Group and Individual Agreement between Field and Dual X-Ray Absorptiometry–Based Body Composition Techniques in Children from Standard Schools and a Sports Academy

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ARTICLE INFORMATION

Article history:
Accepted 18 June 2013
Available online 7 September 2013

Keywords:
Foot-to-foot bioelectrical impedance
Dual x-ray absorptiometry
Body composition
Child athletes
Sports academy

2212-2672/$36.00
http://dx.doi.org/10.1016/j.jand.2013.06.353

ABSTRACT

Percentage fat (%FM) and fat-free mass (FFM) were measured in 37 children from a sports academy and in 71 children from standard schools with dual x-ray absorptiometry (DXA) and bioelectrical impedance analysis (BIA) using the manufacturer's equation (Tanita) and an ethnic-specific prediction equation (Haroun). In the standard school, BIA overestimated FFM and underestimated %FM by a mean of 2.5 kg and 5.2%, respectively, using the Tanita equation. In girls from the sports academy, the Tanita equation underestimated FFM and overestimated %FM compared with DXA (mean difference BIA-DXA; FFM: −1.3 kg; %FM: 1.8%). The Haroun equation improved mean agreement between BIA and DXA in children (11 to 15 years) from the sports academy and for boys from standard schools, but reduced accuracy on individual assessments. These results have important practice implications for dietetics practitioners specializing in sports nutrition and exercise trainers.
J Acad Nutr Diet. 2014;114:91-98.

IN SPORT SCIENCE, CHANGES IN LEAN AND FAT STORES need to be monitored routinely. Measuring body composition remains a constant challenge and, at this time, no single standard method is universally accepted to measure body compartments accurately and precisely.[1] The multi-compartment model, the current "gold standard," or other "reference methods," such as stable isotope dilution techniques and dual x-ray absorptiometry (DXA), are laboratory-based methods and are impractical in large-scale studies or for routine field use.[2]

Measurement of body composition with bioelectrical impedance analysis (BIA) is noninvasive, quick, and provides immediate results. It requires minimal subject cooperation, making it ideal for routine practice and field research. However, the validity of BIA body composition estimation depends on the population and prediction equations used. The foot-to-foot appliance has been tested previously in healthy adults[3,4] and more recently in children from the general population.[5-9] In these studies, the agreement between the foot-to-foot BIA and a reference method was poor on an individual basis and often an association between the agreement of the methods and the size of the body composition compartment assessed (fat mass [FM] or fat-free mass [FFM]) was found.[10] The validity of the foot-to-foot technique has not been studied so far in children who participate in regular sports training and who may have body composition characteristics different from those of the general population, despite similar body size dimensions. We tested foot-to-foot BIA body composition performance in children from a specialist sports academy and others who attend standard schools. Our a priori assumption was that children from the specialist sports academy would be leaner and fitter compared with same age range and body size children who attend standard schools and are less likely to be engaged in sports training. We compared BIA body composition estimates derived from the manufacturer's undisclosed prediction equation (Tanita equation) and one recently developed and validated in British multi-ethnic adolescents (Haroun equation)[11] against results obtained in the same children by DXA.

METHODS

Subject Characteristics and Recruitment

One hundred eight overtly healthy children and young adults (age 10.6 to 19 years) were recruited from local standard schools and a specialist sports academy. Children from the specialist sports academy were recruited by local advertisement. Potential participants from the standard schools were approached by posted invitation letters to lists kindly provided by their general practitioners from several areas of Glasgow to ensure an equal opportunity of recruitment from different socioeconomic classes. For the purpose of this study, we selected all children from the standard schools (n=71) who were similar in age (±1 year) and body mass index (BMI) *z* score range to 37 children from the sports academy (sports activities: swimming n=10; athletics n=7; hockey n=8;

Table 1. Demographic characteristics, anthropometry, body composition, and pubertal development of boys and girls from standard schools and a sports academy in a study comparing DXA[a] and bioelectrical impedance body composition measurement methods

	Standard Schools		Sports Academy	
	Girls (n=43)	Boys (n=28)	Girls (n=18)	Boys (n=19)
	mean±SD[b]			
Age (y)	14.0±2.4	14.8±2.3	14.2±1.8	14.4±2.0
Weight (kg)	48.3±11.3	54.3±14.7	50.0±10.8	54.3±12.0
Height (cm)	155.0±10.0	164.2±14.2	157.4±8.4	164.0±11.8
Weight *z* score (SD)	−0.02±0.9	0.03±0.9	0.01±0.97	0.33±0.79
Height *z* score (SD)	−0.14±1.0	−0.05±0.9	−0.07±0.96	0.19±0.83
BMI[c] *z*score (SD)	0.09±0.96	0.12±0.81	0.10±0.84	0.32±0.93
Leg length (cm)	80.9±6.9	86.9±8.2	80.3±7.2	87.0±6.4
Thigh girth (cm)	47.1±5.8	47.5±6.0	47.6±7.3	48.2±4.2
Waist-to-hip ratio	0.84±0.06	0.86±0.04	0.86±0.06	0.86±0.04
BIA[d]				
Impedance (Ohms)	591±59	551±70	569±69	534±58
Tanita equation				
FFM[e] (kg)	37.0±6.6	46.9±12.6	38.7±5.9	46.5±11.0
FFM (kg)/height $(m)^2$	15.3±1.3	17.0±2.1	15.5±1.3	17.0±2.1
% FM[f]	22.1±7.6	13.3±4.1	21.5±6.5	14.5±7.2
% FM/height $(m)^2$	9.1±3.0	5.1±1.7	8.6±2.2	5.5±3.2
DXA				
FFM (kg)	34.1±6.4	44.9±12.6	40.0±7.4*	46.3±12.5
FFM (kg)/height $(m)^2$	14.1±1.2	16.3±2.3	16.0±1.7*	16.9±2.6
% FM	27.8±8.0	17.6±6.2	19.7±5.2*	16.1±7.3
% FM/height $(m)^2$	11.6±3.3	6.7±2.6	7.9±2.0*	6.3±3.4
Pubertal stage	*n (%)*			
Tanner I	3 (7)	4 (15)	1 (5)	1 (6)
Tanner II	7 (17)	3 (11)	3 (17)	6 (31)
Tanner III	12 (29)	5 (19)	5 (28)	3 (16)
Tanner IV	12 (29)	10 (37)	6 (33)	7 (37)
Tanner V	8 (19)	5 (18)	3 (17)	2 (10)

[a]DXA=dual x-ray absorptiometry.
[b]SD=standard deviation.
[c]BMI=body mass index.
[d]BIA=bioelectrical impedance analysis.
[e]FFM=fat-free mass.
[f]% FM=percentage fat.
*$P<0.05$ between type of schools for the same sex.

football n=1; badminton n=6; gymnastics n=5) (Table 1). The majority were white (n=94) and the rest were from other ethnic backgrounds (Asian n=12, black n=1, Hispanic n=1). There were no differences in age characteristics and pubertal staging between sexes for the two types of schools (Table 1).

Children from the standard schools were asked whether they had been participating in sport-related training on a regular (ie, more than three times per week) basis. Those who did were excluded from the study. No proper assessment of fitness levels was carried out, and the assumption was that athletes from the sports academy would be fitter and leaner compared with students from standard schools. Participants were asked to refrain from exercise on the day of their measurements, and none of them reported use of nutritional supplements. The study protocol was approved by the Yorkhill Hospital research ethics committee and all participants provided written consent/assent.