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Validity Assessment of a Portable Bioimpedance Scale to Estimate Body Fat Percentage in White and African American Children and Adolescents

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Abstract

Objective—To determine accuracy of the Tanita SC-240 body composition analyzer to measure pediatric percent body fat (%BF).

Methods—Eighty-nine African American and white 5–18 year-olds participated in this study. %BF was estimated by DXA and by the Tanita SC-240.

Results—Overall %BF was 33.5 ± 10.5% (Tanita SC-240) versus 34.5 ± 8.7% (DXA). There was no significant difference between the two measures ($p = 0.52$, average error = −1.0%, average absolute error = 3.9%). The Tanita mean %BF estimates significantly differed from the DXA mean %BF in white boys ($p = 0.001$, Cohen's $d = 0.40$) and white girls ($p = 0.006$, Cohen's $d = 0.48$), but differences were of small effect. No differences in %BF estimates were found for African American boys or girls.

Conclusions—In this sample the Tanita SC-240 demonstrated acceptable accuracy for estimating %BF when compared to DXA, supporting its use in field studies.

Keywords

bioelectrical impedance; body fat percentage; dual energy x-ray absorptiometry; children and adolescents; accuracy

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Researchers are faced with a dilemma between cost, practicality and accuracy in body composition assessment (1–3). The current standards for measurement are dual-energy x-ray absorptiometry (DXA), magnetic resonance imaging (MRI), or underwater weighing. These methods are accurate but costly, time consuming, and of limited availability for field studies. Bioelectrical impedance analysis (BIA) scales are practical, safe and inexpensive ways to analyze body composition in the field (4). The Tanita SC-240 is a portable professional grade BIA scale that could be practically employed in field situations, but to our knowledge its accuracy has not been independently tested. The purpose of this study was to determine the accuracy of the Tanita SC-240 to measure body fat percentage (%BF) in a biracial sample of boys and girls.

Participants were a sub-sample of 5–18 year-old children involved in a cross-sectional study of factors related to abdominal adiposity. There were 89 participants in the present analysis (mean age = 12.0 ± 3.6 y). Parents or guardians provided signed informed consent, and the

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Conflict of Interest: The authors have declared that no competing interests exist children provided written assent. All procedures were approved by the institutional review board.

The participants came to the clinic in the morning following a 10 hour fast. There were no instructions provided to the participants regarding exercise the day before the test. Participants were measured wearing light clothing and barefoot. Height and weight were measured twice to the nearest 0.1 cm and 0.1 kg, respectively, and the average was used in the analysis. Body mass index (BMI) was computed as weight (kg)/height(m)^2, and BMI percentiles were calculated (5, 6). Sexual maturation was physician-assessed for participants <9 years and self-assessed for participants ≥9 years using the Tanner criteria (7).

%BF was estimated by DXA using a Hologic QDR 4500A whole-body scanner (Bedford, MA) and by the Tanita SC-240 body composition analyzer (TANITA Corporation, Japan), which is a lightweight portable scale that uses tetra-polar BIA with four electrodes at the feet. The scale has a measurement frequency of 50 kHz, a measurement current of 90 μA, and a measurement range of 150–1200 Ω. It has a maximum capacity of 200 kg and a graduation of 0.1 kg. Participants' information (i.e., height, age, and sex) was entered, and they were asked to step onto the scale and remain still.

The %BF assessed by the Tanita SC-240 was compared to the DXA %BF using a Bland-Altman plot (8). In addition to the calculation of error (Tanita %BF – DXA %BF) and absolute error (|Tanita %BF – DXA %BF|), paired samples t-tests were used to determine if there were differences between %BF estimations by the Tanita versus DXA for the whole sample and for each sex-by-race group. Cohen's d effect sizes were calculated to determine the meaningfulness of the differences using guidelines of d = 0.2 (small effect), d = 0.5 (medium effect), and d > 0.8 (large effect) (9). All data analyses were completed on SPSS 19. A p-value <0.05 was considered significant.

The participants' characteristics, Tanita and DXA %BF assessments, and error calculations by sex and race, are presented in Table 1. Weight was similar between the Tanita and DXA with an average error of 0.2 ± 0.2 kg, where the largest difference was 0.9 kg and only seven participants had a difference >0.5 kg. Based on sexual maturation assessment, 28% were prepubertal (stage 1), 17% were early pubertal (stages 2–3), and 55% were late pubertal or mature (stages 4–5). In the overall sample, there was no significant difference in %BF between the Tanita SC-240 (mean = 33.5 ± 10.5%) versus the DXA (mean = 34.5 ± 8.7%), p = 0.52, d = 0.11. The average error was −1.0%, and the average absolute error was 3.9%. Four participants had errors beyond the 95% limits of agreement (Figure 1). The Tanita %BF estimates were significantly different from the DXA %BF in the white boys (p = 0.001, d = 0.40) and white girls (p = 0.006, d = 0.48). No differences in %BF estimates were found for African American boys and African American girls.

Overall the Tanita SC-240 body composition analyzer demonstrated acceptable accuracy for estimating %BF when compared to estimates obtained from DXA in this biracial sample of boys and girls. The overall mean absolute error of 3.9% was close to the expected error for skinfold measurements (±3.3%), which is another method commonly used in field studies (4). This result is in contrast with other studies that found significant difference in %BF estimates between BIA devices and DXA in youth (10–13).

Considering the Bland-Altman plot and the error and absolute error calculations, for African American boys and girls the Tanita SC-240 did not present a specific pattern of error and did not consistently under- or over-estimate %BF compared to DXA. Those results differ from previous comparisons between BIA and DXA in African American girls where significant bias was found (10, 11). In contrast, for white boys and white girls the Tanita SC-240 consistently under-estimated %BF compared to DXA, though the bias was of small effect (d

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< 0.5) and lower than the BIA bias found by other researchers which ranged from 4.5 to 18.8 %BF (12, 13).

This study was carefully conducted but is not free of limitations. The equations used to estimate %BF are proprietary data. Therefore it is impossible to determine if the difference in measurement error between whites and African Americans is due to limitations with the Tanita SC-240 measurement of impedance or if it was because the same equation was used for both races. Because the errors found in the measurements were of small magnitude (d < 0.5), these limitations may be inconsequential. Because validation is a continuous process, additional studies should be conducted with the Tanita SC-240.

The Tanita SC-240 body composition analyzer demonstrated acceptable accuracy for estimating %BF in this study. There were significant differences between the DXA and the Tanita SC-240 scale for white boys and girls, but those differences were of small effect (d < 0.5). There were no significant differences between %BF measures for African American boys or girls.

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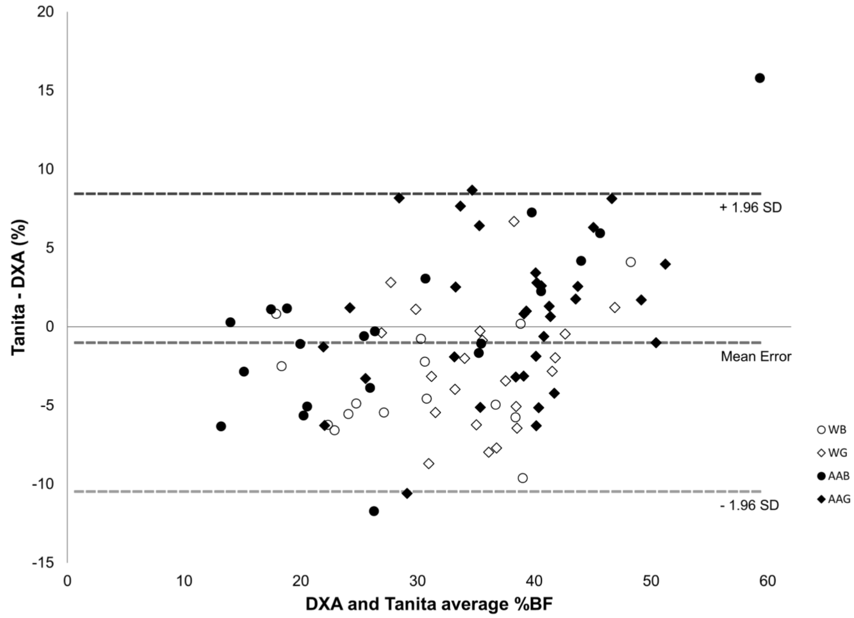

Figure 1.
Bland-Altman plot for error of bioelectrical impedance analysis (Tanita SC-240) versus DXA (Hologic QDR 4500A) to estimate body fat percentage in white and African American children and adolescents.

Note. WB = white boys, WG = white girls, AAB = African American boys, AAG = African American girls.

Table 1

Descriptive characteristics of the sample and comparison of body fat percentages estimated by bioimpedance (Tanita SC-240) versus DXA (Hologic QDR 4500A).

	White Boys (n=15)		White Girls (n=21)		African American Boys (n=20)		African Amerian Girls (n=33)	
	Mean (s.d)	**Min-Max**	**Mean (s.d.)**	**Min-Max**	**Mean (s.d.)**	**Min-Max**	**Mean (s.d.)**	**Min-Max**
Age, years	10.9 (3.7)	5–17	11.8 (3.9)	5–17	11.9 (3.2)	5–18	12.6 (3.6)	5–18
Height, cm	148.0 (22.1)	108.0–180.4	151.3 (19.8)	112.1–178.5	151.3 (16.0)	115.9–173.0	154.0 (13.4)	119.5–179.1
Tanita weight, kg	61.9 (34.6)	17.6–119.8	58.7 (17.6)	23.0–95.4	62.9 (29.2)	19.5–109.3	70.1 (23.5)	28.2–124.7
DXA weight, kg	62.1 (34.6)	17.7–119.5	58.9 (17.6)	23.0–95.5	63.2 (29.2)	19.6–109.6	70.3 (23.6)	28.3–124.9
BMI, kg/m^2	25.8 (8.5)	14.4–38.07	26.0 (8.1)	15.6–40.21	25.1 (4.3)	17.12–33.7	28.9 (6.9)	16.8–45.5
BMI, percentile	82.7 (25.8)	18.5–99.6	84.2 (17.6)	45.4–99.6	90.8 (7.3)	75.9–99.5	90.8 (17.4)	21.1–99.9
Tanita, %BF	28.2* (9.3)	17.1–50.3	34.4* (5.5)	26.6–47.5	28.7 (14.6)	10.0–67.2	38.1 (8.4)	18.9–53.2
DXA, %BF	31.8 (8.5)	17.5–46.2	37.0 (5.3)	26.3–46.3	28.7 (10.5)	13.8–51.4	37.6 (7.4)	22.6–50.9
Error	−3.6 (3.5)	−9.6–4.1	−2.6 (3.9)	−8.7–6.7	0.1 (5.8)	−11.7–15.8	0.5 (4.7)	−10.6–8.7
Absolute error	4.3 (2.6)	0.2–9.6	3.7 (2.7)	0.3–8.7	4.1 (4.0)	0.3–15.8	3.8 (2.7)	0.6–10.6

* = significantly lower than DXA %BF.

Note. %BF indicates body fat percentage; BMI indicates body mass index; DXA indicates dual energy x-ray absorptiometry; s.d. indicates standard deviation, Error = Tanita %BF minus DXA %BF; Absolute error = absolute value of Tanita %BF minus DXA %BF.