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DETERMINATION OF BODY COMPOSITION OF PEOPLE LIVING WITH HIV/AIDS: A COMPARISON OF AIR DISPLACEMENT PLETHYSMOGRAPHY WITH TANITA SEGMENTAL BODY COMPOSITION ANALYZER

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# DETERMINATION OF BODY COMPOSITION OF PEOPLE LIVING WITH HIV/AIDS: A COMPARISON OF AIR DISPLACEMENT PLETHYSMOGRAPHY WITH TANITA SEGMENTAL BODY COMPOSITION ANALYZER

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## ABSTRACT

*Background:* **Body composition (BC) assessment of patients living with HIV is frequently done by a variety of methods. During the past decades, several new technologic developments have introduced different methods of BC assessment. Yet, simple, accurate, and noninvasive methods for assessing BC are needed in clinical, community, and research settings.**

*Objective:* **To compare BC assessed by air displacement plethysmography (ADP) with that assessed by Tanita segmental BC analyzer in patients with HIV/AIDS.**

*Method:* **Eighty-eight adult (> 18 years) HIV/AIDS patients who were on follow up at anti-retroviral clinic in Jimma university medical centre were randomly selected. ADP and Tanita segmental BC analyzer were used to collect data. Agreement between the methods was tested using paired t-test, Pearson's correlation, and linear regression.**

*Result:* **Thirty-nine (57.4%) of the patients were female and 29 (42.6%) were male. About 41(60.3%) of them were malnourished. The patients who were in stage one of the disease accounted 83.8%. Mean value of %BF measured by Tanita segmental BC analyzer was significantly lower than %BF measured by the ADP (mean difference = 3.2, $p < 0.001$). Regardless of the difference in mean, %BF assessed by the two methods were strongly correlated ($r = 0.98$, $p < 0.001$).**

*Conclusion:* **Estimates of %BF by Tanita segmental BC analyzer and ADP in people living with HIV/AIDS in Southwest Ethiopia showed significant difference. Tanita segmental BC analyzer significantly underestimated %BF in HIV/AIDS patients.**

## INTRODUCTION

Patients with malnutrition are frequently diagnosed for their nutritional status. One group of these patients is HIV/AIDS patients (1). During the past decade, several new technologic developments have introduced alternative methods to determine body composition (BC) (2).

The recent introduction of air displacement plethysmography (ADP; LMI, Concord, CA) provides a means to measure BC in research and clinical settings. The ADP procedure, provided commercially as the BOD POD system, uses variation in pressure and volume, while the subject rests inside a sealed chamber, to estimate body density. The ADP method has been validated and used in several research and clinical settings (3-6).

Tanita BC analyzer is an increasingly popular method for BC assessment. Even if Tanita BC analyzer cannot replace the other methods, it is available in many clinical and research centers and provides reproducible results (7-9). Yet, simple, accurate, and noninvasive methods for assessing BC are needed in many clinical, community, and research settings (10).

In Jimma University medical centre (JUMC), ADP and Tanita BC analyzer are used interchangeably to assess nutritional status of patients (11). But the validity of using these two methods interchangeably has not been researched. Hence, the main aim of the present study was to evaluate the agreement of ADP and Tanita BC analyzer for the assessment of percent body fat (%BF) and percent fat free mass (%FFM) in HIV/AIDS patients.

## METHODS

***Study area:*** The study was conducted in JUMC; Jimma; Southwest Ethiopia. JUMC is a university hospital that gives healthcare service for about fifteen million people. It has antiretroviral treatment (ART) clinic in which 7221 people living with HIV/AIDS (PLWHA) have been enrolled into it till February/ 2014 of whom about 4295 PLWHA had been commencing ART drugs and about 2572 were active ART followers at the time of the study. The study was conducted from April 1, 2014 to June 30, 2014.

***Study design and population:*** This is a cross-sectional study. The source population is all PLWHA who were enrolled into HIV care in JUMC ART clinic. All HIV positive adults (≥18 years) who came to the clinic during the study period and those who were willing to consent were included into the study. Pregnant or lactating; terminally ill from HIV or other serious condition and patients who were claustrophbic to the measurements were excluded from the study.

***Sampling procedure:*** Convenience sampling method was used.

***Data collecting instruments***

***Structured Questionnaire:*** Medical history of the participants was collected using a structured questionnaire. Questionnaire data were taken shortly before BC measurement. The questionnaire was presented to the participants by trained and experienced research nurses in JUMC nutritional research centre.

***Anthropometry:*** Body weight was measured to the nearest 0.1 kg and height was measured to the nearest 0.5cm with the patients standing back to a standiometer. Both measurements were made in light clothing and bare foot and nothing in their pockets.

***Air Displacement Plethysmography:*** Measurements were made by trained personnel using standard procedures. The test is a 5-minute long measurement that consists of measuring the subject's body mass using an electronic scale, and body volume (BV), which is determined by sitting inside the ADP chamber. From these two measurements, the subject's body density is calculated. It uses air-displacement and pressure volume relationships to derive an individual's BV. A detailed description of the principles and procedures of ADP was described in detail by other studies (12, 13). For all participants, the Siri equation was utilized to convert body density to %BF **(14).**

**%BF = [495/body density] – 450 _____ 3**

Once %BF is calculated, %FFM can also be determined as follows:

**%FFM = 100 – %BF _____ 4**

All participants were asked to refrain from exercise, food stuffs and drink 2 hours prior to all testing. Participants were given and instructed to wear a bathing suit, and swimming cap. They were told to remove shoes, socks and jewelers. The data were entered into the computer, in which each subject was weighed on a calibrated digital scale and asked to sit still in the chamber with their hands on their lap, instructed to breathe normally, while two 50-s measurements were obtained. A minimum of two 50-s tests was conducted to ensure reliability of measures. If the BV was not within 150 ml of each other, a third test was repeated. The values for weight, fat mass (FM), FFM, %BF and BV were then recorded by the computer connected to the ADP.

The measurements were not accepted as valid unless they met the criteria of having a merit < 1 and an airway Pressure < 35cm $H_2O$ as recommended by the manufacturer company (15). If a participant's measurement did not meet these criteria, his/her results were not used in the data analysis. These guidelines are standard for ADP measurement.

***Tanita segmental BC Analyzer:*** Tanita segmental BC analyzer is a leg-to-leg bioelectrical impedance BC analyzer. Tanita model number BC-418 Segmental BC Analyzer was used for this research. Participants were asked to void their bladder prior to measurement. Height, sex, and age were entered manually; weight was recorded automatically by the Tanita itself. The Tanita software uses in-built prediction equations to estimate %BF, %FFM, FM and FFM. BC measurements were done according to the manufacturer's guidelines and as described in detail by other studies (16, 17).

***Data collection procedure***

The procedure used for obtaining data using the questionnaire, anthropometry, ADP and Tanita BC Analyzer is discussed as follows:

1. First, questionnaire data were taken by trained nurses at ART clinic.
2. Eligible participants were taken for measurement to the research laboratory.
3. The participants were asked to empty bladder and bowel and change into non-bulky clothes and swim cap (provided by the research team).
4. They were informed about the procedure of the measurement.
5. The participant's height was measured to the nearest 0.1m and weight to the nearest 0.1kg using the ADP scale.
6. BC was measured using Tanita segmental BC analyzer followed by ADP.
7. After BC is measured by Tanita segmental BC Analyzer, the participants were asked to sit in ADP. They were also informed that she/he can signal through the window if she/he feels any discomfort

and wants the door to be opened. Close the door tightly. During the 20 sec test, they were informed to breath with their normal tidal breathing. Measurements by Tanita and ADP were done within 25 minutes of one another.

8. The door was opened and closed. The 20 sec test was repeated. If the 2 tests disagreed by more than 150 ml, additional tests were performed until two tests are within 150 ml.
9. The door was opened and connected the participant to the ADP'S breathing circuit for measurement. The door was closed, and the participant was allowed to do a few normal breathing cycles. The participant was asked to perform a puffing maneuver. If necessary, repeat this step until the ADP indicates that the "figure of merit".

Finally, Data were checked for completeness immediately after collection.

***Data quality control:*** Data were collected by research nurses with adequate experience and already working on the equipment. Training was given to data collectors and data clerk on explanation of the study objectives, techniques of approaching the study participants and how to keep confidentiality of the data. Moreover, pilot data collection was done before the actual data collection.

***Data processing and analysis:*** The data were double entered into Epidata v 3.1. and exported to SPSS v16.0 for analysis. Paired t-test was used to compare between group means. Linear regression was also used to see how well the two measurements were reflected to each other. A p-value of $< 0.05$ was considered for statistical significance.

***Ethical approval:*** Ethical approval was obtained from Institutional Review Board of Institute of Health, Jimma University. Informed consents were obtained from the participants.

## RESULT

***Socio-demographic and Clinical characteristics of Study population:*** A total of 88 patients were recruited into this study. From these, 68(77.8%) patients were able to finish the measurements. The demographic characteristics of the study population are indicated in Table 1 and clinical information is indicated in Table 2.

Among the 68 patients, about 39 (57.4%) were female and 29 (42.6%) were male. They ranged in age from 22years to 60years. Despite the fact that the sample contained patients from all category of BMI, about 41(60.3%) were malnourished of whom 4(5.8%) were severely malnourished (BMI<16.0).

**Table 1**
*Demographic characteristics of the patients*

| | Whole Group (n= 68) | | Males (n=2) | | Females (n= 39) | |
|---|---|---|---|---|---|---|
| | **Mean ± SD** | **Range** | **Mean ± SD** | **Range** | **Mean ± SD** | **Range** |
| **Age(years)** | **34.5±7.3** | **22-60** | **36.7±7.2** | **22-50** | **32.0±6.9** | **22-60** |
| **Weight(kg)** | **50.1±8.8** | **35.7-76.0** | **50.6±6.1** | **39.4-62.8** | **49.6±10.4** | **35.7-76.0** |
| **Height(cm)** | **161.5±8.8** | **146.5-182.0** | **168.9±6.8** | **153.3-182.3** | **156.1±5.6** | **146.0-167.3** |
| **BMI(kg/m²)** | **19.2±3.5** | **13.2-31.2** | **17.7±1.7** | **15.8-22.3** | **20.3±4.09** | **13.2-31.2** |
| **predicted BV (L)** | **46.4±9.1** | **32.14-75.45** | **46.80±5.97** | **36.86±59.06** | **47.6±10.97** | **32.14-75.45** |
| **Measured BV (L)** | **47.5±9.0** | **32.73-74.93** | **47.09±5.99** | **36.8±58.62** | **47.8±10.91** | **32.73-74.93** |
| **Predicted BD (kg/l)** | **1.0560±0.02** | **1.0020-1.098** | **1.0750±0.013** | **1.048±1.098** | **1.042±.024** | **1.002-1.096** |
| **Measured BD** | **1.0052±0.02** | **1.0004-1.0694** | **1.0680±0.013** | **1.038±1.089** | **1.039±0.021** | **1.0004-1.0753** |

**n = number of subjects, SD= standard deviation**

About 83.8% of the patients were in stage one of the disease. About 29 (42.6%) had previous history of Pulmonary tuberculosis (PTB). Respiratory infections other than PTB were seen in 41.1% of the patients. All of the patients were in HAART. The mean length of months they had been taking the treatment was 57.79 months (Range= 4-104). About 41(60.3%) were using cotrimozazole prophylaxis. Only 6(8.8%) patients were previous smokers, and 1(1.5%) was current smoker.

**Table 2**
*Clinical characteristics of the patients*

| Variable | | N | Percent (%) |
|---|---|---|---|
| **Stage of the disease** | Stage I | 57 | 83.8% |
| | Stage II | 8 | 11.8% |
| | Stage III | 2 | 2.9% |
| | Stage IV | 1 | 1.5% |
| **PTB history** | Yes | 29 | 42.6% |
| | No | 39 | 57.5% |
| **Lung disease (other than PTB).** | Yes | 28 | 41.1% |
| | No | 40 | 58.9% |
| **Smoking History** | Yes | 6 | 8.8% |
| | No | 62 | 91.2% |
| **Currently smoking** | Yes | 1 | 1.5% |
| | No | 67 | 98.5% |
| **Cotrimoxazole Prophylaxis** | Yes | 41 | 60.3% |
| | No | 27 | 39.7% |
| **Additional treatment** | Yes | 4 | 5.9% |
| | No | 64 | 94.1% |
| **How long on ART (in months)?** | 1-24 | 18 | 26.4% |
| | 25-48 | 11 | 16.2% |
| | 49-72 | 15 | 22.1% |
| | 73-96 | 22 | 32.3% |
| | >96 | 2 | 2.9% |
| **HAART** | TDF/3TC/EFV | 18 | 26.5% |
| | AZT/3TC/EFV | 13 | 19.1% |
| | TDF/3TC/NVP | 2 | 2.9% |
| | AZT/3TC/NVP | 35 | 51.5% |
| | Other | 0 | 0% |

***%BF measured by ADP Vs %BF measured by Tanita segmental BC analyzer:*** Mean value of %BF measured by Tanita segmental BC analyzer was significantly lower than %BF measured by ADP (mean difference = 3.2, $p < 0.001$). Regardless of the difference in mean, they were strongly correlated ($r = 0.98$, $p < 0.001$) (Table 3). Regression of these two variables showed that the intercept of the model line for %BF measured by the ADP(Y) vs %BF measured by Tanita(X) [$y = 4.239 + 0.943x$] was significantly deviated from 0 whereas the slope is not significantly different from 1. Despite the insignificance of the intercept, the coefficient of determination ($R^2$) value obtained from the regression was found to be 0.80, which indicates that 80% of %BF measured by the ADP was explained by %BF measured by the Tanita segmental BC analyzer (Table 4 and Fig. 1).

**Table 3**

*Comparison of BF and FFM estimated from ADP and Tanita segmental BC analyzer, JUMC*

| | Mean difference | SD | p-value | 95%confidence interval for mean difference | | Pearson correlation | p-value for r |
|---|---|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit | | |
| %BF measured by Tanita Vs %BF measured by the ADP | -3.20* | 4.52 | <0.001 | -4.30 | -2.09 | 0.98† | <0.001 |
| FM measured by Tanita Vs FM measured by the ADP | -2.10* | 2.59 | <0.001 | -2.73 | -1.46 | 0.92† | <0.001 |
| FFM measured by Tanita Vs FFM measured by the ADP | -1.9* | 2.4 | <0.001 | -2.4 | -1.3 | 0.91† | <0.001 |

*BF- body fat, SD = standard deviations, * a significant mean difference, r- Pearson's correlation, † strong correlation*

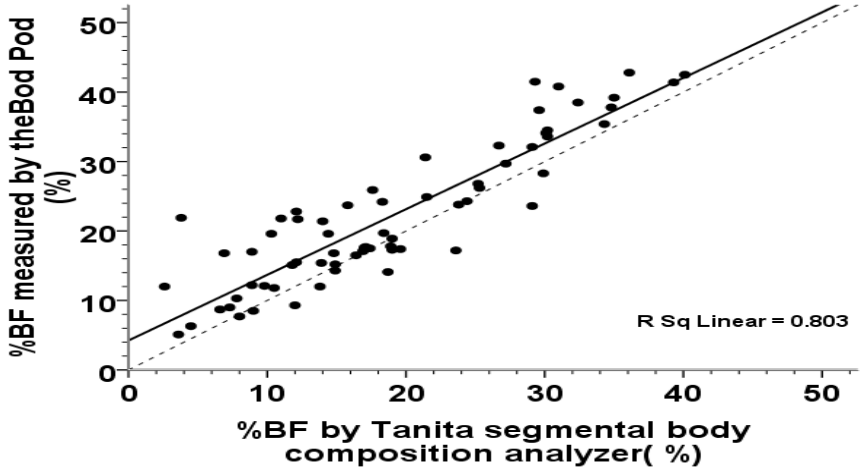


Figure 1: Regression of %BF measured by the ADP against %BF calculated using Tanita segmental BC analyzer. The dashed line represents the line of identity, and the solid line represents the line of best fit for the regression equation. The slope of the regression line (y = 4.239 + 0.945x, R2 = 0·803, p < 0.001) is not significantly different from the line y = x.

**Table 4**

*Summary of regression of BF and FFM measured by Tanita segmental BC analyzer and ADP, JUMC*

| | Regression | | | | |
|---|---|---|---|---|---|
| | **Intercept** | **Slope** | **$R^2$** | **SEE** | **P –value for slope** |
| **%BF measured by Tanita Vs %BF measured by the ADP** | 4.24 | 0.94 | 0.80 | 4.52 | <0.001 |
| **FM measured by Tanita Vs FM measured by the ADP** | 2.51 | 0.95 | 0.85 | 2.6 | <0.001 |
| **FFM measured by Tanita Vs FFM measured by the ADP** | 2.4 | 0.89 | 0.84 | 2.3 | <0.001 |

***FM and FFM Measured by the ADP and Tanita Segmental BC Analyzer:*** Mean FM measured by Tanita segmental BC analyzer was 9.83kg while mean FM measured by the ADP was 11.92kg. Mean difference was 2.10 ($p < 0.001$). A significant underestimation of FM was observed by Tanita segmental BC analyzer. It was underestimated by 17.2 %. Regression between them indicated that the slope was significant ($p < 0.001$) (Table 3 and Fig 2).

The Mean difference of FFM measured by the two measurements was -1.9 ($p < 0.001$). Strong correlation was observed despite the significant mean difference ($r = 0.91$, $p < 0.001$). Linear regression analysis of FFM measured by the two devices revealed that the slope is significant (slope = 0.89, $p = 0.001$).

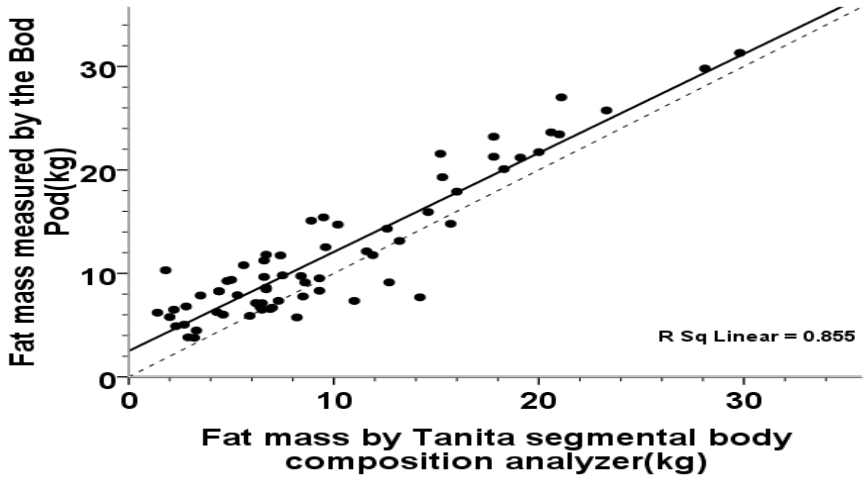


Figure 2: Regression of FM measured by Tanita segmental BC analyzer against FM measured by ADP. The dashed line represents the line of identity whereas the solid line represents the line of best fit. The slope of the regression line (Y = 2.51+ 0.95X) was not significantly different from one ($p< 0.001$).

## DISCUSSION

According to the findings of the study %BF measured by Tanita segmental BC analyzer was significantly different from %BF measured by the ADP. Tanita BC analyzer underestimated %BF. A similar finding was reported in a study conducted on healthy South Asian people (18). In our study a mean difference of 3.20± 4.52(P< 0.001) was found between the two measurements but the study conducted among South Asian people found a mean difference of 4.3%.

According to the argument of the above study, the significant underestimation of %BF by Tanita segmental BC analyzer may be explained by the unique BF distribution of South Asians. South Asians have a significantly greater total abdominal fat and intra-abdominal adipose tissue compared with white Caucasians, for a similar value of BMI. Tanita segmental BC analyzer estimates %BF based on the fat content in legs and does not account well for the greater amount of abdominal fat, whereas %BF measured by ADP accounts for the whole body. That is, the impedance of the current in Tanita segmental BC analyzer might overestimate the content of lean tissue in individuals with proportionally higher intra-abdominal adipose tissue, and thus, estimates of %BF based on current impedance in such individuals would result in an underestimation of BF. In another study, Tanita segmental BC analyzer underestimated %BF, as compared to ADP (19).

Despite the significant mean difference, they correlated strongly. However, a strong correlation alone is not an indication of the strength of agreement between two methods (18). Hence, S. E. Hillier et al. (20) argue that the two methods cannot be used interchangeably, although both measurements had good within- and between day agreement.

On the other hand, a study conducted in USA found no significant difference between % BF measured by the ADP and Tanita segmental BC analyzer. The researchers argued that Tanita segmental BC analyzer provides an acceptable significant correlation with criterion methodologies but may not be accurate enough to give precise, reliable individual BC measurements (21).

Regarding FM the finding of our study indicated that mean FM measured by Tanita segmental BC analyzer was 9.83kg while mean FM measured by the ADP was 11.92kg. Mean difference between them was 2.10 (P< 0.001). A significant underestimation of FM was observed by Tanita segmental BC analyzer. It was underestimated by 17.2%. Our finding is similar to the study conducted among obese children and adults (22). According to that report, compared with ADP, Tanita segmental BC analyzer overestimates FFM and underestimates FM in obese and non-obese children of either sex. Yet, ADP and Tanita segmental BC analyzer estimates of FFM and FM are highly correlated for both obese/non-obese children. However, the large limits of agreement suggest that these methods should not be used interchangeably.

In the current study, clinical characteristics were collected using questionnaire. Laboratory assessment of blood was not taken because of budget constraints. Therefore, factors in the serum which may affect BC were not assessed. Moreover, measurements by Tanita can also 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 FFM, it may arbitrarily elevate FFM which decreases the %BF as

determined by Tanita segmental BC analyzer. The subject who was in acutely ill state may have an artificially lowered FM when compared with those who were with normal, thus skewing the results.

## CONCLUSION

From the findings of the current study it is concluded that estimates of %BF by Tanita segmental BC analyzer and ADP in people living with HIV/AIDS in Southwest Ethiopia showed significant difference. Tanita segmental BC analyzer significantly underestimated %BF. The bias between %BF by Tanita segmental body BC and %BF by ADP is significant enough to say that %BF measured by Tanita BC analyzer is not agreed with %BF measured by the ADP.

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