Disability and Health Journal 10 (2017) 548–551

Contents lists available at ScienceDirect

Disability and Health Journal

journal homepage: www.disabilityandhealthjnl.com

Research Paper

Comparison of bioelectrical impedance and DXA for measuring body composition among adults with Down syndrome

Michael R. Esco, Ph.D. [a,*], Brett S. Nickerson, Ph.D. [a,c], Angela R. Russell, M.Ed. [a,b]

[a] Department of Kinesiology, University of Alabama, USA
[b] Department of Kinesiology, Auburn University at Montgomery, USA
[c] Department of Curriculum and Pedagogy, Texas A&M International University, USA

ARTICLE INFO

Article history:
Received 9 July 2016
Received in revised form
21 February 2017
Accepted 9 March 2017

Keywords:
Trisomy 21
Body composition
Physical fitness
Lean mass
Adiposity

ABSTRACT

Background: Individuals with Down syndrome (DS) have been shown to display high levels of adiposity and a unique body shape. Laboratory methods used to evaluate body composition might be too cumbersome for this special population. Therefore, field methods are desired due to their non-invasive nature.
Objective: to determine the agreement between dual energy x-ray absorptiometry (DXA) and bioelectrical impedance analysis (BIA) for measuring body fat percentage BF% and fat-free mass (FFM) among adults with DS.
Methods: Twenty-one adults (male: n = 10; female: n = 11) with DS participated in this study. BF% and FFM were determined by DXA and BIA.
Results: There was a significant mean difference between DXA and BIA for BF% (41.33 ± 8.98% and 34.23 ± 9.22%, respectively) and FFM (41.80 ± 8.74 kg and 46.95 ± 9.92 kg, respectively). The correlation between the two devices for BF% and FFM were significant ($r = 0.89$ and $r = 0.94$, respectively, $p < 0.001$ for both). The standard error of estimate and total error values were 4.38% and 8.27%, respectively, for BF% and 3.04 kg and 6.13 kg, respectively, for FFM. The 95% limits of agreement ranged from −15.64% below to 1.46% above the constant error (CE) of −7.09% for BF% and from −1.52 kg below to 11.83 kg above the CE of 5.15 kg for FFM.
Conclusions: The significant mean differences and large amount of individual error suggest that BIA may not be an appropriate surrogate body composition measure compared to DXA in adults with DS.

Assessing body composition among individuals with Down syndrome (DS) can have imperative health implications. For example, this population has been shown to display abnormally high levels of body fat percentage (BF%)[1,4] and have an elevated risk of early mortality from obesity related disorders, such as type 2 diabetes and heart disease.[1,3–5] Furthermore, individuals with DS display lower fat-free-mass (FFM) values compared to those without DS, which may lead to reduced bone mineral density and sarcopenia, as well as difficulty performing activities of daily living.[6–8] Therefore, dietary approaches and exercise interventions that are designed to improve body composition among this population are important and should be based on an accurate assessment of BF% and FFM.

Dual energy x-ray absorptiometry (DXA) is a precise laboratory method to evaluate body composition. The technology is based on a three-compartment model that estimates bone mineral density, FFM, and BF%. Because DXA analyzes total and segmental (i.e., arms, legs, and trunk) body composition, it may be considered a preferred laboratory method for individuals with DS who display a unique adiposity distribution pattern.[9,10] However, DXA scans are often not readily available to most Registered Dietiticians or Exercise Physiologists. Additionally, this procedure may be too invasive and time consuming to be widely used within this vulnerable population, as individuals with DS may experience anxiety from the procedure[2] and in some cases, be unable to remain still long enough to complete it.[4] Thus, simplified field techniques are important for practitioners who specialize in weight management strategies among

* Corresponding author. University of Alabama, P.O. Box 870312, Tuscaloosa, AL 35487, USA.
E-mail address: mresco@bamaed.ua.edu (M.R. Esco).

http://dx.doi.org/10.1016/j.dhjo.2017.03.009
1936-6574/

individuals with DS.

Bioelectrical impedance analysis (BIA) is often used in field settings to measure BF% and FFM. The technology involves the passing of an unnoticeable electrical current through the body, which flows faster through FFM compared to fat due to a higher water and electrolyte content in the former.[11] There are many different BIA devices currently available. The most advanced BIA instruments use a multiple range of frequencies.[9,11] Similar to DXA, these types of BIA are often only found in specialized laboratories. Single frequency BIA instruments are more convenient for use in field settings because they are portable, relatively inexpensive, user-friendly, and provide fairly quick measures. Because of these characteristics, single-frequency BIA may serve as an appropriate, non-threatening method for approximating body composition in individuals with DS. However, there has been very limited data regarding the agreement between DXA and BIA among adults with DS. This is an important area of research as most BIA models were validated in samples from the general population. Thus, the precision of this device for measuring body composition among individuals with DS remains unknown. The purpose of this investigation was to determine the agreement between DXA and a commonly used single-frequency BIA device for measuring BF% and FFM among adults with DS.

Methods

Participants

Twenty-one adult volunteers (male: n = 10; female: n = 11) with Down syndrome (age = 28.3 ± 8.5 years, height = 147.6 ± 8.9 cm, weight = 72.1 ± 14.8 kg) participated in this study (Table 1). Data collection for each subject occurred during the morning hours as close as possible to awakening from sleep (i.e., from 7:00am to 9:00am). Each participant was required to report to the laboratory following an overnight fast. In order to control hydration status, the participants were told to avoid consuming caffeine or alcohol, and to refrain from strenuous exercise for 24 h prior to data collection. All of the participants verbally agreed to the testing conditions. The participants and their legal guardians provided written informed consent as approved by the Institutional Review Board for Human Subjects and completed health-history questionnaires.

Bioelectrical impedance analysis

Body fat percentage and FFM were estimated via the RJL Quantum IV (Valhalla Scientific Model 1990B, Clinton, MI), which is a BIA device that passes a single frequency (800 mA at 50 kHz) from the right hand to the right foot. This procedure required entry of the following variables into the BIA device: the participants' height (to the nearest inch), weight (to the nearest pound.), sex (female), and age (in years). Participants wore light clothing, removed their right sock and shoe, and were instructed to lie on an examination table flat on their backs, face up with arms and legs at their side. The right hand and right foot were then wiped with an alcohol pad. Once each surface dried, two electrodes were placed on the top of the right hand and two electrodes on the top of the right foot. Determinations of resistance and reactance were made by the BIA instrument, and BF% and FFM were estimated from the manufacturers' equations. Two trials were performed for each subject and the mean of the two trials was recorded.

Table 1
Descriptive characteristics of subjects.

	All (n = 21)		Male (n = 10)		Female (n = 11)	
	Mean	SD	Mean	SD	Mean	SD
Age	28.3	8.5	25.6	5.8	30.9	11.6
Weight (kg)	72.1	14.8	76.0	11.8	67.1	16.8
Height (cm)	147.6	8.9	153.2	7.1	143.2	7.3
BMI (kg/m^2)	32.4	5.5	32.4	4.9	32.4	6.2
Race/Ethnicity						
African American	n = 2		n = 2		n = 0	
White	n = 19		n = 8		n = 11	

Dual energy x-ray absorptiometry

Criterion BF% and FFM was determined by a DXA (GE Lunar Prodigy, Software version 10.50.086, GE Lunar Corporation, Madison, WI). The DXA was calibrated using a standard calibration block before each scan. While wearing a T-shirt and shorts without any metal, each participant was instructed to lie in a supine position on the scanning bed. Their arms were held by the sides and palms were placed in a neutral position. The participants remained motionless during the scan. Their knees and ankles were held together with a Velcro strap. The procedure was re-initiated if movement occurred while verbal feedback was provided to prompt the participant to remain still. One technician trained for DXA operation performed all measurements.

Data analyses

Data were analyzed with SPSS/PASW Statistics version 22.0 (Chicago, IL). Prior to conducting the statistical tests, the assumptions of normality and homoscedasticity of the BF% and FFM variables were confirmed with Shapiro-Wilks tests ($p > 0.05$) and linear regression of the residuals ($r < 0.01$), respectively. The means and standard deviations were determined for each method with paired samples T-tests. The constant error (*CE*) was determined as the differences between the BIA and DXA ($CE = \text{BIA} - \text{DXA}$). The effect size of the mean difference of BF% was determined using Cohen's *d*. Hopkin's scale was used to determine the magnitude of the effect size.[12] Regression procedures were used to determine the correlation coefficient (*r*), and standard error of estimate (*SEE*) of BIA compared with DXA. Total error (*TE*) was determined as: $TE = \sqrt{\sum (\text{BIA} - \text{DXA})^2/n}$. The 95% limits of agreement between the BIA and DXA were determined by using the method of Bland-Altman.[13] Significance for all tests was determined a priori at an alpha of 0.05.

Results

Criterion BF% via DXA was 41.33 ± 8.98% and predicted BF% via BIA was 34.23 ± 9.22%, which was significantly different ($p < 0.001$) with a moderate effect size of Cohen's $d = 0.78$. The correlation between the two BF% variables was significant and very large ($r = 0.89$, $p < 0.001$). The SEE was 4.28% and the TE was 8.27%. The method of Bland-Altman showed that the 95% limits of agreement ranged from −15.64% below to 1.46% above the CE of −7.09% and the trend between the difference and mean of the BIA and DXA values was small and non-significant ($r = 0.06$, $p = 0.81$) (Fig. 1).

Criterion FFM via DXA was 41.80 ± 8.74 kg and predicted FFM via BIA was 46.95 ± 9.92 kg, which was significantly different ($p < 0.001$) with a moderate effect size of Cohen's $d = 0.55$. The correlation between the two FFM variables was significant and very large ($r = 0.94$, $p < 0.001$). The SEE was 3.04 kg and the TE was 6.13 kg. The method of Bland-Altman showed that the 95% limits of agreement ranged from −1.52 kg below to 11.83 kg above the CE of 5.15 kg and the trend between the difference and mean of the BIA