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Which anthropometric measures best reflect neonatal adiposity?

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Abstract

Background—Studying the determinants and the long-term consequences of fetal adipose accretion requires accurate assessment of neonatal body composition. In large epidemiological studies, in-depth body composition measurement methods are usually not feasible for cost and logistical reasons, and there is a need to identify anthropometric measures that adequately reflect neonatal adiposity.

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Authors' contributions:

L-WC conducted statistical analysis, interpreted the data, and wrote the first draft of the paper. L-WC, M-TT, and IMA contributed to data collection, cleaning, and analysis. M-TT acquired and analyzed ADP and MRI measurements. LP-CS, KHT, PDG, Y-SC, FY, KMG, VSR, and YSL designed and led the GUSTO study. MVF led the magnetic resonance imaging domain in the GUSTO study. S-YC, KMG, MSK and YSL advised on interpretation of results. All authors critically revised the manuscript. YSL had primary responsibility for the final content. All authors have read and approved the final manuscript.

Conflicts of interest:

KMG, Y-SC, and YSL have received reimbursement for speaking at conferences sponsored by companies selling nutritional products. KMG, S-YC and Y-SC are part of an academic consortium that has received research funding from Abbott Nutrition, Nestec and Danone. The other authors have no financial or personal conflict of interest to declare.

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Methods—In a multiethnic Asian mother-offspring cohort in Singapore, anthropometric measures (weight, length, abdominal circumference, skinfold thicknesses) were measured using standardized protocols in newborn infants, and anthropometric indices [weight/length, weight/length² (body mass index, BMI), weight/length³ (ponderal index, PI)] derived. Neonatal total adiposity was measured using air displacement plethysmography (ADP) and abdominal adiposity using magnetic resonance imaging (MRI). Correlations of the anthropometric measures with ADP- and MRI-based adiposity were assessed using Pearson's correlation coefficients (r_p), including in subsamples stratified by sex and ethnicity.

Results—Study neonates ($n=251$) had a mean (SD) age of 10.2 (2.5) days. Correlations between ADP-based fat mass (ADP_{FM}) and anthropometric measures were moderate (r_p range: 0.44–0.67), with the strongest being with weight/length, weight, BMI and sum of skinfolds ($r_p=0.67, 0.66, 0.62, 0.62$, respectively, all $P<0.01$). All anthropometric measures except skinfold thicknesses correlated more strongly with ADP-based fat free mass than ADP_{FM}, indicating that skinfold measures may have more discriminative power in terms of neonatal total body adiposity. For MRI-based measures, weight and weight/length consistently showed strong positive correlations ($r_p=0.7$) with abdominal adipose tissue compartments. These correlations were consistent in boys and girls, across different ethnic groups, and when conventional determinants of neonatal adiposity were adjusted for potential confounding. Abdominal circumference was not strongly associated with ADP_{FM} or abdominal fat mass.

Conclusions—Simple anthropometric measures (weight and weight/length) correlated strongly with neonatal adiposity, with some evidence for greater discriminative power for skinfold measures. These simple measures could be of value in large epidemiological studies.

Keywords

Anthropometry; abdominal circumference; skinfold thickness; neonates; newborns; air displacement plethysmography; magnetic resonance imaging; adiposity; body composition

Introduction

The recent rise in childhood obesity is alarming, given its association with heightened risks of adult obesity and chronic diseases.¹ Increasingly, it has been suggested that obesity may have an early (developmental) origin.² For example, children born small for their gestational age (SGA), an indicator of exposure to a suboptimal intrauterine environment, have higher risks of obesity and chronic diseases later in life, as do the offspring of obese mothers.^{3,4,5} Although a useful measure, weight at birth reflects not only fat mass, but also head size, lean mass and bone mass, hence potentially limiting its accuracy in reflecting adiposity. Accurate measurement of body composition is thus important in revealing the compartment-specific effects associated with prenatal adipose accretion in relation to later health outcomes.

Accurate measures of body composition are usually costly, requiring advanced technical competencies, and are seldom feasible in large epidemiological studies. Simple measures are thus required for large studies. In adults, body mass index (BMI; weight/length²) is correlated with body fatness and risk of obesity-related diseases.^{6,7} However, it is less clear whether BMI is associated with body fatness in neonates and young infants. Ponderal index

(PI; weight/length³) has been suggested as a more suitable index in young infants, owing to their differences in body proportions from older infants and children.⁸ Nonetheless, a study comparing these indices with air displacement plethysmography (ADP)-based body composition showed that BMI is a better predictor of neonatal adiposity than PI.⁹ It thus remains uncertain whether PI, BMI or other anthropometric measures better reflect body fatness among newborn infants.

Several previous studies have attempted to identify anthropometric measures that best reflect body composition in young infants, but those studies focused on proxies of adiposity such as skinfold thicknesses^{10,11} and total-body electrical conductivity.¹² The only study that used a more direct measure of total body composition, namely ADP, only made comparisons with BMI and PI, and only in Caucasian infants.⁹ More evidence is therefore required for other anthropometric measures (e.g., abdominal circumference) and other ethnicities. Risks for chronic cardiometabolic diseases are higher in Asians than in Caucasians of similar BMI.^{13–15} To our knowledge, no study has investigated the correlations between anthropometric measures and abdominal adiposity assessed using magnetic resonance imaging (MRI). We therefore investigated the correlations of several common neonatal anthropometric measures with total body composition measured using ADP, and with abdominal adiposity measured using MRI, in a multiethnic Asian population.

Methods

We studied neonates in the Growing Up in Singapore Towards healthy Outcomes (GUSTO) mother-offspring cohort, described in greater detail elsewhere.¹⁶ Briefly, pregnant mothers of Chinese, Malay, or Indian descent and <14 weeks into their pregnancies were recruited from two of Singapore's major public maternity hospitals (the National University Hospital (NUH) and KK Women's and Children's Hospital (KKH)) from June 2009 until September 2010. To be eligible, study women had to be Singaporean citizens or permanent residents, of homogeneous ethnicity, intending to deliver at NUH or KKH, and planning to reside in Singapore for the next 5 years. Women with significant health conditions, such as type 1 diabetes or psychosis, were excluded. Ethical approval was granted by the Institutional Review Board of the respective hospitals and all mothers provided written informed consent.

Subjects

Of the 1247 recruited mothers, 65 dropped out before delivery. We further excluded 10 twins and 85 *in vitro* fertilization pregnancies, resulting in 1087 eligible singleton live births. At approximately 10 days of life, the neonates underwent ADP and MRI measurements to determine whole body and abdominal adiposity, respectively. At the same visit, neonatal anthropometry (weight, length, abdominal circumference) and skinfold thicknesses (triceps and subscapular skinfolds) were measured. Because ADP and MRI measures required a commitment to the prolonged clinic visit at a time when many women are confined to their home due to cultural beliefs, only a subset of participants consented and completed the measurements. The flow chart of participants is shown in Supplemental Figure 1. The final numbers included for ADP and MRI analyses were 251 and 222, respectively. Although no differences were observed for sex, birth weight, or gestational age at birth, those with an

ADP (Supplemental Table 1A) or an MRI (Supplemental Table 1B) measurement were more likely to be Malay, had a shorter birth length and a higher BMI at birth than those without these measurements. The differences in birth length and BMI may be explained by the higher proportion of Malay neonates, who had a shorter length and higher BMI at birth in our analysis sample.

Anthropometry

Infant weight was measured using a calibrated mobile digital baby scale (SECA model 334; SECA Corp., Hamburg, Germany) to the nearest 1 g, and recumbent length was measured from the top of the head to the sole of the feet using a mobile infant mat (SECA model 210) to the nearest 0.1 cm. Abdominal circumference was measured using an inelastic measuring tape (Butterfly brand, Shanghai, China) and recorded to the nearest 1 mm. Up to three measurements of each measure were taken according to standardized protocols,¹⁷ with the two closest values then averaged. Up to five measurements of triceps skinfold (TS) and subscapular skinfold (SS) were taken using Holtain skinfold calipers (Holtain Ltd, Crymych, UK) on the right side of the body and recorded to the nearest 0.2 mm; the three closest values were then averaged. The sum of skinfold thicknesses (SST) was defined as TS + SS. Anthropometric indices of weight/length, BMI, and PI were derived using the formulae weight/length, weight/length², and weight/length³, respectively. The intra-individual coefficients of variation (CV) for weight, length, abdominal circumference, triceps and subscapular skinfold thicknesses during this period were 0.08%, 0.16%, 0.36%, 2.27%, and 2.60%, respectively.

Body composition

Total body composition of the study neonates was measured based on the principle of ADP using the PEA POD Infant Body Composition System Version 3.1.0 (Cosmed, Rome, Italy), which has been described in detail elsewhere.¹⁸ Briefly, the body mass and volume of the neonates (naked except for a tight-fitting cap to remove air trapped in the hairs) were measured with the PEA POD system. Body density, adjusted for thoracic volume and surface area artifact, was then calculated from body mass and body volume of the infants. By assuming that the body consists of two compartments [fat mass (FM) and fat-free mass (FFM)], each with a known density, the PEA POD system can derive percent and absolute FM and FFM from the measured body volume and mass. Fat mass index (FMI) and fat-free mass index (FFMI) were consequently calculated using the formulae FM/length² and FFM/length², respectively.

Quantification of neonatal abdominal adiposity based on MRI in this study has also been described in detail elsewhere.^{19,20} Briefly, the abdomens of non-sedated, fed, swaddled neonates 5–10 minutes into their sleep were scanned in a supine position within an adult head coil. T1-weighted, water-suppressed axial fast-spin echo sequences were acquired (GE Signa HDxt 1.5 TMR scanner, Wisconsin, USA), and the obtained images were processed using in-house, semi-automated quantitative analysis software (MATLAB 7.13; The MathWorks Inc., Massachusetts, USA) based on morphological image analysis operations. Manual routines were conducted by two trained image analysts to optimize segmentation. Volumes of abdominal fat mass from the level of diaphragm to the top of the sacrum were

quantified for consistency with previously reported analyses in infants.²¹ The abdominal adipose tissues were categorized as superficial subcutaneous adipose tissue (sSAT), deep subcutaneous adipose tissue (dSAT), and internal adipose tissue (IAT).

Statistical analysis

Characteristics of study neonates were first summarized using descriptive statistics [mean, standard deviation (SD), and range]. Because most of the variables were normally distributed and because using Spearman's correlation analysis yielded essentially the same results, Pearson's correlation coefficient (r_p) was used in the assessment of correlation between anthropometric measures and total body composition and abdominal adiposity; r_p values of 0.0 to <0.3, 0.3 to <0.5, 0.5 to <0.7, and 0.7 to 1.0 correspond to negligible, weak, moderately strong, and strong correlations, respectively.²² To assess the variance of body composition explained by anthropometric measures beyond conventional predictors, a basic model was first fitted by including determinants or influencing factors of body composition (infant sex, gestational age at birth, ethnicity, exact age at body composition measurement and maternal height, pre-pregnancy BMI, gestational weight gain) as independent variables in a linear regression analysis. Subsequently, the anthropometric or skinfold measures (e.g., neonatal BMI or sum of skinfolds) were added in one at a time separately, and the increment in variance explained beyond that of baseline predictors was assessed using the r^2 values. Finally, the analyses were also repeated separately for boys and girls, and the three ethnic groups. In a sensitivity analysis, we analyzed correlations between body composition and z-scores of each anthropometric measure (weight-for-age, length-for-age, BMI-for-age, and weight-for-length, all derived using the WHO growth references²³). Because we used Pearson's correlation coefficients and r^2 values, which are not influenced by units of measurements unlike beta coefficients, comparison of correlation with body composition can be done with anthropometric indices in their natural units.

All statistical analyses were conducted using the statistical software package STATA version 13.1 (StataCorp., Texas, USA).

Results

Characteristics of the study newborns are shown in Table 1. The means (SDs) were 10.2 (2.5) d for age, 3.2 (0.4) kg for weight, 49.9 (1.9) cm for length, 12.9 (1.1) kg/m² for BMI, 29.4 (2.4) cm for abdominal circumference, and 12.4 (2.8) mm for sum of skinfolds. The correlation matrix for the anthropometric measurements is shown in Supplemental Table 2. The body composition measures were 0.4 (0.2) kg for FM measured by ADP (ADP_{FM}) and 113.6 (31.9) mL for total abdominal fat volume measured by MRI.

The correlations of anthropometric and skinfold measures with total body composition (ADP) and abdominal fat volume (MRI) are shown in Table 2. Weak to moderately strong positive correlations were observed between the anthropometric measures and ADP_{FM} and ADP_{FMI} (r_p range: 0.30–0.67). The strongest correlations between ADP_{FM} and anthropometric measures were, in decreasing order: 1) weight/length, 2) weight, 3) BMI and, 4) SST (r_p = 0.67, 0.67, 0.62, and 0.62, respectively); for ADP_{FMI} the strongest correlations were 1) weight/length, 2) BMI, and 3) SST (r_p = 0.62, 0.62, and 0.60,

respectively). A few anthropometric measures showed strong positive correlations ($r_p \geq 0.7$) with ADP-based FFM (ADP_{FFM}) and FFMI (ADP_{FFMI}). For ADP_{FFM} , weight showed the highest correlation, followed by weight/length, length and BMI ($r_p = 0.92, 0.88, 0.76, 0.73$, respectively). ADP_{FFMI} showed strong correlations with: 1) BMI, 2) PI, and 3) weight/length ($r_p = 0.81, 0.77$, and 0.74 , respectively). In general, all the anthropometric measures showed stronger correlations with ADP_{FFM} rather than with ADP_{FM} , except for skinfold measurements ($r_p = 0.62$ for SST- ADP_{FM} correlation and 0.42 for SST- ADP_{FFM} correlation). For correlations with MRI-based abdominal adipose tissue, weight and weight/length consistently showed strong positive correlations ($r_p \geq 0.7$) with total abdominal adipose tissue and abdominal adipose tissue compartments (sSAT, dSAT, IAT). Similar results were observed in boys and girls (Supplemental Table 3) and across different ethnic groups (Supplemental Table 4). In sensitivity analysis, similar results and conclusions were reached when z-scores of anthropometric measures were used (Supplemental Table 5), thus we focused on results for the natural units of the anthropometric measures to simplify data interpretation.

Table 3 shows the increment in variance explained for body composition when neonatal anthropometric measurements were added separately into a baseline model including maternal (e.g., pre-pregnancy BMI) and infant (e.g., sex) factors. Concordant with the simple correlation analysis in Table 2, we observed that, in general, addition of weight, weight/length, and BMI explained the most variance beyond that of the baseline predictors in total body FM and abdominal adipose tissue. However, although these anthropometric measures (except for skinfold thicknesses) explained a substantial fraction of the variance in FM, they explained an even higher fraction for FFM. For example, addition of weight into the baseline model led to a 34.9% increment in variance explained for FM vs. a 49.9% increase for FFM.

Discussion

In our multiethnic Asian population, we observed that simple anthropometric measures (weight, weight/length) showed strong correlations with total and abdominal FM. The observations were consistent in boys and girls, across different ethnic groups, and when baseline predictors of neonatal FM were accounted for. Although skinfold measures had slightly less strong correlations with ADP_{FM} compared to weight and weight/length, they were the only measures that correlated more strongly with FM than FFM, suggesting that skinfold measures may have more discriminative power for body composition than weight and length measures during the neonatal period.

Whether PI (weight/length³) or BMI (weight/length²) is a more suitable index of adiposity, thinness, and health in childhood^{8,24,25} has been a subject of ongoing debate. We found that BMI showed stronger correlations with both ADP_{FM} and ADP_{FFM} , as compared with PI. These observations echoed those of previous studies using skinfold- and total-body electrical conductivity-based proxies of adiposity.^{10–12} A recent study by De Cunto *et al.* found BMI to be a moderately strong ($r_p = 0.65$) and better predictor of ADP-based neonatal FM than PI ($r_p = 0.54$).⁹ Consistent with those observations, we observed that although BMI

correlated more strongly with neonatal adiposity than PI, both indices were not better predictors than simple measurement of weight and weight/length.

Surprisingly, abdominal circumference was not strongly correlated with total and abdominal FM. This could be due to challenges in measuring abdominal circumference during the neonatal period, with measurement error induced by factors such as the position at which the circumference is measured, infant movement, feeding state, and build-up of intestinal gas, perhaps increasing heterogeneity and thus impairing specificity of abdominal circumference to reflect adiposity around the age when our neonates were measured (10 days). In our assessment of relative reliability of anthropometric measurements, we also found that the intra-individual CV for abdominal circumference was higher than those for weight and length at around 10 days of age.

We have previously published prediction equations for neonatal body composition^{18,26} and found that weight was the most important predictor of both fat and fat-free mass determined by ADP measurement. Furthermore, subscapular skinfold was also a significant independent predictor of fat mass,²⁶ which corroborates our observation that skinfold has better predictive power than other anthropometric measurements for neonatal body composition. Importantly, we show in the current study that anthropometric indices (i.e., BMI and PI) are not better predictors of neonatal adiposity than simple weight. Furthermore, contrary to our expectation, neonatal abdominal circumference was not a strong predictor of total or abdominal fat mass. These results could guide planning of large epidemiologic studies requiring proxies for neonatal adiposity.

Our study was strengthened by its sample size, especially considering the technical and logistic difficulties in acquiring ADP and MRI measurements during the first few weeks of life. We also included participants of Chinese, Malay, and Indian ethnicities, which together make up more than one-third of the world population.²⁷ Moreover, we included comparisons with both total body composition (ADP) and abdominal adipose tissue (MRI) measurements to provide a more detailed and nuanced picture of neonatal adiposity.

However, our study also has several limitations. First, we measured neonatal length using an infant mobile mat, instead of the gold standard (infant length board),²⁸ thus increasing the likelihood of measurement error compared with weight measurement. Second, a substantial number of neonates did not have the more accurate ADP and MRI-based body composition measurements owing to logistical demands, cultural beliefs (that mothers should be confined to their home for the first 30 days post-delivery), and parental concerns of potential adverse health effects of the ADP and MRI measurements. Thus selection bias cannot be excluded, and the generalizability of our results cannot be assured. Comparison of characteristics of participants with and without ADP or MRI measurement revealed that the subset of neonates used for analysis had a slightly shorter birth length and higher BMI at birth and were more likely to be Malay. However, stratification analysis revealed similar results regardless of ethnicity and infant sex. Moreover, considering the technical demands for measuring neonatal body composition, especially MRI-based abdominal adiposity, our study provides a sizeable study population in a very relevant setting: a tri-ethnic Asian population in which research is lacking.⁹ Another limitation of our study is that we did not obtain other

measurements, such as thigh circumference, which might have provided a more comprehensive set of anthropometric indicators of neonatal body composition.

Conclusions

The higher correlations of neonatal anthropometric indices with FFM rather than with FM underline the importance of accurate body composition methods during this period. Large epidemiological studies face financial and logistical constraints, however. We found that simple anthropometric measures (weight or weight/length) consistently showed strong correlations with adiposity. Skinfold measures may have more discriminative power in terms of total body adiposity, while abdominal circumference is a surprisingly poor indicator of both total and abdominal adiposity during the neonatal period at which we made measurements.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations used

ADP	air displacement plethysmography
BMI	body mass index
CV	coefficient of variation

dSAT	deep subcutaneous adipose tissue
FFM	fat-free mass
FFMI	fat-free mass index
FM	fat mass
FMI	fat mass index
GUSTO	Growing Up in Singapore Towards healthy Outcomes
IAT	internal adipose tissue
KKH	KK Women's and Children's Hospital
MRI	magnetic resonance imaging
NUH	National University Hospital
PI	ponderal index
SGA	small-for-gestational age
SS	subscapular skinfold
sSAT	superficial subcutaneous adipose tissue
SST	sum of skinfold
TS	triceps skinfold

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Table 1

Characteristics of included neonates

Characteristics	<i>n</i>	Mean	SD	Range
Age, d	251	10.2	2.5	5-18
Weight, kg	251	3.2	0.4	2.2-4.4
Length, cm	251	49.9	1.9	43.6-54.5
Weight/length ratio, kg/m	251	6.4	0.7	4.9-8.2
BMI, kg/m ²	251	12.9	1.1	10.3-16.1
PI, kg/m ³	251	25.9	2.2	19.8-32.6
Abdominal circumference, cm	251	29.4	2.4	22.2-38.0
Triceps skinfold, mm	251	6.5	1.4	3.0-11.2
Subscapular skinfold, mm	251	5.9	1.5	2.8-12.0
Sum of skinfold, mm	251	12.4	2.8	5.8-23.2
Total body composition (ADP)				
FM, kg	251	0.4	0.2	0.04-1.1
FMI, kg/m ²	251	1.5	0.7	0.2-4.0
FFM, kg	251	2.8	0.3	2.1-3.8
FFMI, kg/m ²	251	11.4	0.9	8.7-13.8
Abdominal fat (MRI)				
TAAT, mL	222	113.6	31.9	50.0-277.1
sSAT, mL	222	77.6	21.2	36.2-174.5
dSAT, mL	222	13.4	5.6	3.5-38.3
IAT, mL	222	22.6	7.5	7.2-64.3

BMI, body mass index; PI, ponderal index; ADP, air displacement plethysmography; FM, fat mass; FMI, fat mass index; FFM, fat free mass; FFMI, fat free mass index; MRI, magnetic resonance imaging; TAAT, total abdominal adipose tissue; sSAT, superficial subcutaneous adipose tissue; dSAT, deep subcutaneous adipose tissue; IAT, internal adipose tissue

Table 2
Correlations of anthropometric measurements with ADP ($n=251$) and MRI measurements ($n=222$)

	ADP- Total body composition			MRI- Abdominal fat				
	FM	FMI	FFM	FFMI	TAAT	sSAT	dSAT	IAT
Weight	0.67 (0.59, 0.73)	0.58 (0.50, 0.66)	0.92 (0.90, 0.94)	0.64 (0.57, 0.71)	0.83 (0.78, 0.87)	0.79 (0.74, 0.84)	0.73 (0.66, 0.79)	0.74 (0.68, 0.80)
Length	0.44 (0.33, 0.53)	0.30 (0.18, 0.41)	0.76 (0.70, 0.81)	0.18 (0.06, 0.30)	0.64 (0.55, 0.71)	0.62 (0.54, 0.70)	0.52 (0.41, 0.61)	0.57 (0.47, 0.65)
Weight/length ratio	0.67 (0.60, 0.74)	0.62 (0.54, 0.69)	0.88 (0.85, 0.90)	0.74 (0.68, 0.79)	0.81 (0.76, 0.85)	0.77 (0.71, 0.82)	0.73 (0.66, 0.79)	0.72 (0.65, 0.78)
BMI	0.62 (0.54, 0.69)	0.62 (0.54, 0.69)	0.73 (0.67, 0.78)	0.81 (0.77, 0.85)	0.70 (0.63, 0.76)	0.66 (0.58, 0.73)	0.66 (0.57, 0.73)	0.62 (0.54, 0.70)
PI	0.45 (0.35, 0.55)	0.51 (0.41, 0.60)	0.43 (0.32, 0.52)	0.77 (0.71, 0.82)	0.45 (0.34, 0.55)	0.41 (0.30, 0.52)	0.46 (0.35, 0.56)	0.40 (0.28, 0.50)
Abdominal circumference	0.46 (0.36, 0.55)	0.42 (0.31, 0.52)	0.60 (0.52, 0.67)	0.48 (0.38, 0.57)	0.55 (0.46, 0.64)	0.54 (0.44, 0.63)	0.47 (0.36, 0.56)	0.49 (0.38, 0.58)
Triceps skinfold	0.57 (0.49, 0.65)	0.56 (0.47, 0.64)	0.43 (0.33, 0.53)	0.33 (0.21, 0.44)	0.61 (0.52, 0.69)	0.59 (0.50, 0.67)	0.55 (0.45, 0.63)	0.52 (0.42, 0.61)
Subscapular skinfold	0.59 (0.51, 0.67)	0.58 (0.49, 0.65)	0.37 (0.26, 0.47)	0.20 (0.08, 0.32)	0.64 (0.55, 0.71)	0.63 (0.54, 0.70)	0.60 (0.51, 0.68)	0.50 (0.39, 0.59)
Sum of skinfolds	0.62 (0.53, 0.69)	0.60 (0.51, 0.67)	0.42 (0.31, 0.52)	0.28 (0.16, 0.39)	0.65 (0.57, 0.72)	0.64 (0.55, 0.71)	0.60 (0.51, 0.68)	0.53 (0.43, 0.62)

Values are Pearson's correlation coefficients (r_p) with 95% confidence intervals (derived using Fisher's z transformation) in parentheses. All correlations are significant at $P<0.01$.

ADP, air displacement plethysmography; MRI, magnetic resonance imaging; FM, fat mass; FMI, fat mass index; FFM, fat free mass; FFMI, fat free mass index; TAAT, total abdominal adipose tissue; sSAT, superficial subcutaneous adipose tissue; dSAT, deep subcutaneous adipose tissue; IAT, internal adipose tissue; BMI, body mass index; PI, ponderal index

Table 3

Percent of variance of total body composition ($n=251$) and abdominal fat ($n=222$) explained by baseline predictors and after addition of anthropometric measures

	ADP- Total body composition					MRI- Abdominal fat			
	FM	FMI	FFM	FFMI	TAAT	sSAT	dSAT	IAT	
Model 1	16.3	14.4	36.2	19.6	31.8	31.3	24.0	30.1	
Model 1 + Weight	51.2	42.7	86.1	46.7	78.4	74.6	65.2	62.1	
Model 1 + Length	28.1	19.6	64.8	19.6	54.5	53.8	40.9	44.3	
Model 1 + Weight/length ratio	51.6	46.5	81.0	58.8	75.1	70.9	63.7	60.3	
Model 1 + neonatal BMI	45.1	44.9	66.3	69.2	63.3	59.4	54.6	52.7	
Model 1 + PI	31.8	35.2	47.4	67.1	46.0	43.3	39.5	40.9	
Model 1 + Abdominal circumference	28.5	25.1	54.8	33.7	47.0	46.4	35.3	39.6	
Model 1 + Triceps skinfold	39.2	36.9	45.2	26.0	52.6	51.2	41.5	43.4	
Model 1 + Subscapular skinfold	39.2	36.6	41.3	20.9	52.9	51.9	43.2	41.9	
Model 1 + Sum of skinfold	42.0	39.6	43.9	23.4	55.1	53.9	44.5	44.0	

Values are r^2 .

Model 1 (baseline): includes infant sex, gestational age at birth, ethnicity, exact age at body composition measurement and maternal height, pre-pregnancy BMI, gestational weight gain as independent variables

ADP, air displacement plethysmography; MRI, magnetic resonance imaging; FM, fat mass; FMI, fat mass index; FFM, fat free mass; FFMI, fat free mass index; TAAT, total abdominal adipose tissue; sSAT, superficial subcutaneous adipose tissue; dSAT, deep subcutaneous adipose tissue; IAT, internal adipose tissue; BMI, body mass index; PI, ponderal index