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Validity of the body adiposity index in adults with Down syndrome

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ABSTRACT

The purpose of this investigation was to determine the agreement between the body adiposity index (BAI) and dual energy X-ray absorptiometry (DXA) for measuring BF% in adults with Down syndrome (DS). Twenty adults (male: $n = 10$; female: $n = 10$) with Down syndrome volunteered to participate in this study. Criterion BF% was determined by DXA and predicted BF% was estimated by the BAI method. There was a significant mean difference ($p < 0.001$) between DXA BF% (39.94 ± 10.80%) and the BAI BF% (42.60 ± 8.19%). The correlation between the two BF% variables was large and significant ($r = 0.73$, $p < 0.001$). However, the standard error of the estimate and total error was 7.79% and 7.86%, respectively. Additionally, the 95% limits of agreement ranged from 12.21% below to 17.52% above the constant error of 2.65%. Our findings suggest that on average, the BAI significantly overestimated BF% when compared to DXA values. Though there was a strong correlation between both methods, the wide limits of agreement suggest there is large amount of individual error when estimating BF% via the BAI. Therefore, the use of the BAI for individuals with DS does not appear to be accurate for estimating BF%.

1. Introduction

Within the last seven decades individuals with Down syndrome (DS) have seen an increase in life expectancy by more than 40 years (Bittles & Glasson, 2004) primarily due to advancements in medicine for treating health related conditions such as coronary heart disease, hypertension, type II diabetes, and obstructive pulmonary disease (Glasson, Dye, & Bittles, 2014). However, the heightened prevalence of overweight and obesity among this population continues to expose them to the early development of the aforementioned co-morbidities (Loveday, Thompson, & Mitchell, 2012; Usera, Foley, & Yun, 2003). It is because of this that the accurate assessment of body fat percentage (BF%) has become extremely important for professionals who design healthy lifestyle interventions, such as diet and exercise, for people with DS.

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Dual energy X-ray absorptiometry (DXA) is often used as a criterion measure of BF% in research studies. However, this technology is often not readily available to practitioners. In addition, due to its cumbersome nature, conducting DXA scans can be viewed as threatening for individuals with DS who have some form of intellectual disability (Määttä, Tervo-Määttä, Taanila, Kaski, & Iivanainen, 2006). Therefore, body fat methods that are quick, simple, and non-intimidating may be more convenient to use within this special population.

Recently, the Body Adiposity Index (BAI) was developed as an alternative to body mass index (BMI) due to its ability to directly predict BF% via a simple equation of hip circumference to height (i.e., BF% = [hip circumference/height$^{1.5}$] − 18) (Bergman et al., 2011). The ability to administer the BAI in a quick and non-invasive manner makes it a method that could be much more feasible for the assessment of BF% within this vulnerable population. However, the BAI was validated from participants within the general population (Bergman et al., 2011) and has yet to be studied within a group of people with DS. This is an important area of consideration as the merit of any prediction method for specific groups depends on the validity statistics derived from research among subjects with similar characteristics. Therefore, the purpose of this investigation was to determine the agreement between the BAI and DXA for measuring BF% in adults with DS.

2. Material and methods

2.1. Participants

Twenty adults (male: $n = 10$; female: $n = 10$) with Down syndrome (age = 27.8 ± 9.6 years, height = 148.5 ± 8.4 cm, weight = 71.6 ± 14.8) volunteered to participate in this study following recruitment efforts from a local Down syndrome outreach group. Subjects and legal guardians provided written informed consent as approved by the Institutional Review Board for Human Subjects and completed health-history questionnaires.

2.2. Body adiposity index

Height was measured (to the nearest 0.1 cm) with a wall-mounted stadiometer (SECA 220, Seca Ltd., Hamburg, Germany). Body weight was measured (to the nearest 0.1 kg) with a calibrated digital weighing scale (Tanita BWB-800A, Tanita Corporation, Tokyo, Japan). Hip circumference was measured over nonrestrictive athletic attire horizontally at the maximal extension of the gluteus maximum (American College of Sports Medicine, 2010; Bergman et al., 2011). The mean of three measurements was recorded. Predicted BF% was calculated by the BAI method via the following equation:

$$\text{BAI} - \text{BF}\% = \left[\frac{\text{hip circumference}}{\text{height}^{1.5}}\right] - 18$$

2.3. Dual energy X-ray absorptiometry

Criterion BF% was determined by a total body DXA-scan (GE Lunar Prodigy, Software version 10.50.086, GE Lunar Corporation, Madison, WI). Before each scan, the DXA was calibrated according to the manufacturer's instructions using the standard calibration block. While wearing a *T*-shirt and shorts without any metal, each participant was instructed to lie in a supine position on the scanning bed with their arms by the sides and palms in a neutral position. During the scan, participants remained motionless with knees and ankles held together with a Velcro strap. If movement occurred, the scan was re-initiated while the technician provided verbal feedback to prompt the participant to remain still.

2.4. Statistical 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% 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 BAI and DXA (CE = BAI − 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 (Hopkins, Marshall, Batterham, & Hanin, 2009). Regression procedures were used to determine the correlation coefficient (r), and standard error of estimate (SEE) of BAI compared with DXA. Total error (TE) was determined as: $\text{TE} = \sqrt{\sum (\text{BAI} - \text{DXA})^2 / n}$. The 95% limits of agreement between the BAI and DXA were determined by using the method of Bland–Altman (Bland & Altman, 1986). Significance for all tests was determined a priori at an alpha of 0.05.

3. Results

Criterion BF% via DXA was 39.94 ± 10.80% while predicted BF% via BAI was 42.60 ± 8.19%. The mean difference was significant ($p < 0.001$) with a small effect size (Cohen's $d = 0.27$). The correlation between the two BF% variables was large and