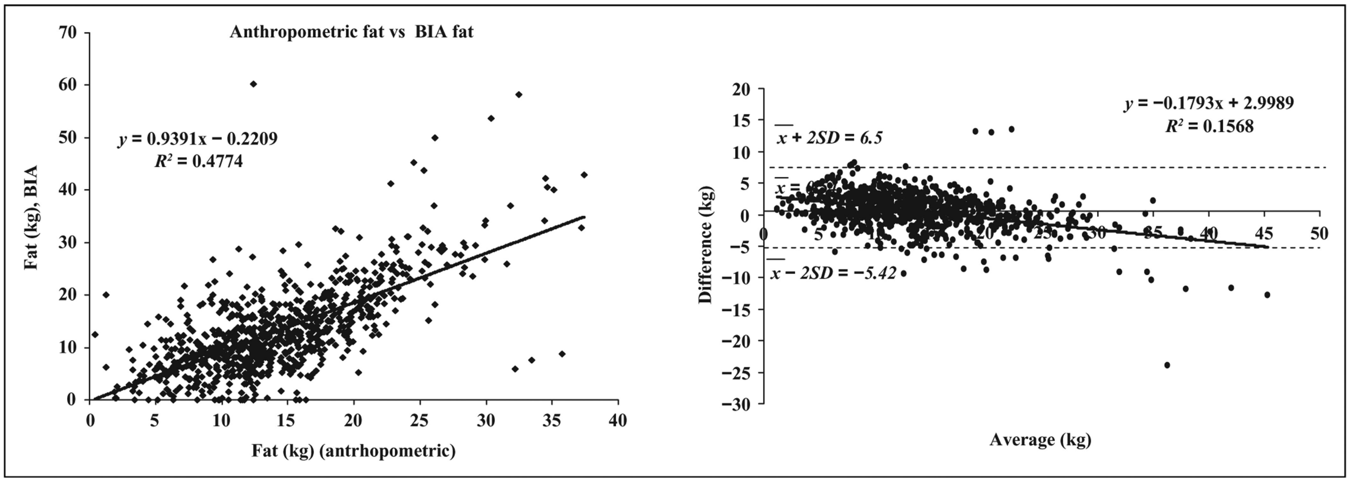

Figure 3.

A, Anthropometric fat compared to bioelectrical impedance analysis (BIA) fat in 620 HIV-positive and 211 HIV-negative Rwandan women. B, Bland-Altman model for BIA method and modified Durnin.

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Table 1

Clinical Characteristics and Body Composition Measurements in Untreated HIV-infected Women and Uninfected Controls[a]

	Untreated HIV-Infected Women	HIV-Negative Controls	*P*	*P* Value (Age- and Height-Adjusted)
Number (n)	620	211		
Age (years)	35.2 ± 7.1	43.3 ± 10.1	<.001	
Weight (kg)	53.9 ± 10.6	54.8 ± 11.2	.306	.804
Height (cm)	157.9 ± 6.8	160.2 ± 7.7	<.001	
BCM (kg)	19.5 ± 3.2	19.8 ± 3.1	.224	
Fat, kg (BIA)	13.2 ± 8.1	13.0 ± 8.4	.792	.983
FFM, kg (BIA)	40.7 ± 4.9	41.8 ± 5.2	.008	.553
Fat, kg (anthro)	15.6 ± 5.3	17.4 ± 5.9	<.001	.123
BMI (kg/m^2)	21.6 ± 3.9	21.3 ± 3.8	.322	.721
WHR	0.88 ± 0.07	0.88 ± 0.07	.749	.113
CD4 count (cells/mm^3)	280 ± 161	897 ± 344	<.0001	

Abbreviations: BCM, body cell mass; BIA, body impedence analysis; BMI, body mass index; FFM, free-fat mass; WHR, waist-to-hip ratio.

[a]Data expressed as mean ± SD.