BODY COMPOSITION IN ADULTS INFECTED WITH HUMAN IMMUNODEFICIENCY VIRUS IN KHON KAEN, THAILAND

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Abstract. A cross-sectional study of 77 patients infected with human immunodeficiency virus (HIV) in Khon Kaen, Thailand examined association of nutritional status with active opportunistic infections (AOIs)/HIV status and assessed degree of correlation between bioelectrical impedance analysis (BIA) and anthropometry. Many patients (41.3%) were malnourished using World Health Organization criteria for underweight, and malnutrition was associated with AOI status. Unconditional odds ratios ($P < 0.05$) for AOI as opposed to no AOI were 4.57 for underweight, 9.87 for severe underweight, 2.55 for triceps < 10th percentile, and 5.22 for mid-arm circumference < 10th percentile. Body fat composition from BIA, anthropometry, and body mass index were moderate to highly correlated ($P < 0.001$), with the highest correlation between BIA and subcapular skinfold ($r = 0.86$) and the lowest between BIA and triceps skinfold ($r = 0.54$). Insights were gained about relative value of using various measurements to assess nutritional status of HIV-infected populations.

INTRODUCTION

Human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) represents a major cause of morbidity and mortality worldwide. AIDS is a leading cause of mortality in Thailand, responsible for 55,000 deaths in its 63.6 million population during the year 2001. Prevalence of HIV is 1.8% in adults 15–49 years of age, second only to Cambodia in the south and southeast Asia regions. Several reports have described HIV in Thailand, but few have described the nutritional status of individuals infected with HIV in this country.

Nutritional compromise in HIV infection is associated with increased morbidity and mortality, even with moderate malnutrition. Survival is closely related to amount of lean body mass. However, an ideal method for assessment of body composition is controversial. Although several techniques exist for measurement of body composition, few are appropriate in field settings.

When selecting a method to assess body composition, important considerations include study objectives, expense, convenience, available technical expertise, invasiveness, and portability. Commonly used field techniques include bioelectrical impedance analysis (BIA) and anthropometry. Both BIA and anthropometry are indirect measurements of body composition, since they require comparison with a reference method to assess composition. Predictions of body composition are derived from equations based on data collected from BIA and skinfold measurements. Equations developed by Lukaski and others and Durnin and Womersley were generated using adult Caucasian populations. Although studies have shown these equations to be applicable in black and Chinese populations, such equations have not been examined in the Thai population. The advantage of more costly BIA over simple anthropometric measurements has been questioned. Many researchers report better correlation with anthropometric measurements than BIA when assessing body composition. Validation of simple, non-invasive techniques for body composition assessment in non-Western societies is imperative.

The aim of this study was therefore two-fold: 1) to examine the association of nutritional status with active opportunistic infections (AOIs) among HIV-infected adults in Khon Kaen, Thailand, and 2) to determine if there was an association between BIA and anthropometric assessment of body composition among HIV-infected adults in this region. Located in northeastern Thailand, Khon Kaen is one of the poorest regions in this country and is recently experiencing economic transition. Results of this study will inform clinicians on the relative value of using various measurements to assess nutritional status of HIV-infected populations.

MATERIALS AND METHODS

Study population. A convenience sample of 77 HIV-infected adult patients was recruited from Srinagarind Hospital, Khon Kaen University Medical Center (Khon Kaen, Thailand) during the period March to May 1999. Participants were more than 18 years of age with a life expectancy greater than 14 days. Subjects were recruited from subsequent patients coming to the outpatient general medicine clinic, the outpatient infection clinic, and the inpatient infectious disease service. HIV status was determined using available laboratory methods at Khon Kaen University Medical Center laboratory that included screening gel particle-agglutination (testing for antibody to HIV-q lysate), followed by confirmatory enzyme-linked immunosorbent assay and a follow-up Western blot for questionable results. AIDS status was determined by World Health Organization (WHO) criteria for opportunistic illnesses.

All patients provided informed consent, both in Thai and in English, through an interpreter. The study was reviewed and approved by the ethical review boards of Tufts-New England Medical Center (Boston, MA) and Khon Kaen University Medical Center (Khon Kaen, Thailand).
**Body composition assessment.** Height and weight were obtained with subjects in light clothing and without shoes, to 0.5 cm and 0.5 kg, respectively. Body mass index (BMI) was calculated as weight in kilograms/height in meters$^{2}$. Mid-arm circumference (MAC) was measured at the midpoint of the upper right arm to the nearest 0.1 cm. Mid-arm muscle circumference (MAMC) was determined using the standard equation of Frisancho.$^{25}$ Anthropometric measurements were taken in triplicate of the triceps and subscapular skinfolds by a single trained investigator. Measurements were averaged. The BIA was conducted using quantum hand-held analyzers (RJL Systems, Clinton, MI). Subjects were placed in the supine position with arms and legs abducted at 30°. Electrode sites were cleaned with alcohol and four electrodes were applied to the right hand and foot except in two instances when intravenous lines interfered with placement site, and the electrodes were applied on the left side. Two current producing electrodes were placed proximal to the metacarpal phalangeal joints. Two voltage sensing electrodes were applied at the pisiform prominence of the wrist and between the medial and lateral malleoli of the ankle. A current of 800 mA at 50 kHz was passed through the body and the mean of three consecutive measurements made in immediate succession was used. Readings that were not stable were not used. The same investigator performed all measurements. The BIA data were analyzed with the Fluid and Nutrition Analysis Version 3.1 program, provided by RJL Systems, using the equations of Lukaski and others.$^{14}$

**Patient history and laboratory data.** Subjects were interviewed and examined. The same investigator conducted interviews through an interpreter. A general physical examination was conducted. The patient’s clinic and/or inpatient records were reviewed for pertinent HIV history, medications, and laboratory data.

**Statistical analysis.** Data were entered into the Statistical Program for Social Sciences (SPSS Version 12.0 for Windows; SPSS Inc., Chicago, IL). Data were analyzed separately for patients with and without AOI. Males and females were stratified because of variations in demographics, health status, and body composition standards. Means, proportions, and their standard deviations, as well as associations and unconditional odds ratios, were generated by SPSS. $P$ values for differences between AOI and no AOI were calculated using the non-parametric Mann-Whitney test because the data were not normally distributed. Associations and $P$ values for differences between body fat assessment techniques were calculated using Pearson’s chi-square test. $P < 0.05$ was considered statistically significant for all analyses.

**RESULTS**

The demographic characteristics, as well as health status, of subjects who participated in the study are shown in Table 1. There were statistically significant differences in AIDS presence, inpatient hospital status, and percent currently receiving anti-retroviral therapy (ART) between AOI and no AOI for all subjects and women. There were statistically significant differences in AIDS presence and inpatient hospital status for men. The AOIs included cryptococcal disease ($n = 16$), tuberculosis ($n = 13$), cytomegalovirus retinitis ($n = 3$), *Pneumocystis* pneumonia ($n = 2$), penicilliosis ($n = 1$), *Nocardia* ($n = 1$), *Mycobacterium avium* avium complex ($n = 1$), esophageal candidiasis ($n = 1$), fever ($n = 1$). Seventeen subjects also had a history of the AOIs mentioned plus histoplasmosis. All subjects had adequate access to food. The ART included zidovudine ($n = 11$), didanosine ($n = 6$), lamivudine ($n = 4$), stavudine ($n = 4$), zalcitabine ($n = 4$), and indinavir ($n = 3$). Duration of ART ranged from two weeks to two years.

Unconditional odds ratios were determined for underweight, as calculated by BMI, and skinfold measurements < 10th percentile using all subjects. Percentiles for skinfold measurements were based on standards developed by Frisancho$^{26}$ using data from the National Health and Nutrition Examination Surveys I (1971–1974) and II (1976–1980), which examined United States persons 1–74 years of age. Unconditional odds ($P < 0.05$) of having AOI as opposed to no AOI were 4.57 times as great for individuals who were underweight, having BMIs < 18.5 compared with those with BMIs ≥ 18.5. Odds ($P < 0.05$) of having AOI as opposed to no AOI were 9.87 for individuals who were severely underweight, and body composition standards. Means, proportions, and their standard deviations, as well as associations and unconditional odds ratios, were generated by SPSS. $P$ values for differences between AOI and no AOI were calculated using the non-parametric Mann-Whitney test because the data were not normally distributed. Associations and $P$ values for differences between body fat assessment techniques were calculated using Pearson’s chi-square test. $P < 0.05$ was considered statistically significant for all analyses.

**Table 1** Demographics and health status categorized by active opportunistic infections (AOIs) or no AOI*

<table>
<thead>
<tr>
<th></th>
<th>All subjects (n = 77)</th>
<th>AOI (n = 40)</th>
<th>no AOI (n = 37)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>33.5 ± 7.9</td>
<td>33.0 ± 8.0</td>
<td>34.1 ± 7.8</td>
<td>0.22</td>
</tr>
<tr>
<td>HIV duration (months)</td>
<td>39.0 ± 37.0</td>
<td>37.2 ± 34.9</td>
<td>40.9 ± 39.6</td>
<td>0.69</td>
</tr>
<tr>
<td>Acquired immunodeficiency syndrome (AIDS)</td>
<td>62 (80.5)</td>
<td>40 (100.0)</td>
<td>22 (59.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hospital status (inpatients)</td>
<td>30 (39.0)</td>
<td>29 (72.5)</td>
<td>1 (2.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Anti-retroviral therapy (ART), (currently receiving)</td>
<td>15 (19.5)</td>
<td>4 (10.0)</td>
<td>11 (29.7)</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Men (n = 50)</th>
<th>AOI (n = 27)</th>
<th>no AOI (n = 23)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>34.4 ± 7.6</td>
<td>33.5 ± 7.3</td>
<td>35.4 ± 7.9</td>
<td>0.15</td>
</tr>
<tr>
<td>HIV duration (months)</td>
<td>43.8 ± 40.9</td>
<td>39.6 ± 38.0</td>
<td>48.6 ± 44.3</td>
<td>0.45</td>
</tr>
<tr>
<td>AIDS</td>
<td>45 (90.0)</td>
<td>27 (100.0)</td>
<td>18 (78.3)</td>
<td>&lt;0.05</td>
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<tr>
<td>Hospital status (inpatients)</td>
<td>21 (42.0)</td>
<td>20 (74.1)</td>
<td>1 (4.3)</td>
<td>&lt;0.001</td>
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<tr>
<td>ART (currently receiving)</td>
<td>7 (14.0)</td>
<td>1 (3.7)</td>
<td>6 (26.1)</td>
<td>0.58</td>
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</tbody>
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<table>
<thead>
<tr>
<th></th>
<th>Women (n = 27)</th>
<th>AOI (n = 13)</th>
<th>no AOI (n = 14)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>31.8 ± 8.2</td>
<td>31.8 ± 9.4</td>
<td>31.8 ± 7.3</td>
<td>0.64</td>
</tr>
<tr>
<td>HIV duration (months)</td>
<td>30.2 ± 27.2</td>
<td>32.3 ± 28.1</td>
<td>28.3 ± 27.2</td>
<td>0.85</td>
</tr>
<tr>
<td>AIDS</td>
<td>17 (63.0)</td>
<td>13 (100.0)</td>
<td>4 (28.6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hospital status (inpatients)</td>
<td>9 (33.3)</td>
<td>9 (69.2)</td>
<td>0.0 (0.0)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>ART (currently receiving)</td>
<td>8 (29.6)</td>
<td>3 (23.1)</td>
<td>5 (35.7)</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

*Data are mean ± SD or number (%). See Results for data on types of AOI and type and duration of ART.
having BMIs < 16.0 compared with those with BMIs ≥ 16.0. Odds (P < 0.05) of having AOI as opposed to no AOI were 2.55 times as great for individuals with triceps skinfolds < 10th percentile as opposed those with triceps skinfolds ≥ 10th percentile. Odds (P < 0.05) of having AOI as opposed to no AOI were 5.22 times as great for individuals with a MAC < 10th percentile as opposed to those with a MAC ≥ 10th percentile.

Table 2 shows body composition of men categorized by AOI. There were statistically significant differences between subjects with AOI and no AOI in mean BMI, percent underweight (BMI < 18.5), weight, mean triceps skinfold, triceps skinfold < 10th percentile, MAC, percent body fat by triceps, percent body fat by subscapular, and percent body fat by triceps plus subscapular.

Table 3 shows body composition of women categorized by AOI. There were statistically significant differences between subjects with AOI and no AOI in mean BMI, weight, mean triceps skinfold, mean subscapular skinfold, MAC, percent MAC < 10th percentile, percent fat-free mass by BIA, percent body fat by BIA, percent body fat by triceps, percent body fat by subscapular, and percent body fat by triceps plus subscapular.

 Associations among percentage of fat estimated from BIA,
subscapular skinfold, triceps skinfold, and sum of triceps plus subscapular skinfolds; and BMI are shown in Table 4. The correlation coefficient was highest between BIA and subscapular skinfold and lowest between BIA and triceps skinfold. All correlations were statistically significant at the \( P < 0.001 \) level.

**DISCUSSION**

Weight loss is very common in HIV and AIDS, and has been correlated with disease progression and mortality. Even at moderate levels, malnutrition has been shown to have a detrimental impact on HIV outcome. This association has been related to survival independent of the CD4 cell count.

Almost half of this population of HIV-infected adults in Khon Kaen, Thailand had evidence of malnutrition when compared with WHO and United States standards. The mean BMI of this population was 18.9 in men and 19.8 in women. This can be compared with population norms for the United States, where mean BMI has been estimated as 25.9 for adult males and 26.3 for adult females. The current WHO BMI cut-off point for underweight is 18.5. Thus, the mean for the entire study population was only slightly above one known cutoff for malnutrition. The mean triceps skinfold was 12.1 mm in men and 16.8 mm in women (United States population mean = 13.5 mm in men and 26.8 mm in women), with 32.0% of men and 37.0% of women < 10th percentile. The mean subscapular skinfold was 7.2 mm in men and 12.1 mm in women (United States population mean = 18.8 mm in men and 23.2 mm in women), with 6.0% of men and 11.1% of women < 10th percentile. The MAC was 24.2 cm in men and 24.1 cm in women (United States population mean = 32.5 cm in men and 31.2 cm in women), with 94.0% of men and 59.3% of women < 10th percentile.

When comparing those with AOI versus those without AOI, those with AOI had worse nutritional status. Those with AOI had a mean BMI of 17.7, compared with a mean of 21.0 (\( P < 0.001 \)) for those without AOI. The value 17.7 falls below the cutoff of 18.5, indicating underweight and malnutrition. In addition, those with AOI had a significantly lower percent body fat when analyzed using both BIA and skinfold measurements (\( P < 0.05 \)) (men skinfold only). Differences in MAMC, a measurement of muscle mass, were not significantly different between those with AOI and those with no AOI.

Associations between body fat assessment techniques were moderate to high for all techniques (\( P > 0.5 \)). However, actual body fat percentages varied based on strengths and weaknesses of measurement techniques, neither of which is the gold standard. The validity of skinfold measurements are dependent on two assumptions. First, subcutaneous adipose tissue thickness represents a constant proportion of total body fat. Second, skinfold sites selected for measurement reflect average subcutaneous adipose thickness. However, the validity of neither assumption has been verified. With a properly trained and experienced anthropometrist, precision is typically within 5%. However, error increases markedly when skinfolds are very large (>15 mm) or small (<5 mm) as may be seen in the Thai population. Likewise, BMI may be skewed in the Thai population. Deurenberg and others indicated that for the same age, sex, and degree of body fat, Thai BMIs are 2.9 kg/m\(^2\) lower when compared with Caucasians. Underestimation of body fat was found when both skinfolds and dual-energy x-ray absorptiometry were used as reference methods. They attributed this relationship to differences in body build and energy balance, calling for population-specific BMI cut-points.

There were several limitations to this study. First, there was no HIV-negative control group. The reference standards used in the analysis were those developed for healthy adults in the Western world, which may not be accurate when applied to Thai men and women, who are generally shorter and slimmer than adults in the United States, with high body fat percentages at lower BMIs. Second, this is a cross-sectional study and thus no information was generated about the temporal relationship between nutritional status and development of AOI. And finally, BIA measurements can be affected by disease status. During periods of acute infections, fluid shifts in the body may lead to an increase in extracellular fluid (ECF). Since ECF is included in fat-free mass, it may arbitrarily elevate the ECF level because any elevation of fat-free mass will decrease the percent body fat as determined by BIA. Therefore, this group may have an artificially lowered fat-free mass when compared with those not in an acutely ill state, thus skewing the results.

In conclusion, nutritional compromise in HIV has long been known to be associated with morbidity and mortality. Nearly half (41.3%) of the HIV-infected adults in this study were malnourished using the WHO BMI cut-off for underweight. Such malnutrition was seen in individuals with and without AOI, and those who were and were not treated with ART. Further study is needed to more fully evaluate the nutritional status of this population, including investigating causes of malnutrition, and exploring the longitudinal relationship between nutrition and HIV disease progression. Ultimately, whether cost-effective nutritional intervention can improve the nutritional status and impact the course of HIV disease in similar settings with limited resources should be assessed.

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REFERENCES


