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Original Research

Bioelectrical impedance is an accurate method to assess body composition in obese but not severely obese adolescents☆,☆☆

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ABSTRACT

The aim of this study was to compare total and segmental body composition results between bioimpedance analysis (BIA) and dual x-ray absorptiometry (DXA) scan and to test the reproducibility of BIA in obese adolescents. We hypothesized that BIA offers an accurate and reproducible method to assess body composition in adolescents with obesity. Whole-body and segmental body compositions were assessed by BIA (Tanita MC-780) and DXA (Hologic) among 138 (110 girls and 28 boys) obese adolescents (Tanner stage 3-5) aged 14 ± 1.5 years. The BIA analysis was replicated on 3 identical occasions in 32 participants to test the reproducibility of the methods. Whole-body fat mass percentage was significantly higher using the BIA method compared with DXA (40.6 ± 7.8 vs 38.8 ± 4.9%, $P < .001$), which represents a 4.8% overestimation of the BIA technique compared with DXA. Similarly, fat mass expressed in kilograms is overestimated by 2.8% using BIA (35.8 ± 11.7 kg) compared with the DXA measure (34.3 ± 8.7 kg) ($P < .001$), and fat-free mass is underestimated by −6.1% using BIA ($P < .001$). Except for the right arm and leg percentage of fat mass, all the segmental measures of body composition are significantly different between the 2 methods. Intraclass correlation coefficient and Lin coefficient showed great agreement and concordance between both methods in assessing whole-body composition. Intraclass correlation coefficient between the 3 BIA measures ranged from 0.99 to 1 for body weight, body fat, and fat-free mass.

Abbreviations: ANOVA, analysis of variance; BIA, bioimpedance analysis; BIA-FFM, fat-free mass percentage assessed by bioimpedance analysis; BIA-FM%, fat mass percentage assessed by bioimpedance analysis; BMI, body mass index; FFM, fat-free mass; FM%, fat mass percentage; DXA, dual x-ray absorptiometry; DXA-FFM, fat-free mass percentage assessed by DXA; DXA-FM%, fat mass percentage assessed by DXA; SD, standard deviation.

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Bioimpedance analysis offers an acceptable and reproducible alternative to assess body composition in obese adolescents, with however a loss of correlation between BIA and DXA with increasing body fat; its validity remains uncertain for segmental analysis among obese youth.

1. Introduction

The continuous progression of overweight and obesity in pediatric population is becoming one of the most critical public health concerns, especially because excessive adiposity favors various metabolic complications from the youngest age [1,2]. Although some anthropometric measures such as body mass index (BMI) are frequently used to diagnose excessive body fat, they remain estimates and do not differentiate between fat mass (FM) and fat-free mass (FFM), showing limited correlation with fat distribution [3,4].

Although some equations calculating body adiposity indexes have been developed to estimate body composition [5], they have shown limited reliability in obese children and adolescents, especially in estimating FM percentage [6]. Dual-energy x-ray absorptiometry (DXA) is today considered as a reference and criterion standard method to assess whole-body composition [7] but also to provide segmental FM, FFM, and bone density in children and adolescents with obesity [8,9]. This clinical method, however, remains expensive and time consuming, and its access is limited for most practitioners. The development of bioimpedance analyzers (BIAs) offers a less expensive, faster, and easy-to-use way to determine body composition, and this technology has been shown to provide satisfactory results among several populations [10–12]. Few studies however questioned the accuracy of BIA in determining obese youth's body composition. Although evidence remains limited, the available results collectively found significant correlations between BIA and DXA results but also indicate that BIA underestimates the percentage of FM and overestimates FFM in obese youth compared with DXA [13–15], which joins up with previously published results in adults [16,17]. Recently, Lyra and collaborators [13] tested the ability of BIA to detect body composition modifications in response to a 3-month lifestyle modification program combining physical training and nutritional advices among 12-year-old obese adolescents (compared with DXA scans). According to their results, only DXA was able to detect both FM and FFM changes, whereas BIA observed FM reduction only, with moreover a lower sensitivity for detecting increased FFM by the end of the intervention [13].

Although the actual literature provides evidence regarding the ability of BIA to determine whole-body composition, none of the published studies tested the reproducibility of BIA in assessing body composition in obese youth. Moreover, newly elaborated bioelectrical impedance analyzers have been developed to provide segmental measures whose accuracy remains unquestioned in pediatric obesity. The aim of the present work was then to compare total and segmental body composition results between BIA and DXA scans in obese adolescents and to test the reproducibility of BIA in this population. We hypothesized that BIA offers an accurate and reproducible method to assess body composition in adolescents with obesity.

2. Methods and materials

One hundred and thirty-eight (110 girls and 28 boys) obese adolescents (Tanner stage 3-5) with a mean age of 14 ± 1.5 years were enrolled in the study (Fig. 1). The adolescents were recruited through pediatric consultations in specialized pediatric clinics (Children Medical Center, Romagnat, France, and Tzanou, La Bourboule, France). Inclusion criteria to take part in the study were as follows: (1) diagnosed as obese according to the international reference curves according to Cole et al [18], (2) aged 12 to 16 years, (3) free of any metallic prosthesis or medical equipment that could interfere with the DXA scans or of any contraindication to scanners, and (4) free of any physical disability or motor impairment. All the adolescents and their legal representative received information sheets and filled in consent forms as requested by ethical authorities (Human Protection Committee, CPP Sud Est VI).

The participants first underwent a clinical evaluation with a pediatrician consisting of an overview of the adolescents' medical history, primary physical examinations, and puberty assessment using Tanner maturation stages. Anthropometric measurements were performed and body composition was assessed using both DXA and BIA.

2.1. *Anthropometric measurements*

A digital scale was used to measure body mass to the nearest 0.1 kg, and barefoot standing height was assessed to the nearest 0.1 cm by using a wall-mounted stadiometer. The BMI was calculated as body mass (kg) divided by height squared (m^2).

2.2. *Body composition*

A bioelectrical impedance measure was also performed with the Tanita MC-780 multifrequency segmental body composition analyzer (although the manufacturer states that this newly developed BIA analysis can be realized at any time of the day, the conditions were standardized for the purpose of the present research, and the BIA was realized after an overnight fast, without any intensive exercise on the day before). This consists of a stand-alone unit where the subject has to step on barefoot (standard mode). Information concerning the subject (age, sex, and height) is entered by the experimenter. Once body mass has been assessed by the scale, the subject has to take grips in both hands (alongside his body) during the impedance measure (hand to foot BIA). A full segmental analysis is performed in less than 20 seconds. Segmental FM and FFM values are indicated by the end of the analysis on the digital screen (trunk, left and right arms and legs), as well as total body fat, FFM, and water. This newly developed BIA technology has been recently validated in adults of various physical activity levels [12]. On the same