Body adiposity index to analyze the percentage of fat in young men aged between seven and 17 years

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Abstract

Background: The body adiposity index (BAI), uses anthropometry to estimate percent body fat (%F). However, previous studies have shown that the BAI has limited accuracy for children and adolescents.

Objective: We propose to develop and validate an adjusted BAI for use in male children and adolescents from seven to 17 years of age.

Methods: The sample consisted of 141 physically active male children and adolescents (age: 12.5 ± 2.14). The %F was determined by X-ray dual energy absorptometry equipment (DXA) as the standard method and by BAI, using an equation that uses height and hip circumference. Arithmetic modeling was used to adjust the structure of the BAI mathematical model.

Results: The BAI arithmetic adjustment was successful, resulting in the mathematical model named in the present study of adjusted body adiposity index (BAI_{ADJ}). BAI and BAI_{ADJ} correlated with DXA (r≤0.70, p <0.001). Regression analyzes indicate that, BAI (CI 95% β: [1.35; 1.90], p<0.0001) and BAI_{ADJ} (CI 95% β: [1.40; 1.90], p <0.0001) have the potential to estimate% F. BAI pointed out a difference in relation to DXA (p = 0.04). While there was no difference between BAI_{ADJ} and DXA (p = 0.1). There was a proportion bias of 13.2%for BAI (p <0.05), but not for BAI_{ADJ} (p> 0.05).

Conclusion: The adjusted model of the body adiposity index proves to be an effective tool for the analysis of the fat percentage in young males. In addition, it demonstrated significant degrees of agreement and validity in relation to DXA.

Key words: Body Composition; Body Adiposity Index; DXA; Children, Adolescents.

Introduction

Body composition reflects the accumulation of nutrients and energetic substrates constituting, in general terms, the amount and proportion of fat and lean mass, which are important components for both health and sport (Willoughby et al., 2018). The verification of body composition in childhood and adolescence is an effective tool for the provision of subsidies for the prevention of future health problems. Body composition, more specifically high? body fat, is associated with health risks, depression, reduced sports performance, reduced self-esteem and altered body image (Després et al., 1990; Daniels et al., 1999; Ritz, 2009; Maranhão Neto et al, 2015).

Data on childhood obesity are alarming, with the World Health Organization (WHO) estimating that in 2025 the number of obese children on the planet will reach 75 million (SES-GO, 2020). In addition, the records of the Brazilian Institute of Geography and Statistics (IBGE, 2019) indicate that one in each group of three children, aged between five and nine years, is overweight in Brazil (IBGE, 2019). Notifications from the 2019 Food and Nutrition Surveillance System revealed that 16.3% of Brazilian children between five and ten years old are overweight; 9.4% with obesity; and 5.2% with severe obesity (SES- GO, 2020). Regarding adolescents, 18.0% are overweight; 9.5% have obesity; and 3.98% have severe obesity (SES-GO, 2020). Therefore, assessing the body composition of children and adolescents is essential to identify issues related to the health of the pediatric population and propose intervention measures, when necessary.

Models of body composition assessment are based on compartments, ranging from two to five divisions (Souza L. Sant'Anna et al, .2009). According to Wilmore et al., (1994) this division can be described as follows: (1) Two-component model: fat mass and fat-free mass; (2) Anatomical model with five components: adipose tissue, muscle, residual, bone and skin; (3) Chemical model with five components: fat, proteins, carbohydrates, water and minerals. Depending on how the body composition assessment method was validated, it will be classified as an indirect or doubly indirect measure (Ripka, 2017). It may also reflect different measures, as in the case of skin folds, which can either contemplate body density, using validated formulas for this, or estimate subcutaneous fat values (Driskell et al., 2011).

In this context, due to the need to assess body composition, especially the adipose tissue compartment, practical methods that can be used in daily life by health professionals were developed, in addition to the use of skinfolds, an alternative for the analysis of fat body fat is the Body Adiposity Index (BAI) developed by Bergman et al., (2011). BAI was proposed with the objective of predicting the percentage of body fat (%F), since the methods used for this purpose require the use of sophisticated equipment (i.e., X-ray dual energy absorptometry equipment (DXA), bioimpedance equipment or a scientific compass to measure skin folds) or have limitations to predict body adiposity such as the body mass index (BMI), which does not distinguish between lean and fat mass (Cerqueira et al., 2018).

However, despite having a good applicability, BAI is not a method that proved to be effective for analyzing %F in pediatric patients (Filgueiras et al., 2019). Our group recently showed the effectiveness of BAI in children and adolescents of both sexes aged between seven and 17 years. Weverified that BAI was significantly correlated with DXA for the analysis of percentage body fat (%F) (De Macêdo Cesário et al., 2020). However, BAI has not provided unbiased %F estimates in this population. Moreover, in the previous study of our group, it was found that BAI points out sensitivity for the analysis of the percentage of body fat in young males compared to females, and that when comparing DXA data with BAI data in male subjects, there was no significant difference between methods (De Macêdo Cesário et al., 2020). This suggests that the mathematical structure of BAI can be adjusted to reduce the proportion bias so that BAI is effective for the pediatric male population (De Macêdo Cesário et al., 2020).

Therefore, the present study has as a central problem to proposing and validate a BAI model using the dual energy X-ray emission absorption method (DXA) for its use in male patients aged 7 to 17 years. It was hypothesized that by adjusting the mathematical structure of BAI, the method may become more accurate for the analysis of %F in the male pediatric population.

Methods

Subjects

The sample consisted of 141 active children and adolescents (rowing, Brazilian jiujitsu, tennis, swimming and volleyball) male aged between seven and 17 years. It is noteworthy that the sample calculation was made with assumptions based on a previous study (De Macêdo Cesário et al., 2020). Thus, an effect size of 0.70 and anαvalue of 0.05 and a β value of 0.80 were adopted. Thus, a sample power of 0.93 was estimated and the margin of possibility of error was 4.9% for the sample size used in the study, less than 5%, indicating that the sample has statistical strength to answer the research question.

According to Matsudo, Rivet & Pereira (1987), participants are classified as level III athletes (on a growing scale from I to VI) characterized by performing physical education at school, being part of a sports team and participating in competitions regional sports. The inclusion criteria were that the subjects should be aged between seven and 17 years old, be male and have been active in their sports practice for at least 6 months prior to this research. Participants who presented musculoskeletal injuries or disabilities that could compromise the performance of the proposed tests, those who were not in the required age group and those who did not give consent to participate in any stage of the study were excluded.

The research was approved by the Ethics and Research Committee of the Federal University of Rio Grande do Norte - Brazil (CAEE: 15865619.70000.5537; Opinion: 3.552.010) according to Resolution 466/12 of the National Health Council, on 12/12/2012, strictly respecting the national and international ethical principles contained in the Declaration of Helsinki. It is worth mentioning that the study complied with all the international requirements and standards of the STROBE checklist for observational studies of incidence and prevalence (Strobe, 2014).

Procedures

Study design

At first, the sample volunteers and their respective guardians were instructed on the details of this research. After 24h, body composition analyzes were performed at DXA, followed by anthropometric analysis (Figure 1).

insert figure 1

Anthropometric analysis

Anthropometric assessments were performed according to the protocol of the International Society of the Advancement of Kinanthropometry (Karupaiah, 2018). Body mass was measured using a digital scale with a variation of 0.1 kg (FILIZOLA®, Brazil). Height was assessed using a stadiometer with an accuracy of 0.1 cm (SANNY®, Brazil). The hip circumference was measured with an anthropometric tape (SANNY®, Brazil), with an accuracy of 0.1 cm.

Body composition

Body composition was assessed using two methods: BAI and dual energy X-ray absorptiometry (DXA). The first makes use of anthropometric measures to estimate the percentage of fat (% fat) according to the following equation (Bergmanet al., 2011):

$$\text{BAI}(\%) = [\text{Hip (cm)} / (\text{Stature (m)} * \sqrt{\text{Stature (m)}})] - 18$$

BAI = Body adiposity index

The second method uses the DXA equipment and is considered one of the gold standard parameters for the analysis of body composition. During analyzes on the DXA equipment, appropriate algorithms were used for the pediatric population (Wasserman et al., 2017). Participants were placed in the supine position on the DXA equipment and instructed to remain in a static position throughout the procedure (without causing discomfort to the subject) (Wasserman et al., 2017). The analysis lasted an average of 10 minutes for each participant. It should be noted that for both BAI and DXA analyzes, a single evaluator was responsible, and all analyzes were performed individually.

Chronological age analysis

The chronological age in months was determined by the sum of the individual's months of life, from his date of birth until the date of analysis of the present study. In this way the sum of months of life was divided by 12, resulting in their chronological age in years (Malina; Bouchard, 2002).

Statistical procedures

Mathematicalmodeling

It was recently reported by our group that BAI pointed a difference between 0.5% and 0.99% in relation to DXA analyzes for the estimate of F% in pediatric patients (De MacedoCesário et al., 2020). However, BAI was not effective in estimating the percentage of fat in pediatric patients, but it demonstrated positive associations for male pediatric patients (De Macedo Cesário et al., 2020). Therefore, it is necessary to develop a model to verify an adequate body adiposity index for the male pediatric population.

Thus, when verifying the results of the present study, it is identified that 1.6 significant difference bias ratio ($p < 0.001$) found between BAI and DXA, from that point on the theoretical arithmetic model was developed following the recommendations of Segel (1980) and Neimark (2012). Based on an existing arithmetic structure (in this case, BAI) the study followed the recommendations of Segel (1980). Therefore, considering the fixed constant contained in the BAI (-18), the following procedure was performed to make the model adjusted for the male pediatric population: the value of the 1.6 proportion bias was divided by two, reaching the value of 0.8 which was subtracted from the constant 18 that is part of BAI's arithmetic structure. BAI's mathematical formula had its final constant value calibrated from 18 to 17.2, to compensate for the 1.6 difference in relation to DXA analyzes. After calibration, the model was called adjusted BAI (BAI_{ADJ}).

Later, regression analyzes were performed and the theoretical model was tested by means of confirmatory factor analysis and by the reproducibility index (Paragios; Chen; Faugeras, 2006). The analyzes indicated that for a better reliability of BAI_{ADJ}, the constant of 17.2 would need to be adjusted to a constant of 17.3. After adjusting the constant, regression analyzes, confirmatory and reproducibility factors were again performed.Then, the results of the BAI_{ADJ} F% analysis were statistically tested to verify the reliability and agreement in relation to the DXA F% analyzes. Thus, the difference between BAI and DXA found in the present study, was reduced by ~ 44% with BAI_{ADJ} (from 1.6 to 0.9) (Details in the results section).

Data normalitytest

The normality of the data was verified by the Kolmogorov-Smirnov test and by the z score for asymmetry and kurtosis (-1.96 to 1.96).

Correlation analysis

Pearson's linear correlation test was performed to verify the existence of an association between the percentage of body fat, measured by DXA (independent variable), BAI and BAI_{ADJ} (dependent variables). The magnitude of the results of each correlation was determined by the scale proposed by Schober, Boer, &Schwarte, (2018): insignificant: $r < 0.10$; weak: $r = 0.10$-0.39; moderate: $r = 0.40$-0.69; strong: $r = 0.70$-0.89; and very strong: $r = 0.90$-1.00.

Regression Analysis

Subsequently, linear regression analyzes were performed. The homogeneity of the regression models was tested using the Breush-Pegan test and the assumptions of normality, variance and independence of the data were not denied. To test the multicollinearity of the regression models, the Durbin Watson test was used.

Comparative and effect size tests

Comparative analyzes between groups were performed using the Student-dependent t test. The effect size was calculated using the Cohen test (d). The magnitude of the effect size was assessed using the scale suggested by Espírito Santo & Daniel (2017): insignificant: <0.19; small: 0.20-0.49; average: 0.50-0.79; large: 0.80–1.29; very large:>1.30 and a 95% confidence interval was calculated.

Reliability and concordance tests

To measure the reliability between the measurements by different methods, we calculated the intraclass correlation coefficient, whose magnitudes were determined by the scale recommended by Miot (2016): absence: <0; bad: 0-0.19; weak: 0.20-0.39; moderate: 0.30-0.59; substantial: 0.60-0.79; almost complete: ≥0.80.

The Bland-Altman plot was performed to verify the dispersion of the data within the limits of agreement, as defined by the differences in means between the measures of the variables (Bland; Altman, 1986), the following magnitude was used: Acceptable agreement between methods = Differences between means - 5.0 to5.0 (Bland; Altman, 1986). In addition, to assess the agreement between BAI_{ADJ} and DXA, Lin's (1989) correlation coefficient of agreement was used. Lin's (1989) correlation correlation coefficient combines precision measures to determine how much the observed data deviates from perfect agreement. In this way, the deviation below 5% of the perfect agreement is taken as acceptable (Lin, 1989).

Analysis of proportion bias and technical error of measures

The proportion bias was measured based on the average of the difference between the methods analyzed (Bland, Altman, 1986). The technical error of the intra-examiner measurement was performed based on the recommendations of Perini et al., (2005): Acceptable <1%. All the aforementioned analyzes were performed using thesoftware open source R (version 4.0.1; Foundation R for StatisticalComputing®, Vienna, Austria), and a level of $p < 0.05$ was considered statistically significant.

Results

Table 1 shows the characteristics of the subjects analyzed in this research. It is noteworthy that the technical error of intra-examiner measurement for anthropometric affections were values below 1%.

insert table 1

Therefore, the mathematical model adjusted (BAI_{ADJ}) by the present research in order to analyze the body adiposity index in young male pediatric patients consist in:

$$BAI_{ADJ} (\%) = [Hip (cm) / (Stature (m) * \sqrt{Stature (m)})] - 17.3$$

The data contained in table 2 indicate that the original body adiposity index and the one adjusted by the present research, show statistically significant correlations with the DXA in relation to the analysis of body adiposity.

Insert table 2

Figure two shows two models of linear regression analysis, model one consisting of DXA and BAI (figure 2-A); and model two in DXA and BAI_{ADJ} (Figure 2B). In this sense, linear regression analyzes show that BAI ($r^2=0.490$; $\beta=1.63$, CI 95% β: [1.35; 1.90], $p<0.0001$) and BAI_{ADJ} ($r^2=0.491$; $\beta=1.65$, CI 95% β: [1.40; 1.90], $p<0.0001$), indicate ability to estimate %F in relation to DXA. It should be noted that multicollinearities were not identified in the regression models (Model1: DXA + BAI. Model 2: DXA + BAI_{ADJ}).

Insert figure 2

In comparisons between methods, BAI showed a significant difference in relation to DXA. While the BAI_{ADJ} developed by the present research did not show any significant difference in relation to DXA (table 3).

Insert table 3

Figure 3 shows two models of reliability analyses, model one consists of DXA and BAI (Figure 3-A); and model two in DXA and BAI_{ADJ} (Figure 3-B). In this sense, the reliability between the methods proved to be significant for both BAI (Bland-

Altman Agreement: [-5] to [5]) and BAI_{ADJ} (Bland-Altman Agreement: [-5] to [5]). Both methods showed differences close to zero in relation to the analysis of body adiposity performed by DXA. It should be noted that both methods also pointed to a standard error below 1.0 (BAI = 0.31; BAI_{ADJ} = 0.31; DXA= 0.73).

Insert figure 3

Both the mathematical models, BAI and BAI_{ADJ} showed significant reliability in relation to DXA for the analysis of the percentage of body fat. However, BAI pointed out a significant proportion bias with approximately 13.2% difference in relation to DXA($r^2 = 0.50$; $\beta = 3.39$; 95% CI β: [-3.78; 1.05]; $p < 0.0001$), indicatingthatthemethodmayoverestimateorunderestimatethepercentageofbodyfat. It is noteworthy that the difference between BAI and DXA was reduced by 44% in the BAI_{ADJ} model, thus BAI_{ADJ} pointed out differences less than 3.5% in relation to DXA, not pointing to a significant proportion bias($r^2 = 0.04$; $\beta = -2.74$; 95% CI β: [1.59; 3.05]; $p < 0.1$) (table 4).

Insert table 4

According to figure 4, the deviation from perfect agreement ($DPA_{(\%)}$) between DXA and BAIADJ is below 5% for body fat percentage data between 15.1 to 20 % ($DPA_{(\%)}$: 4.53), 20.1 to 25% ($DPA_{(\%)}$: 0.74), 25.1 to 30% ($DPA_{(\%)}$: 2.48). $DPA_{(\%)}$over 5% were found in the fat percentage data between 8 to 15% ($DPA_{(\%)}$: 9.72), 30.1 to 35% ($DPA_{(\%)}$: 5.63), 35.1 to 40% ($DPA_{(\%)}$: 11.6), 45.1 to 50% ($DPA_{(\%)}$: 16.7).

In addition, BAI_{ADJ} demonstrated significant correlations with DXA in the analyzes segregated by fat percentage: from 8 to 15%(r=0.702, CI 95% r: [0.699; 0.751], p<0.05), from 15.1 to 20% (r=0.755, CI 95% r: [0.700; 0.780], p<0.05), from 20.1 to 25% (r=0.836, CI 95% r: [0.764; 0.850], p<0.05), from 25.1 to 30% (r=0.702, CI 95% r: [0.694; 0.720], p<0.05); from 35.1 to 40% (r=0.728, CI 95% r: [0.702; 0.741], p<0.05), from 40.1 to 45% (r=0.738, CI 95% r: [0.714; 0.759], p<0.05) and from 45.1 to 50% (r=0.753, CI 95% r: [0.731; 0.804], p<0.05).

Insert figure 4

Discussion

The aim of the present study was to adjust and validate the BAI with the dual energy x-ray emission absorption method (DXA) for its use in pediatric patients. The main results were: (1) The modeling of a mathematical model from BAI was successful. (2) %F analyzes by BAI and BAI_{ADJ} correlated significantly with %F analyzes by DXA. (3) BAI and BAI_{ADJ} show significant power to predict %F. (4) Analyzes of %F by BAI showed significant differences from analyzes of %F by DXA. While there was no significant difference between the analyzes of %F by BAI_{ADJ} in relation to DXA. (5) BAI and BAI_{ADJ} pointed out significant limits of agreement and reliability for the analysis of %F in relation to DXA. (6) BAI pointed out a significant proportion bias of 13.2% for the analysis of %F. While BAI_{ADJ} pointed out a non-significant bias of 3.5% for the analysis of %F. (7) BAI_{ADJ} demonstrated greater sensitivity to analyze fat percentages between 15.1 and 30%.

The analysis of %F by the mathematical model BAI_{ADJ} developed by the present study showed a significant correlation with the analysis of %F by DXA. Similarly to our study, other authors sought to associate BAI for the pediatric population with the methods considered as a reference in the assessment of body composition, indicating significant associations ($p<0.05$) (Diaset al., 2014; Segheto et al. 2017; Colley et al. 2015). In the present study, BAI_{ADJ} proved to be significant in linear regression analyzes to estimate %F in relation to DXA results. This assumption corroborates with De Macêdo Cesário et al., (2020), who also found significant results of linear regression for the forecast of %F by BAI ($p <0.05$).

However, El Aarbaoui et al. (2013) evaluated individuals aged 5 to 12 years, to verify the effectiveness of BAI and a possible need for another more efficient equation for the pediatric population. The results showed that BAI overestimated body fat values in this age group and it was necessary to develop a pediatric equation called pediatric adiposity index (BAIp) to analyze the %F in young pediatric patients. Despite efforts, BAIp was not successful, just like BAI the BAIp method, overestimated %F by more than 3.8% and 4.62% compared to DXA (Thivel et al,. 2015).

In this sense, the present study identified that BAI pointed out significant proportion biases ($p <0.05$), which suggests the inefficiency of the method. This led to the adjustment of the mathematical model, giving rise to BAI_{ADJ} which did not show significant proportion bias with a difference of 13% in relation to DXA ($p> 0.05$) for the analysis of the %F in the sample of young male pediatric patients. In addition, BAI_{ADJ} pointed out significant limits of agreement and reliability in relation to DXA ($p <0.05$). What suggests the efficiency of the predictor method developed by the study in relation to the base method used (i.e., DXA) (Bland; Altman, 1986; Neimark, 2012; Miot, 2016).

It is noteworthy that the BAI_{ADJ} showed greater sensitivity to measure %F with values between 15.1 and 30%, being less sensitive to the very low or very high values of %F. Thus, the results of the present study corroborate with Bergman et al., (2011), where the authors reported that, in adults, the original BAI pointed out greater sensitivity to measure %F for values between 15 and 25%.

In addition, the statistical analyzes showed that BAI_{ADJ} demonstrated results with greater precision and with narrower confidence intervals in relation to the analyzes performed by BAI. It is noteworthy that the confidence intervals (CI) are used to indicate the reliability of an estimate (Ci; Rule, 1987). Thus, among similar estimates, those that indicate lower CI indicate more reliable results in relation to those with higher CI (Ci; Rule, 1987).

Thus, when considering the importance of analyzing body composition for the health and physical performance of the pediatric population (Willoughby et al., 2018; Almeida-Neto et al., 2020a; 2020b; De Almeida-Neto et al., 2020a; 2020b), the present study brings the future perspective to contribute to the practical field of health professionals and that of sport, with the provision of a reliable tool for the assessment of %F in young pediatric patients. BAI_{ADJ} may prove to be extremely important for monitoring and diagnosing interventions aimed at reducing childhood obesity and morbidities associated with excess body fat. As well as being a valuable tool for monitoring the body fat of young athletes, it can contribute to improving sports performance.However, despite the BAI calibration having resulted in a reliable tool (BAIADJ) we suggest that future studies seek to develop specific tools for the pediatric population for the analysis of F% with low financial cost and high reliability.

Despite the importance of the findings, the present study has the following limitations: (1) The study was observational in design, which prevents the establishment of a cause and effect relationship in relation to the correlation analyzes. (2) Only male subjects were analyzed. Thus, it is suggested the production of future studies that test BAI_{ADJ} in female subjects, as well as in subjects with characteristics different from those of the sample used.

Conclusion

It is concluded that the Adjusted Body Adiposity Indexdeveloped by the present research proves to be an effective tool for the analysis of the percentage of body fat in young men aged between 7 and 17 years, when compared with validated studies. Demonstrating significant degrees of agreement and validity in relation to the evaluation of the percentage of fat by the dual energy x-ray absorptiometry (DXA) equipment.

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Author contributions

Tatianny de Macêdo Cesário: Concept Curation of data; Formal analysis; Investigation; Methodology; Validation. **Paulo Francisco de Almeida-Neto**: Formal analysis; Methodology; Writing the original draft. **Dihogo Gama de Matos:** Validation; Writing the original draft; Essay; Review and editing. **Jonathan CK Wells:** Formal analysis; Methodology; Validation; Writing the original draft; Essay; Review and editing. **Felipe José Aidar:** Investigation; Supervision; Writing the original draft. **Roberto Fernandes da Costa:** Research; Supervision; Essay; Review and editing. **BrenoGuilherme de Araújo Tinoco Cabral:** Conceptualization; Formal analysis; Investigation; Methodology; Project management; Resources; Supervision; Validation; Visualization; Writing the original draft; Writing and proofreading.

Data Availability Statement

The data supporting the conclusions of this study are available from the corresponding author, upon reasonablesolicitation.

Declaration of conflicts of interest: The authors declare that there are no conflicts of interest.

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Table 1. Characterization of anthropometric and body composition variables in the sample of the present study

Variable	Values
Sample	141
Age(years)	12.5 ± 2.14
Height (m)	1.55 ± 0.14
Hip circumference (cm)	81.9 ± 11.0
Bodyweight (kg)	46.9 ± 14.7
Body mass index (kg/m^2)	19.9 ± 4.44
Fat mass (kg)	11.8 ± 6.60
Leanmass (kg)	33.3 ± 11.5
DXA (%F)	25.7 ± 8.72

DXA = Dual energy x-ray emission absorptiometry.

Table 2. Correlation between DXA methods with BAI and DXA with BAI_{ADJ}

To analyze the percentage of body fat.

DXA withBAI		DXA withBAI_{ADJ}	
R	p–Value	r	p - Value
0.700*	<0.0001	0.701*	<0.0001

* Statistically significant. DXA = Dual energy x-ray emission absorptiometry. BAI = Body Adiposity Index. BAI_{ADJ} = Adjusted Body Adiposity Index.

Table 3. Comparison between DXA methods with BAI and DXA with BAI_{ADJ}

To analyze the percentage of body fat.

DXA	BAI	ES	IC 95% ES	p –Value
25.7 ± 8.72*	24.1 ± 3.74	0.23	[0.00; 0.47]	0.04
DXA	BAI_{ADJ}	ES	IC 95% ES	p – Value
25.7 ± 8.72	24.8 ± 3.74	-0.13	[-0.36; 0.10]	0.1

* Statistically significant. DXA = Dual energy x-ray emission absorptiometry. BAI = Body Adiposity Index. BAI_{ADJ} = Adjusted Body Adiposity Index. CI = Confidence Interval. ES = Effect Size.

Table 4. Intraclass Correlation Index between DXA with BAI and DXA with BAI_{ADJ} methods for analyzing body fat percentage.

Methods Involved	ICC	IC 95% ICC	p - ICC	Proportion Bias	p– PB
DXA with BAI	0.490*	[0.354; 0.606]	<0.0001	1.60*	<0.0001
DXA withBAI_{ADJ}	0.504*	[0.371; 0.618]	<0.0001	0.90	0.1

* Statistically significant. DXA = Dual energy x-ray emission absorptiometry. BAI = Body Adiposity Index. BAI_{ADJ} = Adjusted Body Adiposity Index. ICC = Intracalsse Correlation Coefficient. CI = Confidence Interval. p - ICC = p value for the ICC. p - PB = p value for the proportion of bias.

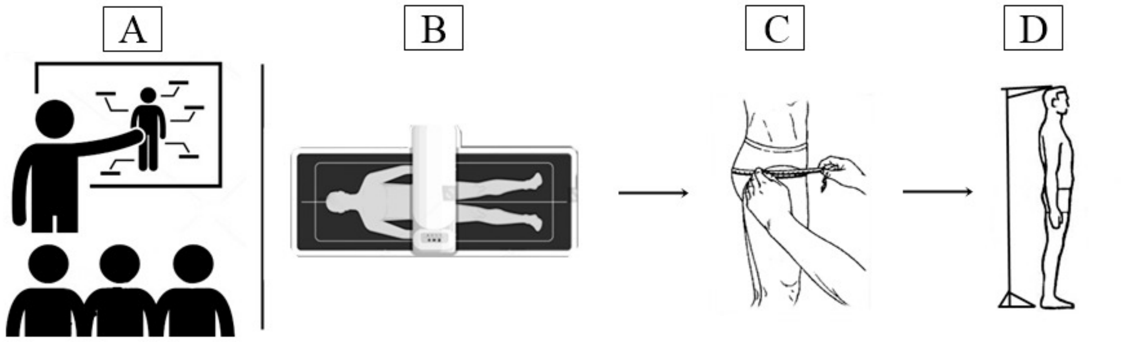


Figure 1. Study design.

Caption : A = Guidelines for participants and their respective guardians. B = Analysis of body composition in DXA. C = Measurement of the hip circumference. D = Measurement of body height.

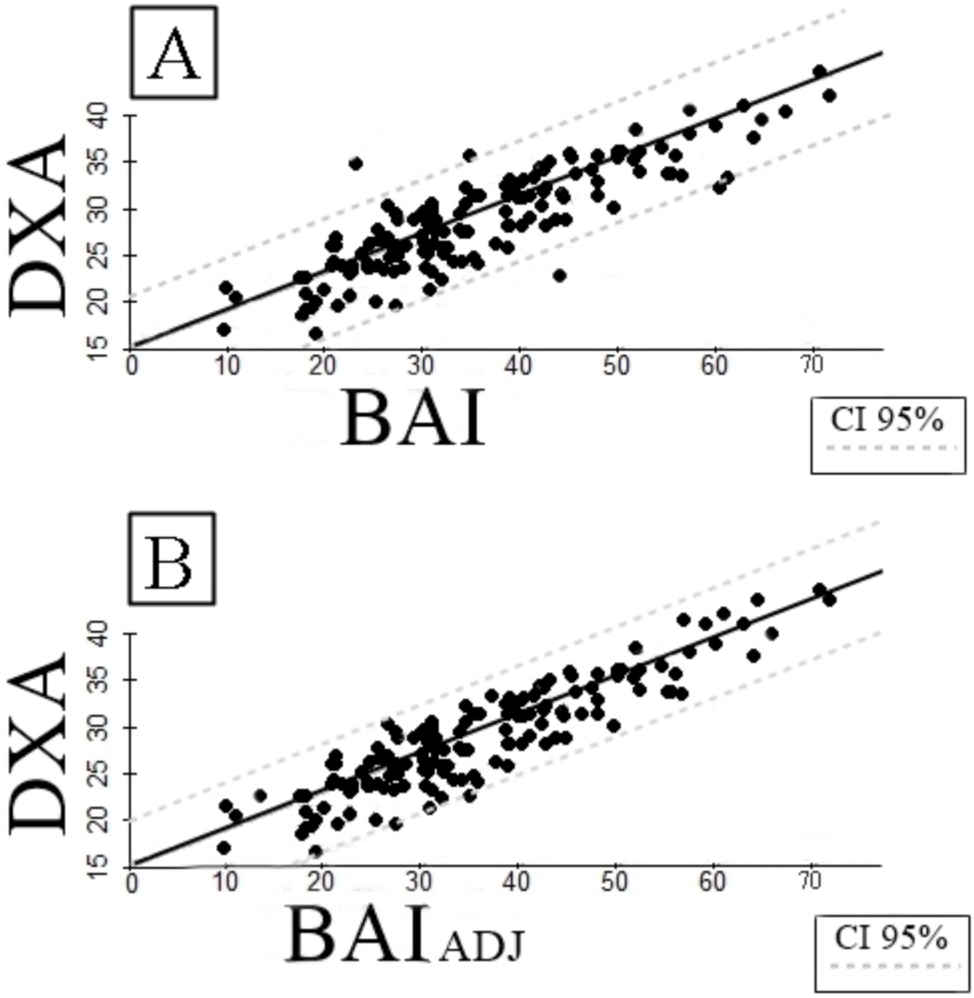
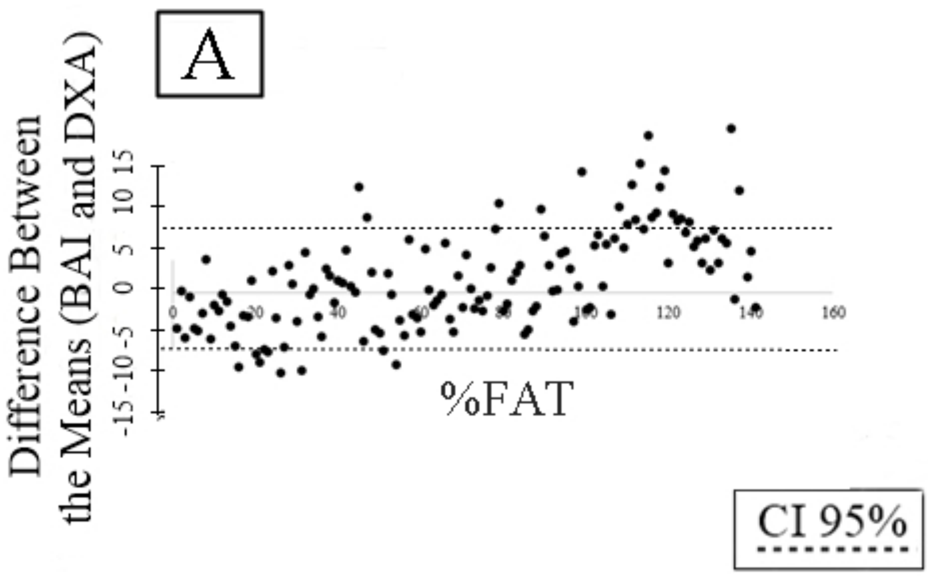


Figure 2. Analyzes of linear regression of BAI and BAIADJ in relation to DXA.

CI = Confidence Interval. DXA = Dual energy x-ray emission absorptiometry. BAIADJ = Adjusted Body Adiposity Index. BAI = Body Adiposity Index.



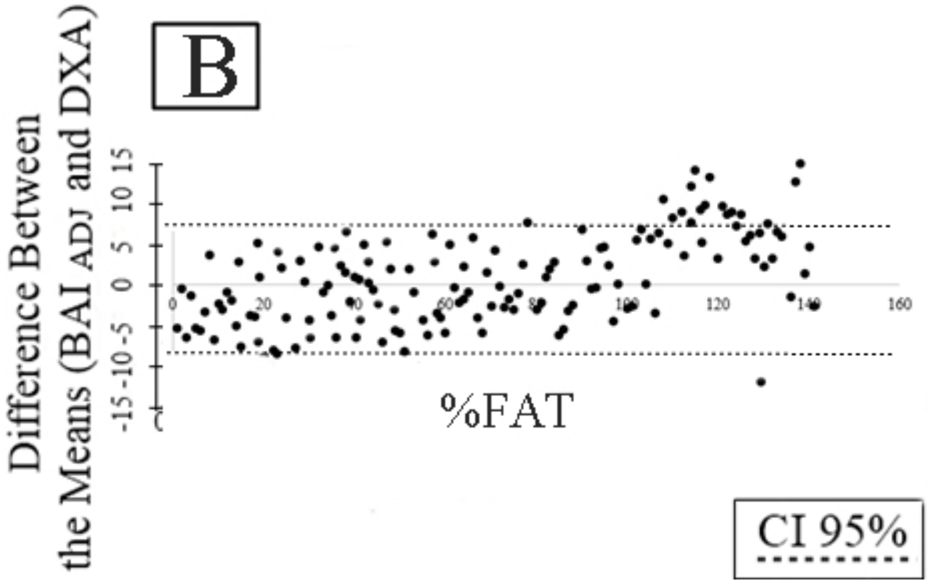


Figure 3. Bland-Altman concordance limits for BAI and BAIADJ in relation to DXA.

CI = Confidence Interval. DXA = Dual energy x-ray emission absorptiometry. BAIADJ = Adjusted Body Adiposity Index. BAI = Body Adiposity Index.

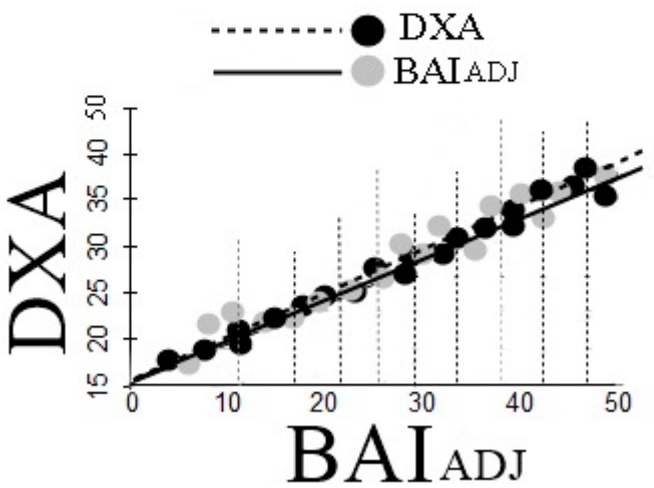


Figure 4. Deviation from perfect agreement between methods.

DXA = Dual energy x-ray emission absorptiometry. BAIADJ = Adjusted Body Adiposity Index.