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Anthropometric measures associated with fat mass estimation in children and adolescents with HIV

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Abstract

To verify the association between anthropometric indicators and body fat percentage (F %) estimated by dual X-ray absorptiometry (DXA) and air displacement plethysmography (ADP) in children and adolescents diagnosed with HIV. This cross-sectional study was carried out with 62 children and adolescents with HIV (8 to 15 years). F % was estimated by DXA and ADP. Anthropometric indicators were skinfolds (abdominal, triceps, subscapular, calf); perimeter relaxed arm (PRA), waist circumference (WC), perimeter neck (PN); body mass index (BMI); waist-to-height ratio (WHR); conicity index and body adiposity index. Linear regressions were performed with 5% significance level. In boys ($R^2_{\text{adj}} = 0.38$ to $R^2_{\text{adj}} = 0.67$) and girls ($R^2_{\text{adj}} = 0.41$ to $R^2_{\text{adj}} = 0.57$), all anthropometric indicators were associated with F% estimated by DXA. For boys, skinfolds were associated with F % estimated by ADP ($R^2_{\text{adj}} = 0.18$ to $R^2_{\text{adj}} = 0.35$). In girls, skinfolds ($R^2_{\text{adj}} = 0.27$ to $R^2_{\text{adj}} = 0.44$, BMI ($R^2_{\text{adj}} = 0.31$), PRA ($R^2_{\text{adj}} = 0.36$) and WC ($R^2_{\text{adj}} = 0.26$) were associated to F % by ADP. Abdominal skinfold was the indicator that most explained the variation in F % measured by DXA and ADP in both sexes. Anthropometric indicators are strongly associated with body fat, measured by reference methods, and can assist health professionals in monitoring the health of children and adolescents with HIV.

Keywords: Body composition; anthropometry, cross-sectional study, lipodystrophy, HIV.

Introduction

Human immunodeficiency virus (HIV) infection is one of these health problems with little reported evidence. HIV infection itself is a factor that causes changes in body composition, mainly due to the antiretroviral therapy (ART) and the use of protease inhibitor (PI), which are required in the treatment. This combination of factors can lead to lipodystrophy syndrome, which changes the body fat distribution of these patients (Handelsman et al. 2013). For this reason, the reported evidence on the anthropometric indicators most associated with body fat in the population without diagnosis of diseases (Freedman et al. 2013; Michels et al. 2013; Silva et al., 2013; Yeung and Stanley 2010) may not be used in the population diagnosed with HIV.

Growth markers such as biological maturation and lifestyle aspects such as physical activity are factors that also cause changes in the body composition of children and adolescents (Naufil et al., 2012; Schuelter-Trevisol et al., 2012). Evidence in the clinical context of HIV has shown that adolescents with advanced maturation and little physically active are two to three times more likely of having body fat accumulation, when compared to those of delayed maturation and physically active (Naufil et al., 2012; Schuelter-Trevisol et al., 2012). In this sense, the investigation of which anthropometric indicator would be more associated with body fat in patients diagnosed with HIV has to take these factors into account. The control of these factors was not taken into account in studies with children and adolescents without diagnosis of diseases that focused on identifying the association between anthropometric indicators and body fat (Freedman et al. 2013; Michels et al. 2013; Silva et al., 2013; Yeung and Stanley 2010).

Body fat can be measured by precise methods such as dual X-ray absorptiometry (DXA), air displacement plethysmography (ADP) and computed tomography. However, these methods are of high operational cost and with little viability in the monitoring of body fat in the outpatient setting (Ellis et al. 1991; Fields et al. 2002; Silva et al., 2013). Anthropometric indicators such as body mass index (BMI), waist circumference (WC) and waist-to-height ratio (WHR) may be an alternative for clinical use due to their low cost and high practicality, being universally applied (Alves Junior et al. 2017).

In the pediatric population, the anthropometric indicators most associated with body fat, as measured by DXA and ADP, were BMI, WC and WHR (Freedman et al. 2013; Michels et al. 2013; Silva et al., 2013; Yeung and Stanley 2010). However, the literature is scarce in evidences that point to the association of anthropometric indicators with body fat measured by reference techniques in pediatric populations with health disorders.

The comparison on the precision of the anthropometric indicators with body fat, measured by DXA and ADP, is necessary because these references techniques estimate body fat by different theoretical assumptions (Silva et al., 2013). The body fat measured by DXA is related to the principle of attenuation of X-rays with two intensities absorbed by the body, differentiating the bone and soft tissues (Ellis et al., 1994). ADP has the inverse relationship between pressure and volume, based on Boyle's Law, to determine body volume (Silva et al., 2013). Both methods are valid for assessing body fat in children and youth and have been used as reference methods (Fields et al., 2002). However, it is not known whether in the pediatric population with HIV the two references techniques have the same associations with different anthropometric indicators.

Considering the practicality of anthropometric indicators in the outpatient environment to measure body fat and the influence of different factors on the fat

concentration and distribution of pediatric patients with HIV diagnosis, this study aimed to verify the association between anthropometric indicators and fat percentage estimated by different reference techniques (DXA and ADP) in children and adolescents diagnosed with HIV, controlling factors related to treatment, maturation and physical activity.

Materials and method

Population and sample

An analytical, quantitative, correlational study, approved by the Ethics Research Committee of the “Joana de Gusmão” Children's Hospital (HIJG), Florianópolis, Brazil (CAAE: 49691815.0.0000.0121) was conducted from November 2015 to June 2016. Sixty-two children and adolescents diagnosed with HIV were recruited in HIJG. Participants met the following inclusion criteria: 1) HIV infection from mother-to-child transmission was verified through medical records; 2) age between 8 and 15 years; 3) the patient was admitted by the pediatric infectious disease specialist at the hospital regardless of the use of ART; and 4) medical records included clinical and laboratory data. Exclusion criteria were: 1) motor impairment 2) speech, hearing and / or cognition impairment; 3) diseases that change body composition, with the exception of HIV infection. Overall, 83 patients who met the eligibility criteria of the present study were cynically followed.

Fourteen patients were excluded for not meeting the following conditions: three due to severe encephalopathy and paralysis; three for not having made contact; four for being transferred to another hospital; and four refused to participate. In addition, four participants withdrew from the study during data collection and three did not perform the wrist-carpal radiography to determine bone age. The final sample consisted of 62 subjects. The sample power was subsequently calculated, considering: $\alpha = 5\%$, $\beta = 80\%$ and the correlation

coefficient (r) between anthropometric indicator and body fat estimated by DXA or ADP (Hulley et al. 2013). In relation to DXA and ADP, the number of participants was estimated by anthropometric indicators, according to the correlation values between these variables reported in literature, and the correlation coefficient ranged from $r = 0.21$ to $r = 0.90$ (Freedman et al. 2013; Gartner et al. 2004; Geliebter et al. 2013; Michels et al. 2013; Neovius et al. 2005; Sardinha et al. 1999 Yeung and Stanley 2010). A minimum of 31 subjects were required for the analyses. The calculation was performed in G * Power® software (Dusseldorf, Germany) (Hulley et al. 2013).

Dependent variable

To evaluate body fat by DXA, General Electric® equipment (Lunar Prodigy Advanced Plus, Milwaukee, USA) and pediatric software were used. Daily and weekly calibrations that preceded evaluations were performed. During evaluations, participants were wearing appropriate clothing, barefoot and without the use of earrings and / or rings (Ellis et al. 1994). The reading of the biometric pattern by specific sensor of the entire body lasted approximately five minutes, while the subject remained in the dorsal decubitus position. DXA assessment was performed by a trained investigator in standardized procedures. The test-retest DXA reproducibility for total body fat was examined in an independent sample, similar in age and sex (11.6 ± 5.8 and 11.5 ± 5.9 kg, intraclass correlation coefficient (ICC) = 1.00; 95% = 0.99-1.00, $n = 10$).

The BOD-POD® equipment (COSMED, Chicago, USA) was used to measure body fat by ADP. There was daily calibration of the device as recommended by the manufacturer and Fields (2002). Subjects were evaluated with adequate clothing, and the use of a swimming cap was requested to minimize the effects of hair volume on air displacement

analysis. During the measurement procedure, the adolescent remained seated with upright posture and normal breathing, hands resting on the thighs and feet touching the floor of the device (Fields et al. 2002). The evaluators performed two to three 50-second tests, totaling about four minutes of procedure duration. The Lohman equation (Lohman, 1989), for estimating body fat from body density, was applied to obtain the percentage of fat free mass and fat mass.

Independent variables

Anthropometric indicators comprised measurements of abdominal skinfold (SFab); triceps skinfold (SFT); subscapular skinfold (SFsub); calf skinfold (SFpan); perimeter of the relaxed arm (PRA); waist circumference (WC) and perimeter of the neck (PN). The calculated anthropometric indicators were BMI (body mass (kg) / height² (m)), WHR [WHR = WC (cm) / height (cm)], conicity index (IConi) [IConi = WC (m) / 0.109 $\sqrt{\text{body mass} / \text{height (m)}}$] (Valdez. 1991); and body fat index (BAI) [BAI = hip circumference (cm) / height x $\sqrt{\text{height (m)} - 18}$] (Bergman et al. 2011).

Skinfolds were measured using a skinfolds caliper (Cescorf®, Porto Alegre, Brazil), with measure unit of 0.1 mm. Body perimeters were measured using an inelastic anthropometric tape (Sanny®, São Paulo, Brazil) with 0.1 cm resolution. Body mass was measured using a portable digital scale (Tanita®, Tokyo, Japan), with maximum capacity of up to 150 kg and resolution of 0.1 kg. Height was measured using the stadiometer (AlturaExata®, Belo Horizonte, Brazil), with measurement capacity of 115 cm to 210 cm and resolution of 0.1 cm.

All anthropometric indicators were measured based on recommendations of the International Society for the Advancement of Kinanthropometry (ISAK), by a single level-

one ISAK anthropometrist. The intra-evaluator measurement technical error (ETM) was performed with 32 children and adolescents from the same age group of the present study, and acceptable values are 5% and 1.5% for skinfolds and perimeters, respectively (Pederson and Gore, 2005). All anthropometric measurements of the present study presented adequate ETM values, with higher value for SFT (2.4%) and PRA (0.9%).

Control Variables

Usual physical activity, bone age, the use of ART and the use of protease inhibitor (PI) in ART were evaluated.

Usual physical activity was estimated by the Physical Activity Questionnaire for Children (PAQ-C) (Crocker et al. 1997), validated for Brazilian children and adolescents (eight to 18 years) (Guedes, and Guedes, 2015). Each question has score from one to five and the final score is obtained by the average of questions, representing the interval from very inactive (1) to very active (5) (Crocker et al. 1997). "Active" were those who had score ≥ 3 and "little active" individuals with scores <3 (Crocker et al. 1997).

Bone age was assessed by left hand wrist-carpal radiography performed at the HIJG Radiology Department. Procedures were standardized according to literature and the bone age obtained was continuously treated (Greulich and Pyles, 1959).

The use of ART was categorized as "yes" for those who used it and "no" for those who do not use it (Naufil et al., 2012). In addition, the use of PI in ART was classified as "yes" for individuals who used antiretroviral drugs (ARV) with PI and "no" for individuals who do not use them (Naufil et al., 2012). Information on the use of ART and PI was obtained from medical records.

Statistical analysis

Descriptive statistics was used by mean and standard deviation. Data distribution presented normality according to the kurtosis and skewness values, in a range from -2 to +2 (George and Mallery, 2002). To compare means between sexes, the t-Student test for independent samples was used. The proportion of categorical variables according to sex was compared by the chi-square test. Pearson's correlation was used to test the relationship between body fat percentage by DXA and ADP with anthropometric indicators. The variables that presented statistically significant correlation ($p < 0.05$) were tested in the linear regression analyses. In the multiple linear regression analysis, physical activity, bone age, use of ART and use of PI were considered as control variables. In addition, regression analyses were estimated using the regression coefficient (β), with 95% confidence interval (95% CI), standard error and adjusted determination coefficient. For all analyses, 5% significance level was adopted. Analyses were stratified by sex and the IBM® Statistical Package for Social Sciences (SPSS) 22.0 (Chicago, United States) was used.

Results

The sample consisted of 62 participants, 28 boys and 34 girls, with mean age of 12.8 years. Girls presented high fat percentage values by DXA and higher SFab, SFT, SFsub and SFpan values compared to boys. Boys had higher IConi values (Table 1). In addition, 44 participants diagnosed with HIV were recruited in HIJG (67.7%) had undetectable viral load (< 40 copies.mL⁻¹) (data not shown in tables)

In boys (Table 2 and 3), it was identified that the association between skinfold values and BAI were higher with fat percentage estimated by DXA. In the simple and

multiple linear regression analysis, all indicators remained strongly associated with fat percentage measured by DXA. SFab presented higher explanatory power (67.4%) in the body fat variation assessed by DXA (Table 3).

Skinfolds were associated with fat percentage estimated by ADP in boys (Table 2 and 3). In the simple and multiple linear regression analysis (Table 3), SFab was the anthropometric indicator with the largest (35.7%) explanatory power on fat percentage measured by ADP.

In girls (Table 2 and 4), an association between skinfolds, BMI, PRA and WC was identified with fat percentage measured by DXA. In the simple and multiple linear regression analysis (Table 4), all anthropometric indicators remained associated with fat percentage and, SFpan (53.9%) and SFab (57.3%) presented greater explanatory power on the fat percentage variation measured by DXA.

For the fat percentage measured by ADP in girls (Table 2 and 4), skinfolds, BMI, PRA and WC were associated in a directly proportional way. In the simple and multiple linear regression analysis, all indicators investigated remained associated with body fat measured by ADP. SFab had greater explanatory power (42.8%) on the fat percentage variation measured by ADP (Table 4).

Discussion

The present study demonstrated that in both sexes, skinfolds were associated with fat percentage measured by DXA and ADP. In girls, it was also identified that BMI, PRA and WC were associated with fat percentage estimated by DXA and ADP. The anthropometric indicator most strongly associated with fat percentage measured by reference methods, after adjusting for confounding factors in both sexes was SFab.

Skinfolds showed associations of greater magnitude with fat percentage measured by DXA and ADP in children and adolescents diagnosed with HIV. This has been observed in previous studies with children and adolescents with no diagnosis of diseases (Freedman et al. 2013; Michels et al. 2013) and is justified because skinfolds present high amounts of adipocytes in the subcutaneous tissue due to the accumulation of acylation stimulating proteins, causing inhibition of lipolysis and fat accumulation (Gao et al. 2015). Subcutaneous fat accounts for 1/3 of the fat in the body (Gao et al. 2015).

The anthropometric indicator that best explained fat percentage variation in both sexes and in the two reference methods was SFab. Individuals diagnosed with HIV who use ART may have adverse effects, such as fat accumulation in the abdominal region and may result in lipodystrophy, which has lipohypertrophy as one of its manifestations, particularly in the region of the cervical dorsum and abdomen (Abrahams et al. 2014). Although lipodystrophy was not investigated in this study, the majority of the sample (83.9%) have used ART in the long term (from the first year of life), which makes patients at risk of body fat redistribution (Abrahams et al. 2014), and for that reason, SFab may have been more strongly associated with body fat estimated by reference techniques.

In boys, SFsub and BAI were associated with fat percentage measured by DXA, but were not associated with fat percentage estimated by ADP. This difference can be a product of the different compartmentalization and the theoretical assumptions for calculating body fat using both reference techniques (DXA and ADP). DXA is a three-compartment method that divides the body into fat mass, fat-free mass and bone, estimating fat by the principle of attenuation of X-rays with two intensities and is not influenced by the amount of fat-free mass in the estimation of body fat (Ellis et al. 1994). ADP is a two-compartment method, which consists of fat-free mass and fat mass, in which specific densities are assumed for

such tissues, which results in indirect influence of one tissue on the other, especially in density changes that occur during growth and development, and in situations in which fat-free mass is altered by pathological conditions, such as diagnosed with HIV (Jacobson et al. 2011).

Anthropometric indicators obtained from perimeters, body mass and height, which were associated in both reference methods, differed according to sex. In girls, BMI, PRA and WC were associated with fat percentage estimated by both reference techniques. This discrepancy between boys and girls can be explained by sexual dimorphism, and in girls, as the age increases, estradiol hormone secretion increases, resulting in body fat accumulation in arms, waist, hip and thighs (Williams et al. 2013). In boys, there is less accumulation of body fat in these regions and greater accumulation of body fat in the central region of the body (Williams et al. 2013). This distribution of body fat seems to be similar in children and young with and without HIV diagnosis.

The explanatory power of anthropometric variables for body fat was higher when the reference technique was DXA when compared to ADP. Patients diagnosed with HIV and using ART, as the majority of patients in this study, may have lipodystrophy that manifests by reducing fat and fat-free mass in regions such as hip and in subcutaneous tissues (Abrahams et al. 2014; Arpadi et al. 2013; Handelsman et al. 2013; Naufil et al., 2012). Due to the influence of the amount of fat-free mass in the fat mass estimation, the ADP technique may present less explanatory power in the clinical context of HIV (Abrahams et al. 2014; Arpadi et al. 2013; Handelsman et al. 2013; Naufil et al., 2012).

Among the study strengths, the use of two reference techniques in the body fat assessment, such as DXA and ADP, as well as the comprehensiveness of the anthropometric indicators analyzed should be highlighted. This contributes to the

discussion of body composition in the context of HIV and the analysis of low-cost alternatives for clinical use. In addition, this study controlled possible confounding factors in the adjusted analyses, a strategy that had not yet been used in association studies between anthropometric indicators and body fat in children and adolescents diagnosed with HIV.

The fact that DXA and ADP overestimate the body fat percentage in individuals with high fat percentage and underestimate it in those with low fat percentage is a study limitation. In addition, the presence or absence of lipodystrophy and the hormonal level in children and adolescents diagnosed with HIV have not been reported. The study design is another factor that does not allow establishing causal relations in association analyses. The investigation of physical activity by means of a questionnaire is also another limitation.

It was concluded that low-cost tools (anthropometric indicators) were associated with fat percentage estimated by DXA and ADP in children and youth diagnosed with HIV. SFab, SFT and SFpan were associated with fat percentage estimated by DXA and ADP in boys and SFab, SFT, SFsub, SFpan, BMI, PRA and WC were associated with fat percentage estimated by DXA and ADP in girls. SFab was the anthropometric indicator that was best associated with fat percentage in both sexes. The access to sophisticated equipment such as DXA and ADP is still difficult, particularly in countries with limited resources. Thus, these results can help health professionals in the choice of anthropometric indicators to monitor the fat of children and adolescents with HIV, using alternatives of low cost and greater practicality. Body fat measurement through anthropometric variables allows the population to have access to less invasive methods in the evaluation of body composition. More studies are needed to verify if these anthropometric indicators could be used to assess lipodystrophy in children and youth diagnosed with HIV.

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None.

Conflict of interest and disclosure

None.

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Table 1. Sample characteristics according to sex.

Variables	Males (n=28)	Females (n=34)	Amplitude (n=62)
	Mean (SD)	Mean (SD)	Min- Max
DXA- body fat (%)	16.57 (7.15)	25.81 (8.11) *	6.1- 44.1
ADP- body fat (%)	12.91 (5.63)	15.17 (8.38)	2.0 – 36.0
SFab (mm)	8.86 (4.07)	11.49 (4.71)*	3.60 – 24.0
SFT (mm)	8.33 (2.48)	10.74 (3.76) *	5.0 – 20.0
SFsub (mm)	6.24 (2.00)	8.23 (3.99) *	3.15 – 20.0
DCpan (mm)	9.32 (2.84)	11.06 (3.87) *	3.15 - 20.0
PAQ-C score	2.35 (0.68)	2.12 (0.55)	1.2 – 3.8
Iconi	1.14 (0.05) *	1.11 (0.66)	0.93 - 1.36
BAI	24.18 (3.30)	25.13 (7.58)	17.30 – 34.48
BMI (kg/m ²)	17.69 (2.69)	18.40 (2.74)	12.62 – 24.80
Bone age	11.66 (2.83)	12.32 (2.54)	5.8 – 17.0
PRA (cm)	20.97 (3.15)	21.54 (3.03)	16.0 – 29.0
WC (cm)	63.59 (6.43)	62.80 (6.72)	3.15- 20.0
PN (cm)	29.53 (3.41)	28.34 (1.99)	23.0 – 38.0
WHR	0.43 (0.03)	0.42 (0.04)	0.36 – 0.54
	n (%)	n (%)	n (%)
Level of physical activity			
Active	08 (12.9)	01 (2.9)	07 (25.0)
Little active	54 (87.1)	33 (97.2)	21 (75.0)
Use of ART			
Yes	52 (83.9)	28 (82.4)	24 (85.7)
No	10 (16.1)	06 (17.6)	04 (14.3)
Use of PI			
Yes	38 (61.3)	20 (58.8)	18 (64.3)
No	24 (38.7)	14 (41.2)	10 (35.7)

ADP- Air displacement plethysmography, SD- Standard deviation, SFab- Abdominal skinfold; SFsub- Subscapular skinfold, SFT- Triceps skinfold, SFpan- Calf skinfold, DXA- dual X-ray absorptiometry, BAI- Body adiposity index, Iconi- Conicity Index; BMI- Body Mass Index; PI- protease inhibitor; Min-, Max-, Maximum. PAQ-C- physical activity questionnaire for children, PRA- Perimeter of the relaxed arm; WC- Waist circumference; PN- perimeter of the neck, WHR- Waist-height ratio, ART- Antiretroviral treatment * Student's t test for continuous variables ($p > 0.05$), Chi-square test for categorical variables ($p > 0.05$).

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Table 2. Correlation between anthropometric indicators and body fat estimated by DXA and ADP.

Variables	DXA				ADP			
	Males		Females		Males		Females	
	R	p	r	p	r	p	r	p
SFab (mm)	0.720	<0.001*	0.753	<0.001*	0.718	<0.001*	0.605	<0.001*
SFDCT (mm)	0.712	<0.001*	0.680	<0.001*	0.630	<0.001*	0.601	<0.001*
SFsub (mm)	0.537	0.003*	0.669	<0.001*	0.402	0.031*	0.531	<0.001*
SFpan (mm)	0.715	<0.001*	0.734	<0.001*	0.710	<0.001*	0.674	<0.001*
BAI	0.504	0.006*	0.198	0.255	0.330	0.086	0.220	0.205
IConi	0.179	0.345	-0.116	0.508	-0.060	0.754	-0.120	0.494
BMI (kg/m ²)	0.309	0.097	0.753	<0.001*	0.235	0.211	0.644	<0.001*
PRA (cm)	0.217	0.250	0.739	<0.001*	0.226	0.230	0.665	<0.001*
WC (cm)	0.265	0.156	0.631	<0.001*	0.178	0.347	0.578	<0.001*
PN (cm)	-0.077	0.687	0.435	0.090	0.002	0.992	0.378	0.200
WHR	0.348	0.201	0.295	0.085	0.193	0.308	0.178	0.308

ADP- Air displacement plethysmography, SFab- Abdominal skinfold; SFsub- Subscapular skinfold, SFT- Triceps skinfold, SFpan- Calf skinfold, DXA- dual X-ray absorptiometry, BAI- Body adiposity index, IConi- Conicity Index; 95% CI - 95% confidence interval, BMI - Body Mass Index; mm- Millimeters, PRA- Perimeter of the relaxed arm; WC- Waist circumference; PN- Perimeter of the neck, WHR- Waist-to-height ratio, * - p <0.05 in the Pearson's correlation.

Table 3. Linear regression analysis between anthropometric indicators and body fat in males.

DXA								
Variables	Simple				Multiple*			
	B (95%CI)	Standard error	<i>p</i>	adjusted <i>R</i>²	B (95%CI)	Standard error	<i>p</i>	adjusted <i>R</i>²
SFab (mm)	1.26 (0.79-1.73)	0.230	<0.001	0.502	1.31 (0.83-1.80)	0.233	<0.001	0.674
SFT (mm)	2.05 (1.26-2.83)	0.382	<0.001	0.490	1.73 (0.85-2.61)	0.424	0.001	0.543
SFsub (mm)	1.83 (0.67-3.00)	0.261	0.003	0.329	1.75 (0.41-3.10)	0.424	0.001	0.543
SFpan (mm)	1.79 (1.11-2.47)	0.332	<0.001	0.494	1.74 (0.85-2.63)	0.424	<0.001	0.542
BAI	1.15 (0.45-1.86)	0.345	0.002	0.261	0.86 (0.18-1.54)	0.326	0.001	0.384
ADP								
	B (95%CI)	Standard error	<i>p</i>	adjusted <i>R</i>²	B (95%CI)	Standard error	<i>p</i>	adjusted <i>R</i>²
SFab (mm)	0.87 (0.42- 1.33)	0.220	<0.001	0.355	0.94 (0.42-1.46)	0.251	<0.001	0.357
SFT (mm)	1.19 (0.44-1.94)	0.364	0.003	0.267	1.13 (0.22-2.03)	0.434	0.001	0.186
SFsub (mm)	1.05 (0.85-2.02)	0.471	0.031	0.129	-1.61 (-5.90- 2.67)	2.06	0.441	0.035
SFpan (mm)	1.30 (0.59-2.01)	0.345	<0.001	0.328	1.19 (0.30-2.09)	0.428	<0.001	0.214

ADP- Air displacement plethysmography, SFab- Abdominal skinfold; SFsub- Subscapular skinfold, SFT- Triceps skinfold, SFpan- Calf skinfold, DXA- dual X-ray absorptiometry, BAI- Body adiposity index, IConi- Conicity Index; 95% CI - 95% confidence interval, BMI - Body Mass Index; mm- Millimeters, PRA- Perimeter of the relaxed arm; WC- Waist circumference; PN- Perimeter of the neck, WHR- Waist-to-height ratio., B: regression coefficient; *R*²: determination coefficient; * The multiple linear regression model was adjusted by level of physical activity, skeletal maturation, use of ART and use of PI.

Table 4. Linear regression analysis between anthropometric indicators and body fat in females.

DXA								
Simple					Multiple*			
Variables	B (95%CI)	Standard error	p	adjusted R ²	B (95%CI)	Standard error	p	adjusted R ²
SFab (mm)	1.29 (0.88-1.69)	0.199	<0.001	0.555	1.34 (0.82-1.85)	0.249	<0.001	0.573
SFT (mm)	1.50 (0.95-2.06)	0.274	<0.001	0.470	1.50 (0.84-2.17)	0.325	<0.001	0.509
SFsub (mm)	1.37 (0.82-1.92)	0.270	<0.001	0.429	1.16 (0.51-1.80)	0.316	<0.001	0.411
SFpan (mm)	1.53 (1.02-2.04)	0.251	<0.001	0.523	1.45 (0.85-2.05)	0.292	<0.001	0.539
BMI (kg/m ²)	2.28 (1.53-2.92)	0.341	<0.001	0.396	2.35 (1.22-3.37)	0.508	<0.001	0.516
PRA (cm)	1.97 (1.32-2.62)	0.320	<0.001	0.530	2.35 (1.22-3.37)	0.508	<0.001	0.504
WC (cm)	0.76 (0.43-1.10)	0.164	<0.001	0.387	2.33 (1.29-3.37)	0.508	<0.001	0.504
ADP								
	B (95%CI)	Standard error	p	adjusted R ²	B (95%CI)	Standard error	p	adjusted R ²
SFab (mm)	1.07 (0.56-1.58)	0.281	<0.001	0.442	1.05 (0.37-1.72)	0.396	<0.001	0.428
SFT (mm)	1.34 (0.70-1.99)	0.317	<0.001	0.341	1.34 (0.53-2.14)	0.392	<0.001	0.332
SFsub (mm)	1.16 (0.52-1.80)	0.315	<0.001	0.277	0.96 (0.19-1.73)	0.374	<0.001	0.231
SFpan (mm)	1.46 (0.89-2.04)	0.412	<0.001	0.396	1.43 (0.74-2.12)	0.336	<0.001	0.304
BMI (kg/m ²)	1.96 (1.12-2.80)	0.250	<0.001	0.348	2.02 (0.73-3.31)	0.330	0.003	0.307
PRA (cm)	1.86 (1.12-2.60)	0.363	<0.001	0.434	2.20 (0.98-3.42)	0.396	<0.001	0.364
WC (cm)	0.72 (0.36-1.09)	0.179	<0.001	0.318	0.68 (0.17-1.19)	0.249	0.001	0.255

ADP- Air displacement plethysmography, SFab- Abdominal skinfold; SFsub- Subscapular skinfold, SFT- Triceps skinfold, SFpan- Calf skinfold, DXA- dual X-ray absorptiometry, BAI- Body adiposity index, IConi- Conicity Index; 95% CI - 95% confidence interval, BMI - Body Mass Index; mm- Millimeters, PRA- Perimeter of the relaxed arm; WC- Waist circumference; PN- Perimeter of the neck, WHR- Waist-to-height ratio., B: regression coefficient; R²: determination coefficient; * The multiple linear regression model was adjusted by level of physical activity, skeletal maturation, use of ART and use of PI.