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Short Communication

Agreement of bioelectric impedance analysis and dual-energy X-ray absorptiometry for body composition evaluation in adults with cystic fibrosis

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Abstract

Malnutrition in cystic fibrosis (CF) is associated with increased mortality and can lead to fat-free (FFM) and fat mass (FM) loss. Dual-energy X-ray absorptiometry (DXA) is used and validated to measure FFM and FM. DXA's high cost has led to the utilization of less costly techniques such as bioelectrical impedance analysis (BIA). The aim of this study was to determine the agreement of FFM, FM and %FM measurements taken with DXA and BIA in adults with CF. We measured FFM, FM and %FM in 34 adults with CF with a leg-to-leg BIA and an iDXA and determined agreement using Bland–Altman analysis. While DXA and BIA measurements were well correlated ($r > 0.8$), mean biases between both methods were between 8 and 11%. BIA underestimated FM and %FM and overestimated FFM. In a clinical research setting where these measurements are used to phenotype patients, BIA cannot replace DXA.

Keywords: Body composition; Bioelectrical impedance analysis; Dual-energy X-ray absorptiometry; Bland–Altman analysis

1. Introduction

Cystic fibrosis (CF) is the most common autosomal genetic disease among Caucasians [1] and is associated with exocrine pancreatic insufficiency [2] and malnutrition [3]. Malnutrition can lead to fat-free (FFM; bones, muscles and organ mass) and fat mass (FM) loss [4]. Studies have suggested that loss of FFM is associated with lung disease and disease severity [3,5,6], and that body mass index (BMI) is not sensitive enough to detect its depletion [5,6]. It is important to accurately detect malnutrition by measuring FFM and FM losses as they are linked with decreased lung functions and increased mortality in CF [3].

Dual-energy X-ray absorptiometry (DXA) was first developed to evaluate bone mass but is also widely used and validated to measure FFM and FM [7]. The DXA uses X-rays with two different energy levels. Then, the energy of the attenuated rays is used in equations and the DXA can determine if the matter scanned is either fat-free mass, fat mass or bone [8]. DXA's high cost has led to the utilization of less costly techniques such as bioelectric impedance analysis (BIA) for body composition analysis. Leg-to-leg BIA uses an electric current that runs from one foot to the other and uses the resistance of mass to determine if it is either FM or FFM [9].

Three studies in patients with CF have compared these two techniques and reported discordant results [10,12]. While Pichard *et al.* reported good agreement of FFM between BIA and DXA [10], King *et al.* showed that BIA incorrectly estimated FFM in adults with CF [11]. Furthermore, Beaumesnil *et al.* found

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significant differences of FFM and FM between both methods in children and adults with CF [12]. None of these studies evaluated the accuracy of BIA to measure FFM, FM and percentage FM (%FM) in a group of adults with CF. Therefore, the aim of this study was to determine the agreement between measurements of FFM, FM and %FM taken with BIA and DXA in adults with CF.

2. Material and methods

This cross sectional study included 34 adults with CF (15 men and 19 women) and is a sub-analysis of a larger project studying CF-related diabetes. All CF subjects were recruited from the Centre Hospitalier de l'Université de Montréal (CHUM) and tested at the Institut de Recherches Cliniques de Montréal (IRCM). Participants were excluded if they were pregnant or having a pulmonary exacerbation diagnosed by a CF pulmonologist of the CHUM and defined by a change in sputum production (volume, colour, consistency), new or increased haemoptysis, increased cough, increased dyspnoea, fatigue or lethargy, fever >38 °C, anorexia, sinus pain, a >10% decrease in FEV_1 compared to previously recorded values, intravenous antibiotic treatment and change in chest sounds [13]. The protocol was approved by the Research Ethics Committees of the CHUM and IRCM. Study participants did not fast prior to the tests but did not ingest caffeine or do any type of physical exercise 8 h before. Tests were done while participants were wearing light clothing and no metal objects.

After measuring weight and height, all subjects performed a barefoot leg-to-leg BIA using a Tanita Body Composition Analyzer TBF-310 (Tanita Corporation of America, Arlington Heights, IL, USA) and a DXA using a Lunar iDXA (GE HealthCare, Mississauga, ON, Canada) to estimate FFM, FM and %FM. For the DXA, all subjects were lying supine on a flat couch for 15–30 min. The DXA was calibrated with a phantom every morning before scans.

2.1. Statistics

Data are expressed in either mean ± standard deviation (SD) (for age, BMI) or median ± interquartile range (IQR) (for FFM, FM, %FM) depending on whether they are normally distributed. Statistical analysis was done with R (R 2.13.0). We compared measures of FFM, FM and %FM taken with DXA and BIA between men and women using Wilcoxon signed-rank tests. We corrected for multiple comparisons and considered that a $p \leq 0.0083$ was significant ($p = 0.05/6$ comparisons $= 0.0083$). We also associated FFM, FM and %FM measured by DXA and BIA using Spearman correlations. Then, Bland–Altman (BA) analysis was used to evaluate agreement of both methods [14]. Bias was defined as the percentage difference between both methods ((BIA − DXA) / DXA * 100) for measures of FFM, FM and %FM and limits of agreement were ±2 standard deviations (SDs) of the bias.

3. Results

Characteristics of 34 adults with CF included in the study are shown in Table 1. Study participants were 30 ± 9 years old and had a wide range of BMIs varying from 17.8 to 27.9 kg/m^2 with an average of 22.0 ± 2.56 kg/m^2. Average FFM, FM and %FM are also shown in Table 1 and they were statistically different between men and women ($p \leq 0.0083$).

Fig. 1 illustrates the associations between measures of FFM (A), FM (B) and %FM (C) obtained with DXA (D) and BIA (B). The associations between FFM, FM and %FM measurements were strong with correlation coefficients of 0.915, 0.914 and 0.833 respectively.

The mean bias for FFM was −8.04%, 10.2% for FM and 9.79% for %FM. BA analysis plots showing the distribution of the biases for FFM (A), FM (B) and %FM (C) are presented in Fig. 2. The biases of FFM are heterogeneously distributed. There is a trend for BIA overestimating FFM for people with <40 kg of FFM and underestimating for the others. The distributions of FM and %FM biases are also heterogeneous. BIA seems to underestimate FM and %FM in individuals with <20 kg (~15%) of FM. Results of mean biases for FM, %FM and FFM were similar between men and women (results not shown).

4. Discussion

Although measures taken with both techniques were highly correlated, mean biases between both methods were between 8 and 11% for all three measurements using BA analysis.

Table 1
Characteristics of subjects with cystic fibrosis (CF).

	Total (n = 34)	Men (n = 15)	Women (n = 19)
Age (years)	30 ± 9 [20–48]	29.1 ± 8.72 [20–45]	30.8 ± 8.97 [20–54]
BMI (kg/m^2)	22.0 ± 2.56 [17.8–27.9]	22.0 ± 2.98 [18.1–27.9]	22.0 ± 2.25 [17.8–26.1]
FFM (kg) [a]	43.4 ± 10.3 [29.8–66.4]	47.7 ± 7.51 [40.7–66.4]	39.2 ± 6.56 [29.8–50.7] [#]
FM (kg) [a]	14.2 ± 8.27 [4.82–27.6]	8.91 ± 6.85 [4.82–27.6]	16.4 ± 6.47 [9.00–25.3] [#]
%FM [a]	23.5 ± 12.38 [8.8–38.8]	14.8 ± 6.45 [8.80–31.7]	28.7 ± 8.90 [17.1–38.8] [#]
FFM (kg) [b]	46.6 ± 8.85 [37.8–61.2]	50.4 ± 8.00 [42.8–69.0]	41.6 ± 4.10 [37.8–47.8] [#]
FM (kg) [b]	12.9 ± 8.65 [3.8–25.4]	8.20 ± 8.70 [3.8–25.4]	14.6 ± 8.90 [7.60–25.2] [#]
%FM [b]	21.2 ± 13.3 [7.6–36.3]	13.9 ± 10.0 [7.6–29.4]	26.7 ± 9.00 [16.3–36.3] [#]

BMI: body mass index, FM: fat mass, FFM: fat free mass.
[a] Measured with dual-energy X-ray absorptiometry.
[b] Measured with bioimpedance analysis.
[#] $p \leq 0.0083$ vs men.