Validation of methods for estimating HIV/ AIDS patients' body fat

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Skinfold thickness. Body constitution. Validity. Acquired immunodeficiency syndrome. HIV. Circunferences.

Abstract

Objective
To validate different methods for estimating HIV/Aids patients' body fat: total body skinfold thickness, central (trunk) skinfold thickness, peripheral (limb) skinfold thickness, waist circumference (WC) and waist-to-hip ratio (WHR). Dual-energy X-ray absorptiometry (DEXA) and computed tomography of the abdomen (CTA) were used as the gold standard.
Methods
An analysis was done on 15 adult HIV/AIDS patients (10 men and 5 women) who were being treated at the AIDS Clinic at a public university hospital, São Paulo, Brazil. Their total subcutaneous fat (TSF) was estimated from the sum of the thicknesses of the biceps, triceps, subscapular, midaxillary, suprailiac, abdominal and medial calf skinfolds. The central subcutaneous fat (CSF) was estimated by summing the subscapular, axillary, suprailiac and abdominal skinfold measurements. The peripheral subcutaneous fat (PSF) was estimated by summing the biceps, triceps and medial calf skinfold measurements. These were compared with DEXA. The WC, WHR and CSF were compared with CTA. In the statistical analysis, the Pearson correlation coefficient (r) and Mann-Whitney test were utilized.
Results
There was a correlation between fat mass measured by DEXA and by TSF, CSF and PSF, even after adjusting for age ($r \geq 0.80$ for all). WC, WHR and CSF presented correlation with total abdominal fat measured by CTA, even after adjusting for age ($r \geq 0.80$ for all).
Conclusions
The methods for estimating body fat should be chosen according to the type of fat to be evaluated and can be used in research and healthcare services instead of DEXA and CTA for HIV/AIDS patients.

INTRODUCTION

Individuals infected with the human immunodeficiency virus (HIV) and AIDS patients in this era of highly active antiretroviral therapy may be affected by morphological and metabolic alterations that lead to an increase in risk factors for cardiovascular diseases.[4,12] Imaging methods such as whole-body dual-energy X-ray absorptiometry (Dexa) and computed tomography of the abdomen (CTA) are considered to be good techniques for measuring body fat mass[15] and, as such, they have been used in studies on HIV/ AIDS patients.[2,3,14,16] However, the costs of these examinations are still very high in developing countries like Brazil (on average, US$ 49.00 and US$ 173.00, respectively), thereby making research on this

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subject difficult and often impossible. Faced with this situation, the alternative is to utilize doubly indirect methods to estimate fat mass, such as summed skinfold thickness and circumferences,[7] despite the possible variability between evaluations.[13] The more accessible of these methods, such as the total body skinfold thickness, waist circumference and waist-to-hip ratio have already been used in research on HIV/ AIDS patients carried out in developed countries,[11,14,17] but studies on this topic are scarce in Brazil.

Thus, the objective of the present study was to validate the measurements of total body skinfold thickness, waist circumference and waist-to-hip ratio as doubly indirect methods for assessing the total fat of the trunk, abdomen, limbs and whole body among Brazilian HIV/AIDS patients who were using highly-active antiretroviral therapy.

METHODS

This was a study carried out at the AIDS Clinic, a healthcare unit linked to the Clinical Division for Infectious and Parasitic Diseases at a public university hospital, São Paulo, Brazil. This is located in the central region of the city of São Paulo and has about 4,000 registered HIV/AIDS patients. It is considered to be a reference center for multidisciplinary care of individuals living with HIV/AIDS.

The data collection was performed between October 2001 and February 2002. The sample consisted of fifteen adult HIV/AIDS patients, of whom ten were men and five were women. The sample size[10] was estimated from the means of the correlation coefficients (ranging from 0.75 to 0.97; mean =0.87) from previous studies for validating estimates of body fat percentage, body fat mass or fat-free mass that compared these with the values measured by Dexa.[8,15,19-21] The values α=5% and β=20% were assumed.

The individuals were selected randomly, on the basis of consecutive sampling. This technique consisted of interviewing individuals who fulfilled the selection criteria at a specific point in time.[10] Thus, the first six individuals who arrived for their periodic consultation with an infectious disease physician during any of the attendance shifts of the service were approached and invited to participate in the study. The individuals selected needed to have been undergoing highly active antiretroviral therapy for at least three months in relation to the date on which they entered the study. The exclusion criteria were the presence of any active opportunistic infection that could influence the analysis of body fat at the time of assessment; any surgical intervention such as liposculpture or liposuction performed within three months prior to the assessment; presence of any incapacitating illness that would hinder the measurements and examinations; pregnancy; and, finally, current use of corticosteroids, anabolic steroids and hormonal contraceptives, in view of the possible influence of these medications on body fat.

In this study, the gold standard method used for evaluating body fat was whole-body Dexa imaging,[3] which assessed total fat, trunk fat and limb fat (arms and legs), in kilograms. CTA was also used as a gold standard[3] for evaluating visceral, subcutaneous and total abdominal fat in the L4-L5 plane, in square centimeters. The Dexa and CTA examinations were carried out at the Institute of Radiology of Hospital das Clínicas, University of São Paulo, by technicians who were specifically trained for this study.

For the Dexa examination, the Hologic QDR 4500 equipment was utilized (Hologic Inc., Waltham, Massachusetts, USA). Standard procedures were adopted for positioning the subjects while performing the examination. Subjects were firstly asked to remove all metal objects and their shoes, and were then positioned in dorsal decubitus, inside the machine. The examination was performed by means of transversal sweeps from the head to the feet, to obtain images that were processed through Hologic's specific software.

For the CTA examination, the CT Pace equipment was utilized (General Electric, Milwaukee, Wisconsin, USA). Firstly, a scouting image of the lumbar region was obtained in order to determine the location of the L4-L5 disc plane. Following this, the CTA image in the L4-L5 plane was obtained at 120 kV, 200 mA and a thickness of 10 mm. The field of view (FOV) needed to be such that it would allow the whole abdomen wall to be viewed. The areas of visceral and subcutaneous fat were then determined from this image, and also the sum of the visceral and subcutaneous fat, to give the total for abdominal fat. To define the area of the visceral fat, a line was traced out on the tomography image, by means of an electronic cursor, along the transversalis fascia anteriorly and the fascia of the quadratus lumborum musculature posteriorly, thus excluding the vertebral body. After delineating this region, the tomography computer was programmed to calculate only the area of the fat present in this region, with the determination of the minimum and maximum attenuation coefficients that would correspond to fat. In this work, coefficients of -250 to -50 Hounsfield units were adopted. Thus, the equipment would exclude from the calculation any structures not formed by fat. Following this, the area of subcutaneous fat was calculated by tracing out a line immediately externally to the skin surrounding the whole abdominal circumference. At the point where this line met the initial point of the tracing, it was made to pass anteriorly to the plane of the abdominal wall musculature, thereby obtaining a region that was external to the muscle plane and internal to the skin plane, all around the abdominal circumference. Finally, the same procedure for excluding non-fatty structures was repeated, by means of adopting the same limiting values for the attenuation coefficients. The areas of visceral and subcutaneous fat and the total fat were determined in square centimeters.

The total subcutaneous fat (TSF) was evaluated by summing skinfold measurements from the whole body, in millimeters (mm), utilizing the thicknesses of the biceps, triceps, subscapular, midaxillary, suprailiac, abdominal and medial calf skinfolds. The central region (trunk) subcutaneous fat (CSF) was determined by summing thicknesses of the subscapular, midaxillary, suprailiac and abdominal skinfold measurements. The peripheral (limb) subcutaneous fat (PSF) was determined by summing the biceps, triceps and medial calf skinfold measurements.

For the measurement of the skinfolds, the standardization proposed by Guedes (1994)[7] was followed:

1. The biceps skinfold thickness was obtained along the longitudinal axis of the arm, on its anterior face at the point of the greatest apparent circumference of the belly of the biceps muscle.
2. The triceps skinfold thickness was obtained along the longitudinal axis of the arm, on its posterior face, and its exact observation point was halfway between the superolateral margin of the acromion and the olecranon.
3. The subscapular skinfold thickness was obtained obliquely to the longitudinal axis, following the orientation of the costal arches, at a point located two centimeters below the lower angle of the scapula.
4. The suprailiac skinfold thickness was obtained obliquely, two centimeters above the anteroposterior iliac crest, at the level of the anterior axillary line.
5. The midaxillary skinfold thickness was obtained obliquely, along the orientation of the intercostal arches. Its location was the intersection point between the midaxillary line and an imaginary horizontal line that passes through the xiphisternal junction.
6. The abdominal skinfold thickness was obtained along the longitudinal axis of the body, at approximately two centimeters to the right of the lateral margin of the umbilicus.
7. The medial calf skinfold thickness was obtained with the individual seated, with the knee flexed at 90^{o}, ankle in anatomical position and unsupported foot. This skinfold was taken along the longitudinal axis of the body, at the level of the greatest circumference of the leg.

The skinfolds were measured three times using Lange skinfold calipers with a constant pressure of 10 g/mm^3 and precision of 1.00 mm. The average of these measurements was adopted.

To measure the circumferences, the standardization proposed by Heyward & Stolarczyk[9] (2000) was followed. The waist circumference was measured at the midpoint between the last costal arch and the iliac crest, while the hip circumference was measured at the point of greatest posterior protuberance of the buttocks. The waist and hip circumferences were measured to a precision of 0.1 cm, using a Sanny non-stretchable anthropometric glass-fiber tape, and the average of two measurements was adopted. The height and body weight were measured to a precision of 0.1 cm and 0.1 kg, respectively, utilizing a Filizola digital balance and an anthropometric tape attached to the wall of the evaluation room. The weight measurements were made once and the height measurements were made three times, adopting the average value. All these measurements were made by a single physical education professional who was experienced in the field of measurements and evaluations.

Data analysis was done using the SPSS software, version 10.0. The Pearson correlation coefficient (r) and partial correlation coefficients, adjusted for age, were calculated. Age adjustment was done because age can influence both subcutaneous and visceral body fat.[13] The goodness of fit to normal distribution was evaluated using the Kolmogorov-Smirnov test. The correlations were considered strong when the values were greater than or equal to 0.80.[13] The means were compared between men and women using the Mann-Whitney test.

This study was approved by the research ethics committee of the School of Public Health, University of São Paulo, and by the research projects evaluation committee of Hospital das Clínicas, School of Medicine, University of São Paulo. All participants in the study agreed to their participation and signed an informed consent statement.

RESULTS

Table 1 shows the demographic and clinical characteristics of the sample. Most of the individuals were more than 35 years old (60%), and the mean ages according to gender were similar (men =37.5 years and women =35.8 years; p=0.953). The mean length of time for which the patients had been undergoing highly-

Table 1 - Descriptive statistics of the study variables, AIDS Clinic, São Paulo, 2002.

Variables	Men (N=10)		Women (N=5)	
	minimum-maximum	mean (SE)	minimum-maximum	mean (SE)
Age (years)	28.0-58.0	37.5 (3.1)	32.0-41.0	35.8 (1.7)
Duration of therapy (months)*	10.0-69.0	37.6 (5.3)	22.0-61.0	40.0 (6.4)
CD4+ (cells per mm^3)	39.0-796.0	437.7 (71.6)	150.0-642.0	443.0 (94.7)
HIV viral load (log^{10})	0.00-3.80	1.44 (0.51)	0.00-3.18	1.65 (1.68)
Height (cm)	160.9-184.1	172.1 (2.2)	153.9-158.8	156.5 (0.9)
Waist circumference (cm)**	71.0-108.0	85.3 (4.0)	74.5-87.0	81.1 (2.3)
Waist-to-hip ratio	0.80-1.10	0.92 (0.03)	0.80-1.00	0.88 (0.04)
TSF (mm)	40.4-180.6	99.3 (15.2)	107.7-148.8	137.7 (7.6)
CSF (mm)	27.4-146.6	79.2 (13.4)	80.3-123.3	101.8 (7.7)
PSF (mm)	13.0-43.9	20.1 (2.8)	19.3-52.1	35.9 (6.6)
Total fat (kg)	2.2-22.1	10.3 (3.3)	4.3-19.8	15.2 (2.9)
Percentage of fat	4.8-22.9	14.1 (1.9)	8.8-36.2	26.4 (4.7)

*Highly active antiretroviral therapy, including protease inhibitors and reverse transcriptase inhibitors
SE: standard error
TSF: Total subcutaneous fat
CSF: Central region (trunk) subcutaneous fat
PSF: Peripheral (limb) subcutaneous fat

active antiretroviral therapy was similar for men and women (respectively, 37.6 and 40.0 months; p=0.754). One man and one woman had CD4+ cell counts that were lower than 200 cells per cubic millimeter. However, considering that no problem was observed that could influence the body fat at the time of data collection, it was decided to keep them in the analysis. It was seen that the men were taller (p=0.001), but that the percentage of fat mass was higher in the women than in the men (p=0.040). For the remainder of the variables, the means were similar (p>0.05 for all of them).

Table 2 presents the analysis of the correlations using Dexa. The correlations of fat mass were strong for all measurements, and continued to be statistically significant, even after adjustment for age.

The analysis of the measurements made using CTA is presented in Table 3. The measurements of visceral fat and subcutaneous fat presented significant correlations, but lower than 0.80. Only total abdominal fat had significant correlations higher than 0.80. All of the correlations kept their significance even after adjustment for age.

DISCUSSION

The patient population that was followed at the AIDS Clinic of Hospital das Clínicas, University of São Paulo were mainly male homosexuals with a high level of schooling.[6] Although recent data on the Brazilian HIV/AIDS epidemic show that heterosexuals are now the most predominantly exposed group and that the level of schooling of most people living with AIDS is low,[1] we believe that this does not affect the validation of the methods carried out in the present survey.

In the present study, examinations performed using Dexa and CTA were taken to be the gold standard for comparisons with anthropometry. According to Lohman[13] (1992), for predictive techniques to be valid, the correlation coefficient must be greater than 0.80. In the present study, both whole-body subcutaneous fat and central region subcutaneous fat measured by skinfold summation presented such correlation with total fat and trunk fat measured using Dexa, regardless of age. This was also found for peripheral subcutaneous fat measured by skinfold summation in relation to limb fat measured via Dexa.

One advantage of skinfold summation is that it allows analysis of the fat according to body segments.[9] Skinfold summation is already being utilized with this aim in studies among HIV/AIDS patients in developed countries.[5] For this reason, skinfold summation has an advantage over other methods like

Table 2 - Pearson correlation coefficients (r) and partial correlation coefficients (r_{adj}) for measurements using dual-energy X-ray absorptiometry (Dexa).

Variables	DEXA (N=15) Total fat (kg) r(p)	Trunk fat (kg) r(p)	Limb fat (kg) r(p)
Pearson correlation coefficients			
Total subcutaneous fat (mm)	0.89 (<0.001)*	-	-
Central region subcutaneous fat (mm)	-	0.90 (<0.001)*	-
Peripheral subcutaneous fat (mm)	-	-	0.85 (<0,001)*
Coefficients adjusted for age			
Total subcutaneous fat (mm)	0.86 (<0.001)*	-	-
Central region subcutaneous fat (mm)	-	0.88 (<0.001)*	-
Peripheral subcutaneous fat (mm)	-	-	0.84 (<0.001)*

*$r \geq 0,80$

Table 3 - Pearson correlation coefficients (r) and partial correlation coefficients (r_{adj}) for measurements using computerized tomography of the abdomen (CTA).

Variables	TCA (N=12)**		
	Visceral fat (cm²) r(p)	Subcutaneous fat (cm²) r(p)	Total abdominal fat (cm²) r(p)
Pearson correlation coefficients			
Waist circumference (cm)	0.61 (0.037)	0.88 (<0.001)*	0.89 (<0.001)*
Waist-to-hip ratio	0.74 (0.006)	0.61 (0.035)	0.75 (0.005)
Central region subcutaneous fat (mm)	0.69 (0.014)	0.77 (0.004)	0.84 (0.001)*
Coefficients adjusted for age			
Waist circumference (cm)	0.60 (0.050)	0.90 (<0.001)*	0.89 (<0.001)*
Waist-to-hip ratio	0.74 (0.009)	0.72 (0.013)	0.82 (0.002)*
Central region subcutaneous fat (mm)	0.68 (0.021)	0.79 (0.004)	0.84 (0.001)*

*r≥0,80
**Measurement made for 8 men and 4 women

bioimpedance, since the latter is inefficient in analyzing fat according to body segments.[18]

There are more than 93 measuring points for skinfolds on the body.[7] In the present study, skinfolds representative of TSF, CSF and PSF that are often utilized in anthropometry studies were analyzed.[7,9] It was also decided that skinfolds that were more accessible should be evaluated, given that the recruitment of the sample took place among subjects who were attending their periodic consultation with an infectious disease physician. Since they did not have prior notification, they were not appropriately dressed (e.g. wearing shorts and T-shirt) for the assessment of certain skinfolds such as the thigh skinfold.[7]

In the present study, the waist circumference was correlated with subcutaneous fat and total abdominal fat evaluated using CTA, regardless of age. On the other hand, the waist-to-hip ratio and the sum of the skinfolds of the central region subcutaneous fat had a lower, but still significant correlation with the measurements via CTA. The correlation was only greater than 0.80 for total abdominal fat measured using CTA, regardless of age. Previous studies using samples of American adult men[5] and French adult men and women[17] have shown that both the waist circumference and the waist-to-hip ratio are good methods for estimating abdominal fat in HIV/AIDS patients. The waist-to-hip ratio is of special interest because it shows up morphological alterations such as reduction in the hip circumference accompanied by increase in the waist circumference. However, caution must be taken, because the measurement of the hip circumference presents greater potential for error.[13]

Another interesting result was the high correlation between the CSF and total abdominal fat. This shows that waist circumference, waist-to-hip ratio and central region subcutaneous fat can be representative of total abdominal fat, including both visceral and subcutaneous fat.

In conclusion, the results have shown that both the sum of skinfold thicknesses and body circumferences are valid as doubly indirect methods for evaluating the distribution of total and regional fat in HIV/AIDS patients. They are useful both in research and for following up patients undergoing highly active antiretroviral therapy at healthcare services, whenever imaging equipment like Dexa or CTA is unavailable for routine evaluation. However, it is important to emphasize that the choice of doubly indirect measurement must be made in accordance with the type of fat to be evaluated.

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