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Anthropometry versus imaging for the prediction of inflammation among Hispanic girls

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Abstract

Objective—To compare total and regional estimates of body composition, by direct and indirect techniques, for the optimal prediction of CRP among young (9–12 year old), Hispanic girls (*N*=232).

Methods—Standard anthropometric techniques were used to measure height, weight, and waist circumference. Dual energy X-ray absorptiometry (DXA) and peripheral quantitative computed tomography (pQCT) assessed body composition. Fasting serum CRP was measured by the Beckman Coulter AU5812 Clinical Chemistry Analyzer. Associations between each total and regional body composition parameter and CRP were tested using linear regression (log-transformed, continuous CRP) and ordinal logistic regression (CRP < 1.0, ≥1.0–2.9, and ≥ 3.0 mg/L), controlling for maturation, dietary energy, physical activity, and medications.

Results—All measures of total and regional body fat were positively associated with CRP ($P<0.0001$), except for intermuscular fat by pQCT. There were no clinically relevant differences in their association with CRP between anthropometric (BMI; waist circumference) and DXA-derived (total fat and regional fat: trunk, gynoid, android fat, leg) measures of fat.

Conclusions—Measurement of body habitus in Hispanic girls, by multiple commonly available means, predicts CRP equally well.

Keywords

Inflammation; Adiposity; C-Reactive Protein; Obesity; Children

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INTRODUCTION

Circulating c-reactive protein (CRP) is a biomarker of inflammation[1] and an indicator of cardiovascular disease (CVD) risk.[2,3] CRP has been linked to excess adiposity, particularly central adiposity in adults.[4] The Hispanic population, specifically Mexican Americans in the US, tends to have a higher prevalence of total and central adiposity for a given BMI compared to Non-Hispanic (NH) blacks and NH whites.[5] Given this elevated prevalence of adiposity, Hispanics in the US may also have a higher prevalence of elevated CRP.[6] Since CVD remains the leading cause of death in the US,[7] early detection of risk factors and timely prevention are paramount. This has led to the investigation of inflammation among children with obesity, especially since the prevalence of overweight/obesity among children in the US is at an all-time high (31.8% children aged 2–19 with BMI≥85th percentile).[8] The percentage of Hispanic children that fall in the overweight/obese categories by BMI percentile in the US is also higher than other racial/ethnic groups (38.9% children aged 2–19 with BMI≥85th percentile).[8] Alarmingly, obesity among Hispanic children doubled during the last decade of the 20th century.[9] Attention to this upward trend is vital since obesity in childhood tracks with obesity in adulthood.[10–13] Hispanic children and adolescents of overweight and obese status have been shown to have elevated markers of endothelial dysfunction and vascular inflammation in association with total and central adiposity, [6,14–16] which increases their risk for future cardiovascular disease. However, the optimal measure of adiposity to predict CRP among children is not well studied.

Whether regional or total body fat is most predictive of CRP in Hispanic children is not known. Additionally, whether more direct measures of adiposity are superior to anthropometric measures for predicting CRP among Hispanic children unclear. If field measures, like anthropometric measures, are as good as imaging for the prediction of CRP, then they can be realistically implemented on a large scale for early identification of elevated cardiovascular risk. Therefore, the aim of this analysis was to examine the relationship between CRP and total and regional body composition. We also sought to compare anthropometric versus imaging estimates of total and regional adiposity to predict CRP. We examined these relationships among Hispanic girls, an underserved and potentially higher risk population, that may be targeted for early intervention.

METHODS

Study population

Girls aged 9–12 years were recruited between October 2013 and December 2017 from the greater Tucson, Arizona area through schools, medical clinics, and community events to participate in the “Soft Tissue and Bone Development in Young Girls (STAR)” study. The STAR sample size at the time of this analysis was *N*=332. We sought to better understand the relation between adiposity and inflammation specifically among the underserved population of Hispanics girls and therefore restricted the present analysis to Hispanic girls only (*N*=239). Within the subsample of Hispanic girls, five girls with missing CRP values and two with missing DXA data were excluded, giving a final sample size of *N*=232. Details of the study have been published.[17] In brief, exclusion criteria were self-report diagnosis of diabetes (Type 1 and 2), taking any medications that alter body composition (e.g. endocrine

therapies, diabetes medications), physical disability that limits physical activity, and learning disability that limited completion of questionnaires or otherwise made the participant unable to complete assessments or provide informed consent. Participants were not scheduled for measurement within two weeks of any illness (i.e. cold or flu), to avoid potential false elevation of CRP. The University of Arizona Human Subjects Protection Committee approved the study prior to initiation, and written informed assent and consent were obtained from all participants and their parents or legal guardians, respectively.

Anthropometric and body composition measures

A detailed description of anthropometric measurements in this cohort has been published.[17] In brief, weight was measured to the nearest 0.1 kg using a calibrated scale (Seca, Model 881, Hamburg, Germany). Standing and sitting height were measured at full inhalation to the nearest mm using a stadiometer (Shorr Height Measuring Board, Olney, MD). BMI was calculated from weight and height (weight (kg)/height $(m)^2$). Centers for Disease Control and Prevention growth charts were used to assess BMI percentiles by age and gender. Girls were categorized as underweight ($<5^{th}$ percentile), normal weight ($\geq 5^{th}$ and $<85^{th}$ percentiles), overweight (≥85th and <95th percentiles), or obese (≥95th percentile). A flexible tape was used to measure waist circumference (WC) at the umbilicus (nearest cm) while standing and tibia length (nearest mm) on the non-dominant leg. All measures were measured in duplicate and the mean of the two measurements was recorded.

Whole-body and regional fat and lean masses were obtained using dual energy x-ray absorptiometry (DXA; GE/Lunar Radiation Corp, Madison, WI). The Prodigy model was used for the first 212 participants and the iDXA for the remaining 20 participants. Standard manufacturer subject positioning and data acquisition protocols were used. Regional body composition estimates were generated by the DXA software, including android, gynoid, legs, and trunk as previously described.[17,18] The within-subject variation for soft tissue in our laboratory has been previously reported.[19]

Peripheral quantitative computed tomography (pQCT) at 66% of the tibia length from the distal growth plate was used to obtain regional soft tissue measurements for the calf, including muscle cross-sectional area, skeletal muscle density, subcutaneous fat, and intermuscular fat (XCT 3000, STRATEC Medizintechnik GmbH, Pforzheim, Germany, Division of Orthometrix; White Plains, NY). Details regarding XCT settings and tissue quantification have been previously described.[17,18] All pQCT scans were analyzed using Stratec XCT software, Version 6.0, and operators were trained for pQCT data acquisition and analyses following guidelines provided by Bone Diagnostic LLC (Spring Branch, TX).

Calibration of both DXA and pQCT instruments was performed daily according to manufacturer guidelines. Analyses were performed by one certified technician.

Blood Collection and Assay

Fasting blood samples were drawn by venipuncture and centrifuged after sitting no more than 30 minutes at room temperature to allow for clotting. Serum was separated, aliquoted into cryovials, and immediately frozen and stored at −80°C for later analysis of CRP. A high sensitivity turbidometric CRP assay was performed by the University of Washington,

Department of Laboratory Medicine in Seattle, WA using a Beckman Coulter AU5812 Clinical Chemistry Analyzer and latex bead-conjugated CRP antibody. The inter-assay coefficient of variation (CV) was 3.46% for low concentration controls and 1.28% for high concentration controls (0.69 mg/L and 5.6 mg/L, respectively). Lower limit of detection (LLOD) for the high sensitivity CRP assay was ≤ 0.2 mg/L. If CRP was undetectable, a value of 0.1 mg/L was assigned.

Maturation

Maturation was assessed via chronological age, Tanner stage, and maturity offset. In alignment with prior publication in this cohort,[17,18] and due to limitations in age and Tanner stage to account for between-subject variation in maturation,[20] we selected maturity offset for the analyses herein. Maturity offset estimates physical maturity from chronological age and anthropometric measures (height, weight, sitting height, and leg length) using the Mirwald equation.[21] Maturity offset, an estimate of years from peak height velocity, is strongly related to skeletal maturation. A negative maturity offset represents the number of years until peak height velocity will be reached, whereas a positive maturity offset represents the number of years since peak height velocity was reached.[21]

Assessment of Other Covariates

A self-report questionnaire was used to obtain information on demographics, medical history, and medications at baseline. The Youth Adolescent Food Frequency Questionnaire (YAQ) was used to estimate total energy intake, as well as macro- and micronutrients, as previously published.[22] Frequency, intensity, duration, and type of physical activity were measured by the Previous Year Physical Activity Questionnaire (PYPAQ), which has been shown to reliably estimate physical activity in children and adolescents.[23] A total PYPAQ score was computed using the following formula [PYPAQ score=Σ_{1-n}(duration (average minutes/session)×frequency ([months/12]×days/week)×load (peak strain score) × METs), where n was the number of activities a subject reported during the past year].

Statistical Analysis

Differences in baseline characteristics by BMI category were evaluated by one-way ANOVA for continuous variables and Fisher's Exact Test for categorical variables. Associations between each body composition parameter and CRP were tested using linear regression (log-transformed, continuous CRP; CRP_{log}) and ordinal logistic regression (CRP <1.0, ≥1.0–2.9, and ≥ 3.0 mg/L). The CRP cut-points were derived from the literature in adults in which <1 mg/L is classified as normal; ≥1 – 2.9 mg/L as moderately elevated; and ≥3 mg/L as high.[24] The following covariates were specified *a priori*: age, maturity offset, total energy intake (kcal; log-transformed), dietary fat (%), physical activity score (log-transformed), and asthma (*N*=24, primarily albuterol) and allergy medication use (*N*=26, i.e. loratadine, cetirizine, benedryl, etc.). Fully adjusted models had a slightly smaller sample size due to missing data for some covariates: physical activity (*N*=11) and dietary measures (*N*=4). Models related to absolute lean or fat were mutually adjusted. Multivariable linear regression models were repeated in sensitivity analyses limited to girls with CRP < 10 mg/L, a common cut-off used to exclude those with acute illness. Results were similar to that of the full cohort; therefore, ordinal logistic regression models were not repeated with the cut-off.

For the ordinal logistic regression models, body composition measures were standardized, by subtracting the mean and dividing by the standard deviation, to more easily compare the resulting odds ratios. Exclusion of iDXA participants did not substantially change our results (data not shown); therefore, DXA results from both machines are reported together. A p-value <0.05 was considered statistically significant. All analyses were performed using Stata version 15.1 (StataCorp, College Station, TX).

RESULTS

The girls participating in the study averaged 10.7 ± 1.1 years of age and were close to reaching peak height velocity based on maturity offset (Table 1). Fifty-eight percent of participants had BMI <85th percentile (normal weight) with <2% (*N*=4) considered underweight.[25] Another 42% were categorized as overweight or obese (BMI ≥85th percentile). The girls were similarly aged across BMI categories. However, those in the obese category were the most mature (i.e., somatic maturity) by maturity offset. The lowest physical activity score was among the overweight group, as was the lowest caloric intake, though physical activity was not significantly different across groups. Approximately 1/3 of the total daily energy intake was derived from dietary fat (mean 2330 kcal/day across groups). The majority of participants were not taking medications; 10–11% took asthma or allergy medication. Only 2% (*N*=5) took medication for attention-deficit/hyperactivity disorder.

When evaluating body composition more directly, mean total body fat mass for the cohort was 33.5%, with a reciprocal mean total body lean mass of 63%. DXA measures of regional fat, relative to total mass for the given region of interest (i.e. android, gynoid, trunk, leg) ranged from 34%–43%. All measures of adiposity (anthropometric, DXA and pQCT) increased across BMI categories, except for pQCT derived skeletal muscle density, which is inversely correlated with muscle fat content,[26] while lean mass (%) decreased (Table 2). C-reactive protein levels averaged 2.2mg/L, with mean values increasing across BMI categorical groups, such that mean values in obese girls exceeded high-risk CMD criteria for CRP according to adult criteria (≥3mg/L). Overall, 44 girls (19.0%) had CRP ≥ 3 mg/L, and 8 girls (3.4%) had CRP ≥ 10 mg/L.

Absolute and percent lean mass were inversely correlated with CRP (P≤0.01; Table 3). Figure 1 demonstrates the linear relationship between BMI and CRP_{log}, as well as total body fat (%) and CRP_{log}. In linear regression models, CRP_{log} was associated with all direct and indirect measures of total and regional adiposity (All P ≤ 0.01; Table 3), except for intermuscular fat.

To further explore the relative importance of the lean and fat compartments and central versus total adiposity, two of the primary independent variables were included in the models simultaneously, in addition to the other covariates. Specifically, in models of DXA-derived absolute lean and fat masses (kg), the two compartments were mutually adjusted and both compartments remained significant in predicting CRP, though the absolute value of the partial correlation was substantially higher for fat than lean (Table 3).

Anthropometric and DXA-derived values were more strongly correlated with CRP than those derived using pQCT in independent regression models. These relationships persisted in models adjusted for age and maturity offset, as well as when models were further adjusted for physical activity, diet, and medication use. The overlap between anthropometric and DXA measure confidence intervals from regression analyses demonstrated no significant differences between these measures for predicting CRP (data not presented). Sensitivity analyses using data from girls with CRP < 10 mg/L (97%) were similar (All $P \leq 0.001$, except lean mass (kg) and intermuscular adipose tissue area with P>0.05; (Table 4).

When using the common adult risk-based categories of CRP, both image- and anthropometry-based estimates of total and regional body fat had significant positive associations with CRP, except for pQCT-derived intermuscular adipose tissue area (Table 5). Skeletal muscle density by pQCT was negatively associated with CRP categories. The strongest odds ratios were for waist circumference (OR: 9.33; 95% CI: 4.44, 19.6) and total absolute body fat (OR: 15.0; 95%CI: 6.35, 35.3). Lean mass was inversely associated with CRP [OR, kg: 0.24 (0.09–0.64); OR %: 0.13 (0.07–0.25)]. Note that the large estimates can be attributed to the scaling method used (see Methods); several body composition variables have large standard deviations (see Table 1), so a one-unit change is quite substantial.

DISCUSSION

This study uniquely examined the association between CRP and total and regional body composition, measured by DXA, pQCT, and anthropometry, among Hispanic girls aged 9–12 years. We found that CRP was significantly related to all measures of body composition by DXA; correlations of measures of total and regional adiposity with CRP were similar. Lean mass by DXA was significantly inversely related to CRP. Anthropometric estimates (BMI) of fat and fat distribution (waist circumference, and waist-to-height ratio) were significantly, positively related to CRP. Each of these common DXA and anthropometric measures provided clinically meaningful associations and none were considerably superior to others in independent models. The sub-compartment analyses by pQCT, though significant for each measure, except for intermuscular adipose tissue area, did not enhance our ability to assess risk of high CRP in this cohort.

Our results are in agreement with prior studies that have consistently demonstrated an association between anthropometric measures of excess total and regional adiposity and CRP among both males and females and Hispanic-only, as well as multiethnic, cohorts of children and adolescents.[14,15,27–34] Body fat (%), by more direct measures (DXA and air displacement plethysmography), has also been significantly, positively associated with CRP among children and adolescents across studies,[29,35,36] though Hispanic representation has been limited. In a study that estimated adiposity by both anthropometry and air displacement plethysmography, results were aligned with ours, though direct comparisons between BMI and body fat were not made. Similarly aged girls (8–11 y), of either Hispanic or African-American decent, demonstrated significant positive relations between to CRP and both BMI and total body fat (%).[16] Even under disease conditions, such as type 1 diabetes, higher levels of CRP were demonstrated in children with obesity compared to normal weight children classified by BMI. Though sample size was small, these studies have fair

representation of the Hispanic ethnicity.[16,37] Prior studies examining the association between lean mass and CRP among Hispanic children could not be identified.

Investigations comparing anthropometric indices versus more direct measures of body fat are rare, but they have tended to favor more direct measures of body fat in predicting CRP levels in children and adolescents.[16,38] Our results differ in that anthropometric measures of waist circumference and BMI, for example, were not significantly different than DXA total body fat in terms of the strength of their associations with CRP in independent models. It is possible that this difference in results is due to our inclusion of only Hispanic girls, whereas the other studies were done in multiethnic cohorts[16,38] and utilized air displacement plethysmography, instead of DXA, to assess body composition.[16] Our equivalent results across total and regional measures of adiposity for the prediction of CRP also contrast with studies in adults, where central adiposity more strongly correlated with CRP than total adiposity.[39,40] Further, fat may be more important than lean for the prediction of CRP, as evidenced by the larger partial correlations for fat than for lean.

Our finding that anthropometric measures, as proxies of adiposity, perform as well as DXA body composition assessments for the prediction of CRP indicates that simple field measures are sufficient to estimate the risk of elevated inflammation, making the measures more accessible and less costly. These findings among Hispanic girls are novel. The substantial proportion of girls aged 9–12 years, nearly 20%, that had elevated CRP levels according to adult standards (≥3mg/L) clearly indicates that young Hispanic girls are an at-risk population. It highlights the need to identify those at greatest risk early and intervene early to address the problems of adiposity and CVD risk in this underserved community; any of the anthropometric or DXA measures presented herein could be used for this purpose.

Interestingly, the relationship between CRP and body composition (total and regional) was generally stronger than previously described for various metabolic biomarkers (i.e. insulin, TG, HDL, LDL, glucose) and the same body composition and anthropometric measures used in this cohort.[17,18] Nevertheless, similar to this analysis, any measure of total or regional adiposity performed equally well for predicting metabolic dysfunction in young Hispanic girls.[17,18] The relatively higher strength of the correlations between CRP and body composition measures further supports their use in predicting cardiovascular disease risk among Hispanic girls, in addition to common lipid measurements already recommended by the American Academy of Pediatrics before and after puberty, at ages 9–11 years and ages 17–21 years, respectively.[41]

In spite of many study strengths, including the robust characterization of the cohort, there were some limitations. The upgrade from the GE Prodigy (N=212) to the GE iDXA machine (N=20) occurred after the study was underway. Though the iDXA sample was too small to allow for stratified analyses, others have shown a high level of agreement across machines within the same manufacturer (R^2=0.85–0.99)[42], and exclusion of the iDXA participants did not change our results (data not shown). The present study is also limited to Hispanic girls and therefore, taken alone, cannot be generalized to non-Hispanics and boys; however, it adds to the literature and serves an important purpose by expanding the available evidence to support the underserved community of Hispanic girls. Since the study did not include older

adolescents the findings must be replicated in post-pubertal children and young adults. Linking the findings herein to cardiovascular outcomes is also an important future research goal. Major strengths of the study are the relatively large sample size and the use of multiple measures of body composition, including lean mass and skeletal muscle density.

CONCLUSION

Estimates of total and regional body composition in young Hispanic girls can be used to predict elevated levels of CRP, a marker of chronic low-grade inflammation linked to cardiovascular disease in adults. Further, in 9–12-year-old Hispanic girls, field measurements and direct measurements may provide reasonable estimates of body composition for the prediction of elevated CRP. Management of body weight in youth may support a reduction of cardiovascular risk, beyond ameliorating metabolic dysfunction. Future longitudinal investigation is needed to more directly link these measures of body composition and low-grade inflammation in childhood with cardiovascular outcomes in adolescence and adulthood.

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STUDY IMPORTANCE QUESTIONS:

WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT?

- Elevated C-reactive protein (CRP) is a marker of inflammation and cardiometabolic risk
- Elevated CRP is linked to BMI, waist circumference, and body fat among children

WHAT DOES YOUR STUDY ADD?

- Ability of field techniques versus imaging analyses of total and regional adiposity to predict CRP
- Age and population specific results

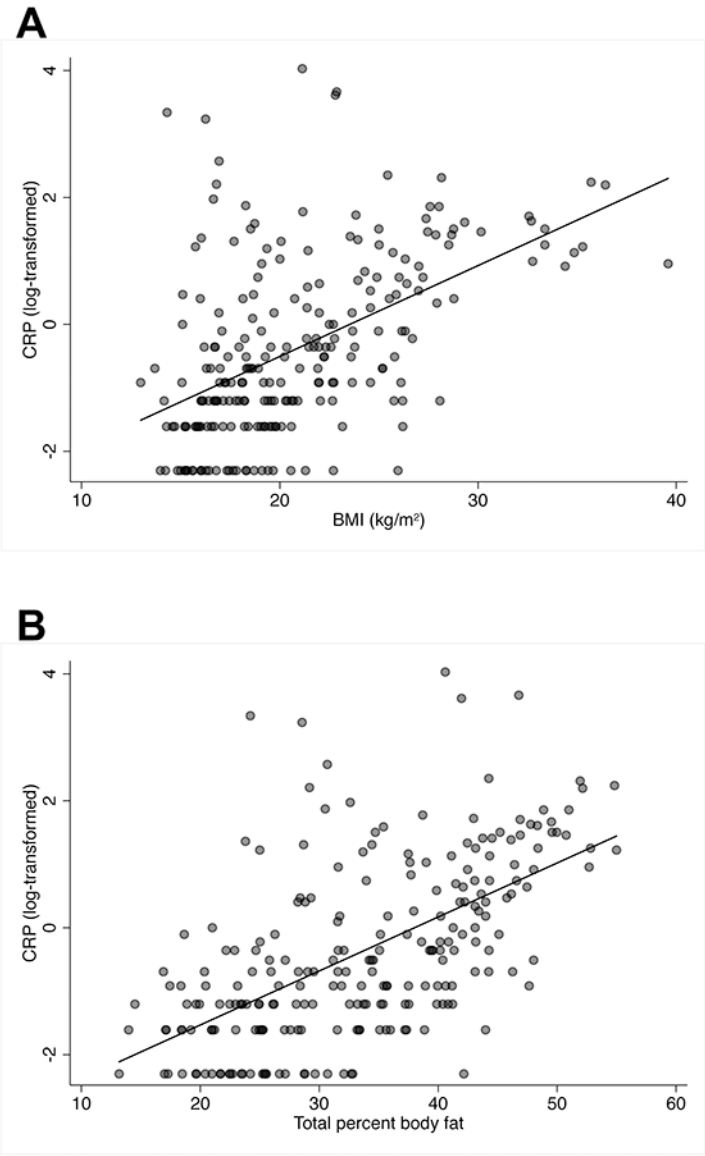

Figure 1.

C-reactive protein association with BMI (A) and percent total body fat (B) among young Hispanic girls (*N*=232). (A) Pearson's rho = 0.51; p < 0.001; (B) Pearson's rho = 0.59; p < 0.001.

Table 1.

Baseline characteristics (mean ± SD or *n* (%)) of Hispanic girls in the STAR study, overall and across categories of body mass index (BMI).

Characteristic	**Total (*n* = 232)**	**Normal (< 85th %ile)[a] (*n* = 134)**	**Overweight (85th to < 95th %ile) (*n* = 41)**	**Obese (> 95th %ile) (*n* = 57)**	***P*-value[b]**
Age (y)	10.7 ± 1.1	10.7 ± 1.1	10.9 ± 1.2	10.6 ± 1.0	0.349
Maturity offset (y)	0.25 ± 1.2	−0.08 ± 1.1	0.58 ± 1.3	0.78 ± 1.0	< 0.001
Weight (kg)	44.9 ± 14.6	36.1 ± 7.2	49.3 ± 9.7	62.4 ± 13.4	< 0.001
Height (cm)	145.3 ± 9.4	143 ± 9.0	147 ± 9.8	149 ± 8.2	< 0.001
Physical activity score[c]	6361 ± 8365	6971 ± 9538	5226 ± 5936	5673 ± 6542	0.422
Dietary intake[c]					
Total energy (kcal)	2330 ±1230	2448 ±1238	1913 ±744	2358 ±1374	0.051
Total fat (%)	31.1 ± 3.9	31.1 ± 3.7	30.8 ± 4.4	31.1 ± 4.2	0.918
Use of medication for:					
Asthma	24 (10.3)	7 (5.22)	5 (12.2)	12 (21.1)	0.004
Allergy	26 (11.2)	13 (9.70)	5 (12.2)	8 (14.0)	0.625

[a] Includes underweight (< 5th percentile; *n* = 4)

[b] One-way ANOVA for continuous variables and Fisher's Exact Test for categorical variables

[c] Missing data: waist circumference (*n* = 7), physical activity (*n* = 11), diet (*n* = 4)

Table 2.

Inflammation and body composition among Hispanic girls, overall and across categories of body mass index (BMI): mean ± SD

Characteristic	Total (n = 232)	Normal (< 85th %ile)[a] (n = 134)	Overweight (85th to < 95th %ile) (n = 41)	Obese (> 95th %ile) (n = 57)
CRP (mg/L)	2.2 ± 5.8	1.2 ± 3.6	2.5 ± 8.7	4.3 ± 6.9
Anthropometric				
BMI (kg/m^2)	20.9 ± 5.0	17.5 ± 1.9	22.4 ± 1.8	27.7 ± 4.0
Waist circumference (cm)[b]	76.0 ± 13.2	67.1 ± 6.3	81.3 ± 6.0	93.0 ± 9.9
Waist/Height Ratio	0.52 ± 0.08	0.47 ± 0.04	0.55 ± 0.03	0.62 ± 0.05
DXA-derived body composition				
Total lean mass, kg	26.6 ± 5.6	24.3 ± 4.2	27.5 ± 5.3	31.4 ± 5.6
Total lean mass (%)	63.0 ± 9.4	69.5 ± 5.8	57.2 ± 3.6	51.7 ± 4.2
Total body fat, kg	15.9 ± 33.5	9.7 ± 3.6	19.1 ± 4.6	28.1 ± 8.1
Total body fat (%)	33.5 ± 9.7	26.7 ± 5.9	39.4 ± 3.6	45.4 ± 4.4
Android fat (%)	38.0 ± 13.7	28.5 ± 9.2	47.7 ± 4.5	53.4 ± 5.7
Gynoid fat (%)	43.3 ± 7.5	38.5 ± 5.3	48.0 ± 3.7	51.4 ± 3.8
Trunk fat (%)	34.2 ± 11.6	26.0 ± 7.2	41.6 ± 4.0	47.9 ± 5.2
Leg fat (%)	37.4 ± 8.6	31.7 ± 5.6	42.2 ± 4.7	47.5 ± 4.3
pQCT-derived body composition (tibia)				
Subc[c] fat area (cm^2)	24.7 ± 11.9	17.3 ± 4.7	27.8 ± 6.7	40.0 ± 11.2
IMAT[c] area (cm^2)	5.7 ± 1.8	5.0 ± 1.3	6.0 ± 1.5	7.2 ± 1.9
Total fat area (cm^2)	24.4 ± 11.8	17.0 ± 4.8	27.2 ± 7.0	39.8 ± 10.4
SkM[c] density (mg/cm^3)	0.80 ± 0.01	0.80 ± 0.01	0.79 ± 0.01	0.78 ± 0.02

[a] Includes underweight (< 5th percentile; n = 4)

[b] Missing data: waist circumference (n = 7), physical activity (n = 11), diet (n = 4)

[c] Subc = subcutaneous; IMAT = intermuscular adipose tissue; SkM = Skeletal Muscle

Table 3.

Associations (partial correlations) between DXA- and pQCT-derived body composition and anthropometric measures and C reactive protein (CRP_{log}) from multivariable linear regression

Body composition measure	Model 1[a] (n = 232)		Model 2[b] (*n* = 217)	
	Partial correlation	Adjusted R^2	Partial correlation	Adjusted R^2
Anthropometric				
BMI (kg/m^2)	0.51	0.33	0.47	0.32
Waist circumference (cm)[c]	0.55	0.37	0.52	0.36
Waist/Height Ratio[c]	0.56	0.38	0.53	0.37
DXA-derived body composition				
Total lean mass, kg	−0.16	0.12	−0.19	0.37
Total lean mass %	−0.57	0.39	−0.54	0.38
Total body fat, kg	0.54	0.36	0.51	0.37
Total body fat %	0.58	0.40	0.55	0.39
Android fat %	0.55	0.37	0.51	0.35
Gynoid fat %	0.58	0.40	0.55	0.39
Trunk fat %	0.56	0.38	0.53	0.37
Leg fat %	0.56	0.37	0.53	0.37
pQCT-derived body composition (tibia)				
Subc[d] fat area(cm^2)	0.46	0.29	0.43	0.28
IMAT[d] area (cm^2)	0.07	0.10	0.09	0.13
Total fat area (cm^2)	0.47	0.29	0.44	0.30
SkM[d] density (mg/cm^3)	−0.24	0.15	−0.24	0.18

All P< 0.01, except intermuscular adipose tissue area with P>0.05.

[a]Adjusted for age and maturity offset

[b]Further adjusted for physical activity score (log-transformed), total energy intake (log-transformed), total percent dietary fat, asthma medication use, and allergy medication use. Additionally, DXA-derived absolute lean (kg) and fat (kg) models were mutually adjusted.

[c]Sample size for waist circumference models: *n* = 225 and 210 for Model 1 and 2, respectively

[d]Subc = subcutaneous; IMAT = intermuscular adipose tissue; SkM = Skeletal Muscle

Table 4.

Sensitivity analysis, restricted to Hispanic girls with CRP < 10 mg/L

Body composition measure	Model 1[a] (*n* = 224)		Model 2[b] (*n* = 210)	
	Partial correlation	Adjusted R^2	Partial correlation	Adjusted R^2
Anthropometric				
BMI (kg/m^2)	0.57	0.41	0.53	0.40
Waist circumference (cm)[c]	0.62	0.45	0.58	0.45
Waist/Height Ratio[c]	0.63	0.46	0.58	0.45
DXA-derived body composition				
Total lean mass, kg	−0.09	0.12	−0.10	0.42
Lean mass %	−0.59	0.42	−0.54	0.42
Total body fat, kg	0.59	0.43	0.55	0.42
Total body fat %	0.60	0.43	0.55	0.42
Android fat %	0.56	0.39	0.51	0.39
Gynoid fat %	0.58	0.42	0.55	0.42
Trunk fat %	0.57	0.40	0.53	0.40
Leg fat %	0.58	0.42	0.55	0.42
pQCT-derived body composition (tibia)				
Subc[d] fat area(cm^2)	0.52	0.36	0.48	0.36
IMAT[d] area (cm^2)	0.12	0.13	0.15	0.19
Total fat area (cm^2)	0.54	0.37	0.51	0.39
SkM[d] density (mg/cm^3)	−0.26	0.18	−0.23	0.22

All $P < 0.001$, except lean mass (kg) and intermuscular adipose tissue area with P>0.05

[a] Adjusted for age and maturity offset

[b] Further adjusted for physical activity score (log-transformed), total energy intake (log-transformed), total percent dietary fat, asthma medication use, and allergy medication use. Additionally, DXA-derived absolute lean (kg) and fat (kg) models were mutually adjusted.

[c] Sample size for waist circumference models: *n* = 217 and 203 for Model 1 and 2, respectively

[d] Subc = subcutaneous; IMAT = intermuscular adipose tissue; SkM = Skeletal Muscle

Table 5.

Associations between DXA- and pQCT-derived body composition and anthropometric measures and C-reactive protein (CRP) categories <1.0, ≥1.0–2.9, and ≥3.0) using ordinal logistic regression

Body composition measure (standardized)	Model 1[a] (*n* = 232) OR (95% CI)	Model 2[b] (*n* = 217) OR (95% CI)
Anthropometric		
BMI (kg/m^2)	6.34 (3.65–11.0)	5.55 (3.08–10.0)
Waist circumference (cm)[c]	10.3 (5.26–20.0)	9.33 (4.44–19.6)
Waist/Height Ratio[c]	5.34 (3.32–8.57)	4.99 (2.95–8.45)
DXA-derived body composition		
Total lean mass, kg	0.41 (0.19–0.90)	0.24 (0.09–0.64)
Total lean mass %	0.13 (0.07–0.22)	0.13 (0.07–0.25)
Total body fat, kg	16.5 (7.38–37.0)	15.0 (6.35–35.3)
Total body fat %	8.22 (4.61–14.7)	7.57 (4.09–14.0)
Android fat %	5.82 (3.44–9.86)	5.34 (3.06–9.33)
Gynoid fat %	7.22 (4.40–13.3)	6.92 (3.84–12.5)
Trunk fat %	6.48 (3.76–11.2)	5.98 (3.35–10.7)
Leg fat %	7.64 (4.40–13.3)	7.48 (4.11–13.6)
pQCT-derived body composition (tibia)		
Subc[d] fat area(cm^2)	7.32 (3.91–13.7)	6.16 (3.19–11.9)
IMAT[d] area (cm^2)	1.13 (0.79–1.62)	1.19 (0.80–1.76)
Total fat area (cm^2)	7.32 (4.01–13.4)	6.95 (3.64–13.3)
SkM[d] density (mg/cm^3)	0.54 (0.41–0.73)	0.52 (0.37–0.72)

All $P < 0.03$, except intermuscular adipose tissue area with P>0.05

CRP <1 = normal; >1–2.9 = moderately elevated; >3 = high by adult standards

[a]Adjusted for age and maturity offset

[b]Further adjusted for physical activity score (log-transformed), total energy intake (log-transformed), total percent dietary fat, asthma medication use, and allergy medication use. Additionally, DXA-derived absolute lean (kg) and fat (kg) models were mutually adjusted.

[c]Sample size for waist circumference models: *n* = 225 and 210 for Model 1 and 2, respectively

[d]Subc = subcutaneous; IMAT = intermuscular adipose tissue; SkM = Skeletal Muscle