The Brazilian Journal of
INFECTIOUS DISEASES

www.elsevier.com/locate/bjid

Original article

Are traditional body fat equations and anthropometry valid to estimate body fat in children and adolescents living with HIV?

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ARTICLE INFO

Article history:
Received 11 December 2016
Accepted 3 March 2017
Available online 19 May 2017

Keywords:
Body fat
HIV
Skinfold thickness
Anthropometry
DXA

ABSTRACT

The aim of this study was to assess the validity of traditional anthropometric equations and to develop predictive equations of total body and trunk fat for children and adolescents living with HIV based on anthropometric measurements. Forty-eight children and adolescents of both sexes (24 boys) aged 7–17 years, living in Santa Catarina, Brazil, participated in the study. Dual-energy X-ray absorptiometry was used as the reference method to evaluate total body and trunk fat. Height, body weight, circumferences and triceps, subscapular, abdominal and calf skinfolds were measured. The traditional equations of Lohman and Slaughter were used to estimate body fat. Multiple regression models were fitted to predict total body fat (Model 1) and trunk fat (Model 2) using a backward selection procedure. Model 1 had an $R^2 = 0.85$ and a standard error of the estimate of 1.43. Model 2 had an $R^2 = 0.80$ and standard error of the estimate = 0.49. The traditional equations of Lohman and Slaughter showed poor performance in estimating body fat in children and adolescents living with HIV. The prediction models using anthropometry provided reliable estimates and can be used by clinicians and healthcare professionals to monitor total body and trunk fat in children and adolescents living with HIV.

Introduction

Children and adolescents living with HIV undergoing highly active antiretroviral therapy (HAART) often exhibit changes in body fat such as lipoatrophy (loss), lipohypertrophy (central accumulation), or a combination of both.[1] These changes are associated with metabolic abnormalities such as mitochondrial toxicity, dyslipidemia, and insulin resistance, which can increase the risk of cardiovascular and cerebrovascular diseases.[2] Moreover, changes in body fat can affect body image perception, cause poor adherence to HAART, and compromise quality of life.[3]

The prevalence of lipodystrophy ranges from 26% to 55% among children and adolescents living with HIV.[4–6] This variability can be attributed to the subjectivity of visual inspection

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http://dx.doi.org/10.1016/j.bjid.2017.03.015

– mainly used for diagnosis – and to differences in time of exposure and in type of HAART. Objective methods have been used for measuring body fat.[7,8] Air-displacement plethysmography is a precise densitometric method for evaluating body fat, while dual energy X-ray absorptiometry (DXA) is an imaging-based alternative technique. DXA is a safe and accurate method,[9] especially when a more comprehensive compartmental analysis of body composition is required. However, both methods are expensive and require sophisticated infrastructure and human resources, thus rendering the application of these assessments difficult under conditions of limited resources.

Anthropometry is a noninvasive, low-cost and easy-to-use method that could be applied as an alternative to estimate body fat. Skinfold thickness studies have been performed to estimate body fat in the general population because of the increase in obesity.[10] However, it is unknown whether the commonly used equations of Lohman[11] and Slaughter[12] are valid for children and adolescents living with HIV. Studies have used these equations indiscriminately to predict body fat[13] or skinfold to evaluate thickness of subcutaneous body fat.[14,15] However, the predictive value of anthropometric measurements to estimate body fat using specific equations requires further investigation. The aim of this study was to assess the validity of traditional anthropometric equations and to develop predictive equations of total body fat and trunk fat for children and adolescents living with HIV based on anthropometric measurements.

Methods

Study design and patient population

This was a cross-validation study completed in 2010 in Florianópolis, capital of the State of Santa Catarina, southern Brazil. The city has the third highest human development index (0.847) in Brazil (average of 0.727). The GINI coefficient, a measure of inequality of income distribution, is 0.566 in Florianópolis, while this index ranges from 0.284 to 0.808 in Brazil.[16]

The target population were children and adolescents living with HIV acquired by mother-to-child transmission who were followed up at a referral hospital for the treatment of pediatric HIV infection. Patients were selected based on a screening performed in 2008 and participation in a previous study.[17] The criteria for inclusion were mother-to-child transmission of HIV reported in the medical records, age 7–17 years, availability of clinical and laboratory records, receiving care at this hospital, absence of concomitant diseases, and no use of diuretic agents that could alter body composition.[18]

Dual-energy X-ray absorptiometry (DXA)

Total, segmental and percentage of body fat were evaluated by DXA using the Hologic Discovery WI Fan-Bean® system (Bedford, MA, USA). X-ray attenuation was computed using pediatric software (version 14.4:5). This method has been used for body composition analysis because it provides reproducible and accurate measurements of body fat.[9] In addition, the technique is safe and emits radiation of 4.2–5.2 μSv, equivalent to the radiation received on a sunny day.[9] The equipment was calibrated daily as described by the manufacturer. Phantoms were used for calibration, guaranteeing internal quality control of the equipment. The coefficient of variation of the equipment during the study was 1% for bone mineral density evaluation as reported elsewhere.[18] For the assessment, the participants wore appropriate clothing without metal and were barefoot. The measurements were standardized and performed by two radiology technicians. Whole-body composition assessment by DXA was completed within approximately 10 min. The body fat percentage was obtained and age-, sex- and ethnicity-specific z-scores were calculated based on LMS values.[19]

Anthropometry

All anthropometric measurements were performed according to the Anthropometric Standardization Reference Manual.[20] Height was measured with a Tonelli® stadiometer (120A; Criciúma, Brazil) to the nearest 1 mm, and body weight was measured with a Tanita® digital scale (BF683W, Arlington Heights, IL, USA) to the nearest 0.1 kg. The body mass index (BMI) was calculated based on height and weight.[21] Arm and waist circumference was measured with a non-elastic anthropometric tape to the nearest 0.1 cm.[20] Triceps, subscapular, abdominal, and calf skinfolds were measured with a Cescorf® caliper to the nearest 0.1 mm.[20] The four skinfolds were used to calculate the trunk-limb ratio and sum of skinfolds ($\sum$4 skinfolds). Body weight and height were measured in duplicate, while circumferences and skinfold thickness were obtained in triplicate. The means of the anthropometric variables were used for subsequent analysis.

All anthropometric measurements were taken individually in a private room. The examiners were previously trained and calibrated. Technical errors of measurement were established with 16 age- and sex-matched healthy peers. These errors were 0.19 cm and 0.51 kg for height and body weight, respectively, 0.22 and 0.52 cm for arm and waist circumference, respectively, and 0.41, 0.27, 0.44, and 0.50 mm for triceps, subscapular, abdominal and calf skinfolds, respectively. The intra-class correlation coefficients for the anthropometric measures ranged from 0.76 to 1.0. All anthropometric measures were adequate according to the International Society for the Advancement of Kinanthropometry.

The equations of Lohman and Slaughter were used to predict body fat for the cross-validation analysis. The equation of Lohman was developed to estimate body fat in children aged 6–17 years[11] and the equation of Slaughter for children aged 8–18 years.[12] Table 1 shows the two equations adjusted for sex, race and maturity.

Demographic and clinical data

Age, sex, and skin color of the HIV-infected children and adolescents, as well as the socioeconomic and education level of the legal representative/parents, were collected using a questionnaire applied by interview. Immunological data and clinical symptoms, duration and type of HAART, HIV RNA viral load, and $CD4^+$ T lymphocyte count were obtained from the