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Between-slice intervals in quantification of adipose tissue and muscle in children

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Abstract

Magnetic Resonance Imaging (MRI) is increasingly being used in children to quantify adipose tissue (AT) and skeletal muscle (SM) *in vivo*. it is unclear whether the every 5 cm whole body MRI protocol used in adults is appropriate when applied in children. Whole body MRI continuous 1 cm thick slices were acquired in 73, aged 5–17-year-old healthy children. images were segmented into subcutaneous (SAT), visceral (VAT), intermuscular At (IMAT), and SM. the percentage difference between volumes measured by the continuous protocol and volumes estimated with protocols of different between-slice intervals (i.e., interval = 2, 3, 4 and 5 cm) was larger with an increase in interval size, depot size, weight and body mass index percentile. For group comparisons, studies will require less than 5.4% more subjects if an every 5 cm protocol is used for equivalent power as the every 1 cm protocol. For individual subject comparisons, interval protocols can be used to reliably distinguish between subjects who differ in SM or SAT volume by 0.14 to 0.64 l (i.e., 1 to 5% of SM or SAT volume) or more, or in VAT or IMAT volume by 0.06 to 0.21 l (i.e., 10 to 30% of VAT or IMAT volume) or more. the every 5 cm image acquisition protocol can be considered as accurate as the contiguous protocol for group comparisons in children, as well as for comparison of SM and SAT among individual children. however, a smaller slice interval protocol would be more accurate for comparison of VAT or IMAT among individual children.

Keywords

Magnetic resonance imaging; body composition; skeletal muscle; subcutaneous adipose tissue; visceral adipose tissue; intermuscular adipose tissue; measurement error

Introduction

Although the increasing prevalence of excess adiposity in children was first reported almost two decades ago (1), childhood obesity continues to increase at an alarming rate (2–4). Magnetic resonance imaging (MRI) and computed tomography (CT) is increasingly being used in children to quantify volumes of adipose tissue and other body components *in vivo*. Whole body measurement of adiposity and body composition has the unique advantage of depicting total body and regional adipose tissue distribution and other components changes.

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Whole body and regional body composition mapping is extremely important in elucidating the relationship between body components, growth and maturation, obesity and its related physiological and patho-physiological changes.

The contiguous MRI protocol is considered as the “golden standard” in measuring tissue level body composition including adipose tissue and skeletal muscle (5). However, the contiguous MRI protocol is extremely time-consuming to analyze. For example, a continuous scan of 1 cm slice thickness resulted in ~200 slices, taking 3 to 5 days to be analyzed into skeletal muscle (SM), subcutaneous, visceral and intermuscular adipose tissue (SAT, VAT and IMAT), depending on the skills and experience of the analyst (5). Therefore, a whole body protocol with between-slice intervals is more practical to be used. For example, the most widely applied adult whole body MRI protocol is acquired every 5 cm (6–8). The influence of between-slice interval on measurement accuracy has been tested in adults (9), as well as by the Visible Human Project of the National Library of Medicine (10,11). To the best of our knowledge there is no previous study that has investigated the influence of between-slice interval on accuracy and it is unclear whether the every 5 cm adult MRI protocol is appropriate when applied in children.

Accordingly, the aim of the present study was to investigate the relationship between measurement accuracy and different between-slice intervals in a sample of healthy children who completed contiguous whole body MRI scans. In particular, we are interested in whether the every 5 cm adult whole body MRI protocol is appropriate for quantifying SM, SAT, VAT and IMAT in children.

Methods

Protocol and design

The primary study aim was to examine the relationships between between-slice intervals and the errors in quantifying SM, SAT, VAT and IMAT in healthy children. The residual compartment is defined as total tissue minus SM, SAT, VAT, IMAT and lungs. The residual compartment is mainly composed of organs, bones and connective tissue.

Subjects were established as healthy based upon a medical history, physical examination, and screening blood studies. All subjects had a standardized contiguous whole body MRI scan along with additional measures, including weight, height, age, and self-reported ethnicity. Pubertal stage was established using physical examination criteria by the same pediatric endocrinologist: breast stage for girls, testicular size by orchidometer for boys, and pubic hair stage for both boys and girls (12–14). Limited by the schedule of the pediatric endocrinologist, some children did not go through the physical examination and pubertal status was therefore available for 58 out of 73 children.

The present study analyzed existing data. The exempt status of the present study was reviewed and approved by the Institutional Review Board of St. Luke's-Roosevelt Hospital. The original study was approved by the Institutional Review Board of St. Luke's-Roosevelt Hospital, and each subject gave written consent to participate.

Subjects

Subjects were 73 healthy children, aged 5–17 years old, with a wide range of fatness. Three major ethnic/ race groups were included in the study, Caucasian (n=14), African American (n=31), and Hispanic (n=22). The subjects also included a small percentage of other ethnicities (n=6). The subject characteristics are summarized in Table I.

Anthropometric measurements

Body weight was measured to the nearest 0.1 kg and height to the nearest 0.1 cm, using an appropriately calibrated scale and stadiometer.

Magnetic resonance imaging

Whole-body MRI was performed as previously reported by our group (15,16) except that the cross-sectional images were acquired continuously, instead of every 5 cm. All subjects were scanned with T1-weighted, spin-echo sequence, TR/TE 210 ms/17 ms, contiguously with 1 cm slice thickness on a 1.5T General Electric system (6X horizon, Milwaukee, WI). The protocol involved acquisition of approximately two hundred 1 cm thick axial images from fingers to toes with the subject in a supine position, using the L₄–L₅ intervertebral disc as the point of origin. Following image acquisition, SM, SAT, VAT, IMAT and residual were segmented by trained and quality-controlled technicians using image analysis software (SliceOmatic, Tomovision Inc., Montreal, Canada). The IMAT component in the present study included inter- and intra-muscular adipose tissue (17). The coefficient of variation for repeated measurements of the same scan by the same observer of MRI-derived SM, SAT, VAT, and IMAT volumes in our laboratory are 1.4%, 1.7%, 2.3%, and 5.9%, respectively (18,19).

Volume calculation from different between-slice intervals

The estimated volumes of all tissue compartments including SM, SAT, VAT, IMAT and residual were calculated with a slice thickness of 1 cm and intervals of 2, 3, 4 and 5 cm, with L₄–L₅ as the starting point. the between-slice interval is defined as the distance between the centers of adjacent slices with slice thickness of 1 cm. For example, when we use a between-slice interval of 2 cm, we start from the L₄–L₅ slice, and then include every other slice towards the toes in one direction and then include every other slice towards the fingers in the other direction. When the between-slice interval is 3, 4 and 5 cm, we skip 2, 3, and 4 slices, respectively.

The tissue volumes either from the original set of contiguous slices or from the generated sets of different intervals were calculated as follows:

$$V = h \sum_{i=1}^N A_i$$

where V is volume, A_i is each scan's cross-sectional area, h is the between-slice interval, and N is the number of total slices included (11). When the actual volume is calculated for the original contiguous slices (V_{true}), the between-slice interval is equal to the thickness of the slice, which is 1 cm. Estimated volume is calculated for different between-slice intervals (V_{interval}), with h as 2, 3, 4 and 5 cm, respectively.

Statistical methods

Group data are presented as the mean $\pm$ standard deviation, SD. For each compartment of each between-slice interval, we calculated the percentage differences of the volumes resulting from V_{true} and V_{interval} . For each tissue component, tissue volume or the percentage difference was regressed separately onto a system of dummy variables representing between-slice intervals, where the contiguous scan served as the reference group. A random intercept model was used where between-slice interval was treated as a fixed effect. These models were implemented in Proc Mixed in the SAS statistical package (SAS for Windows, 9.1, Institute Inc. Cary, North Carolina, USA). The correlation between

percentage volume difference at different between-slice intervals and actual volume was calculated. A regression model with V_{true} as dependent variable and V_{interval} as independent variable was developed for each tissue compartment with between-slice intervals at 2, 3, 4 and 5 cm, respectively.

For each tissue component at each between-slice interval, multiple regression models were applied to establish if the percentage volume differences depend on variables including age, weight, height, BMI percentile, sex and ethnicity. Potential two-way interactions among covariates were also tested. A total of 20 multiple regression models were therefore tested (i.e., five tissue components at four between-slice intervals).

The calculation of impact of measurement error on the power of a research design has been carried out as described before (Muller & Szegedi, 2002; Perkins et al., 2000). In a comparison of two equal-sized groups on a continuous measure, the increased number of subjects required due to measurement error (N^*) divided by the number required assuming no measurement error (N) is related to measurement reliability (R), as $N^* = N/R$. The reliability of observed scores is the square of the correlation coefficient of those scores with the true values (Dunn, 2000). The power calculation was performed in the whole sample, as well as in subgroups of different ages, obesity status and pubertal status. The selection of different subgroups aimed to facilitate future study designs and was also based on the factors that potentially influence percentage volume differences. The investigated subgroups included: 1) 5–11-year-old girls; 2) 5–11-year-old boys; 3) 12–17-year-old girls; 4) 12–17-year-old boys; 5) normal weight girls (i.e., BMI percentile <85) [20,21]; 6) normal weight boys; 7) girls at risk of overweight or overweight (i.e., BMI percentile ≥ 85) [20,21]; and 8) boys at risk of overweight or overweight. The power calculation was also carried out in children who had pubertal stage data available (i.e., for 58 out of 73 children). The pubertal stage subgroups included: 1) prepubertal girls; 2) prepubertal boys; 3) pubertal girls; and 4) pubertal boys.

All analyses were carried out using the SPSS statistical package (SPSS for Windows, 16.0, SPSS Inc., Chicago, USA) or SAS. Two-tailed ($\alpha=0.05$) tests of significance were used.

Results

Between-slice interval and accuracy

The tissue volume measured at different slice intervals was not significantly different from the volume of the contiguous protocol for each tissue component except for SM at the 5 cm between-slice interval and SAT, and residual at the 3 cm between-slice interval (Table II).

With an increase in between-slice interval for each tissue, there was an increase of the mean percentage difference between the estimated volume and the actual volume for all tissue components (Table III). The percentage differences at various between-slice intervals were significantly different for all tissue components from the contiguous scan protocol. The mean percentage differences are larger for smaller compartments (i.e., VAT and IMAT) than larger compartments (i.e., SM and SAT) at the same between-slice interval.

In the regression equations with actual volume as dependent variable and estimated volume as independent variable, none of the intercepts of any tissue component at any between-slice interval was significant. The R^2 of all regression models were very large (i.e., >0.98) (Table IV). For the every 5 cm protocol, the 95% confidence interval (CI) for an individual subject's estimated tissue volume was ± 0.214 l for SAT, ± 0.105 l for VAT and ± 0.085 l for IMAT (Table IV). The every 5 cm protocol can thus be used to distinguish reliably between subjects who differ in SAT volume by 0.428 l or more, VAT volume by 0.210 l or

more, and IMAT volume by 0.170 L or more. Similarly, the every 5 cm protocol can be used to distinguish reliably between subjects who differ in SM volume by 0.642 L or more and residual volume by 0.910 L or more.

Factors potentially influencing accuracy

The correlations between percentage differences and tissue volumes are presented in Table V. There were significant negative correlations ($r = -0.235$ to -0.437 , $p < 0.05$) between percentage differences and the volume of all adipose tissue components, including SAT, VAT and IMAT, but not for non-adipose tissue components including SM and residual.

Among the 20 multiple regression models with percentage difference for each tissue component at each between-slice interval as dependent variable and age, weight, height, BMI percentile, sex and ethnicity as independent variables, 12 models had independent variables that significantly entered the models. The 12 models with dependent variables including SM at 4 cm intervals, SAT at 2, 3, 4 and 5 cm intervals, VAT at 2, 3, 4 and 5 cm intervals, and IMAT at 2, 3 and 5 cm intervals are presented in Table VI. The regression equation R^2 values range from 0.044 to 0.214. In 11 out of 12 models, BMI percentile or weight significantly entered the regression model. Sex entered two regression models and height entered one regression model.

Power estimates

For all depots including SM, SAT, VAT, IMAT and residual, studies will require less than 5.4% (ranges from 0.0% to 5.4%) more subjects for between-slice interval protocols (i.e., 2, 3, 4 and 5 cm) that have equivalent power compared with the contiguous protocol for the whole sample, as well as for the different age, BMI percentile and pubertal groups.

Discussion

Measurement accuracy and between-slice interval

In the present study we examined the relationship of between-slice interval and measurement accuracy in a diverse sample of children, varying in ethnicity, age, and BMI percentile. There are minimal differences among the mean tissue volumes at different between-slice intervals for each tissue, as shown in Table II. The results indicate that between-slice intervals do not degrade the estimation of the mean volume for reasonable size subject groups. On the other hand, the error of volume estimates with between-slice interval for individual subjects represented as the absolute percentage difference is relatively large (Table III). The results show that the larger the between-slice interval, the less the accuracy across all tissue components. At the same between-slice interval, the mean percentage difference is smaller for SM and SAT than that for VAT and IMAT. This suggests that measurement accuracy is smaller for components of larger volume.

Of note, the percentage differences calculated and discussed in the present study are caused by design considerations and not due to variations among laboratories or analysts. The percentage differences calculated in the present study are different from the CVs reported within and between analysts' CVs [22,23], which will vary among analysts and laboratories.

The percentage difference of SAT and SM are smaller than those in adult studies and in the visible Woman (9–11). One explanation for this observation is that only trunk adipose tissue was included in the study of Thomas et al. (9) and that in Shen et al.'s study SAT and SM were studied separately in the trunks and limbs (11). In the present study SAT and SM were studied at the whole body level. Sampling a body region may cause exclusion of the last slice of the tissue component depending on the total number of subject slices. The last slices

for trunk adipose tissue are at the shoulder region for the upper portion and at the pelvic region for the lower portion. When considering whole body adipose tissue, the last slices are at the fingertips and at the toes. Both a shoulder slice and a pelvic slice have a much larger amount of adipose tissue than the fingertip or toe slices. Therefore, the inclusion or exclusion of a slice at the separation between trunk and limbs by sampling a body region causes a larger error than the exclusion and inclusion of finger or toe slices for whole body components. In addition, SAT and SM at the whole body level are larger than those at the regional level. The percentage differences for VAT are higher in our pediatric data than for the visible Woman data (11). This may be attributed to the smaller amount of VAT present in our children than in the Visible Women (i.e., 0.64 L vs. 4.3 L).

Power analyses showed that in group studies, using protocols with between-slice intervals would require at most 5.4% more subjects for estimating tissue volume than a contiguous whole body protocol. As a 5.4% increase in sample size is negligible, a protocol with between-slice intervals including an every 5 cm protocol can be used reliably for group comparison studies even in younger normal weight subjects or pre-pubertal children.

For individual subject comparisons, protocols of 2 to 5 cm between-slice intervals can only be used to distinguish reliably between subjects who differ in SM volume by 0.25 to 0.64 L or more, and SAT volume by 0.14 to 0.43 L or more. Because both SM and SAT are relatively large (i.e., mean of SM and SAT >10 L), the use of the protocols with between-slice intervals can be used reliably to distinguish differences between individual subjects if the differences are greater than ~1 to 5%. On the other hand, because both VAT and IMAT are relatively small in children (i.e., mean of VAT and IMAT are about 0.5 to 0.6 L), the use of the 2 to 5 cm interval protocol would only be reliable to distinguish differences between individual subjects if the difference is greater than 0.06 to 0.21 L (i.e., ~10 to 30%). Therefore, the between-slice interval protocols, especially the every 5 cm protocol estimate have limited application when evaluating individual subjects for VAT and IMAT. The selection of a contiguous scanning protocol or a protocol with a between-slice interval would depend on the anticipated detectable differences of tissue components of interest between individual subjects.

Factors influencing accuracy

For each adipose tissue component including SAT, VAT, and IMAT, accuracy is greater when component size is larger (Table V). on the other hand, the accuracy for non-adipose tissue components including SM and residual was not influenced by depot size. There is no apparent explanation for the discrepancy between adipose tissue components and non-adipose tissue components. The inherent characteristic shape of adipose tissue and non-adipose tissue components may be a potential cause of this phenomenon.

As tissue component size cannot be known before the MRI scan, multiple regression models have also been established to investigate the relationship between measurement accuracy and subject characteristics, which are usually used for inclusion and exclusion criteria to aid investigators for future study design. When we examined the effects of subject age, body weight, height, BMI percentile, sex, and ethnicity on measurement accuracy, BMI percentile and weight were the variables that significantly contributed to errors of most tissue components. This observation indicates that obese or heavier subjects have less measurement error than lean subjects for the same between-slice interval. Although children are shorter in stature than adults, height does not significantly contribute to measurement error for most tissues, once controlled for BMI percentile or weight. Boys have a larger error than girls for SM at the 2 cm between-slice interval and IMAT at the 5 cm between-slice interval, suggesting that muscle is more evenly distributed across the body in girls than in boys. Further power analyses for group studies showed that the study power of between-

slice protocols in subgroups of age, obesity status, and pubertal stages was not far from the study power in the whole sample (i.e., 0% vs. 5.4% increase in sample size). Therefore, the results of the present study can be applied to healthy subjects of a wide range of characteristics.

Study generalization

As the cost and complexity involved in contiguous MRI scanning and multiple body components data analysis is substantial, there would be a substantial effort for investigators to duplicate the present study in a different population. Therefore, whether the results of the present study can be generalized to a longitudinal cohort, a population with co-morbidities, or a population with characteristics different from those of the present study subjects is an important question that we examine in the discussion that follows.

Although the present study was not conducted with a longitudinal component, it is probably safe to generalize the results to sample size calculation or protocol selection in longitudinal study designs. As a group or individual likely differs more from another group or individual than it does from itself at the time of follow-up, the minimal detectable differences in a longitudinal study design should not be larger than those calculated in a cross-sectional sample.

If a disease does not cause large changes in tissue amount or shape from those observed in healthy ambulatory children, it is probably appropriate to generalize the results of the present study to the populations with diseases. On the other hand, a contiguous MRI protocol may be the best choice for studying subjects with disproportionate muscle growth (e.g., body builders) or atrophy (e.g., hemiparesis).

Based on the subgroup power analysis, it would be appropriate to apply our results to most study designs. However, for children younger than 5 years old, a contiguous MRI protocol may still be the best choice as the tissue depots may be much smaller in the ≤ 5 -year-old group than in the 5–11-year-old group.

Although the subjects included mostly Caucasians, African-Americans and Hispanics in the present study, as ethnicity did not contribute to measurement error, it is likely that the results can be generalized to other ethnicities.

In addition, the study results should also be reliable when used for component power calculations in adults when between-slice information is unavailable from previous studies (9–11). The tissue components in adults are larger than those in children and accuracy is greater for larger components. The actual power in adults should therefore be greater than the power calculated using the children's data.

Conclusions

For tissue volume estimates, accuracy decreases as between-slice interval increases. An every 5 cm whole body MRI protocol is appropriate for estimating SM and SAT for both group and individual comparisons in children. For VAT and IMAT, the every 5 cm whole body MRI protocol is as accurate as the contiguous protocol for comparing groups. However, for comparing differences between individual subjects, a smaller between-slice interval reduces the error and may be more suitable for evaluating differences in VAT or IMAT. The influence of age, weight, height, BMI percentile, sex and ethnicity on accuracy of between-slice interval protocols is relatively small.

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Table I

Subject characteristics.

	Boys	Girls
Sample size	45	28
Age (years)	11.2±3.3	11.0±3.2
Weight (kg)	53.9±17.7	47.6±19.4
Height (cm)	156.4±15.6	150.0±13.0
BMI percentile	75.3±26.7	64.0±35.3
Skeletal muscle (L)	16.7±8.5	14.5±5.1
Subcutaneous adipose tissue (L)	11.4±7.2	15.9±10.9*
Visceral adipose tissue (L)	0.502±0.397	0.593±0.498
Intermuscular adipose tissue (L)	0.456±0.356	0.616±0.571
Residual (L)	13.8±4.1	12.7±2.9

Age, weight, height, body mass index (BMI) percentile, skeletal muscle, subcutaneous, visceral and intermuscular adipose tissue and residual volumes are presented as mean±standard deviation.

* Significantly different from Boys at $P<0.05$.

Table II

Tissue volume comparison among all between-slice intervals.

	Contiguous scan	Tissue volume (L)				
		2 cm interval	3 cm interval	4 cm interval	5 cm interval	
Skeletal muscle	15.87±7.44	15.87±7.42	15.84±7.42	15.85±7.42	15.96±7.48*	
Subcutaneous adipose tissue	13.12±8.96	13.12±8.95	13.09±8.93*	13.11±8.95	13.12±8.97	
Visceral adipose tissue	0.537±0.437	0.534±0.433	0.542±0.442	0.532±0.435	0.545±0.447	
Intermuscular adipose tissue	0.518±0.454	0.518±0.453	0.520±0.456	0.521±0.454	0.516±0.457	
Residual	13.39±3.68	13.38±3.68	13.34±3.65*	13.41±3.69	13.38±3.71	

* Significantly different from the Contiguous scan group at $P<0.05$.

Table III

The percentage difference between actual (V_{true}) and estimated volumes (V_{interval}) with different between-slice intervals (mean $\pm$ standard deviation).

	Percentage difference between the estimated volume and the actual volume			
	2 cm interval	3 cm interval	4 cm interval	5 cm interval
Skeletal muscle	0.30% $\pm$ 0.43% *	0.41% $\pm$ 0.35% *	0.59% $\pm$ 0.63% *	1.04% $\pm$ 0.77% *
Subcutaneous adipose tissue	0.26% $\pm$ 0.23% *	0.53% $\pm$ 0.45% *	0.59% $\pm$ 0.49% *	0.85% $\pm$ 0.86% *
Visceral adipose tissue	3.14% $\pm$ 2.99% *	5.23% $\pm$ 6.01% *	8.14% $\pm$ 8.15% *	9.70% $\pm$ 8.58% *
Intermuscular adipose tissue	3.06% $\pm$ 2.41% *	4.75% $\pm$ 4.48% *	6.93% $\pm$ 7.30% *	9.55% $\pm$ 8.77% *
Residual	0.38% $\pm$ 0.28% *	0.68% $\pm$ 0.45% *	0.81% $\pm$ 0.57% *	1.45% $\pm$ 0.93% *

* Significantly different from the Contiguous scan group (i.e. 0% difference) at $P < 0.05$.

Table IV

The 95% confidence interval (CI) for an individual subject's estimated tissue volume resulting from different between-slice intervals.

	2 cm interval		3 cm interval		4 cm interval		5 cm interval	
	95% CI (L)	R ²	95% CI (L)	R ²	95% CI (L)	R ²	95% CI (L)	R ²
Skeletal muscle	± 0.124	0.99993	± 0.151	0.99989	± 0.229	0.99976	± 0.321	0.99952
Subcutaneous adipose tissue	± 0.0725	0.99998	± 0.130	0.99995	± 0.172	0.99990	± 0.214	0.99985
Visceral adipose tissue	± 0.0314	0.99868	± 0.0609	0.99502	± 0.0892	0.98933	± 0.105	0.98516
Intermuscular adipose tissue	± 0.0317	0.99880	± 0.0517	0.99668	± 0.0696	0.99399	± 0.0850	0.99101
Residual	± 0.127	0.99969	± 0.199	0.99920	± 0.257	0.99874	± 0.455	0.99608

R² is derived from the regression model with V_{true} as dependent variable and V_{interval} as independent variable for each tissue component at each between-slice interval.

Table V

Correlation between percentage difference and actual tissue volumes.

	2 cm interval	3 cm interval	4 cm interval	5 cm interval
Skeletal muscle	$r=-0.147, P=0.214$	$r=-0.153, P=0.198$	$r=-0.225, P=0.056$	$r=-0.173, P=0.143$
Subcutaneous adipose tissue	$r=-0.320^*, P=0.006$	$r=-0.314^*, P=0.007$	$r=-0.235^*, P=0.045$	$r=-0.357^*, P=0.002$
Visceral adipose tissue	$r=-0.359^*, P=0.002$	$r=-0.239^*, P=0.042$	$r=-0.299^*, P=0.010$	$r=-0.437^*, P<0.001$
Intermuscular adipose tissue	$r=-0.328^*, P=0.005$	$r=-0.272^*, P=0.020$	$r=-.300^*, P=0.010$	$r=-.430^*, P<0.001$
Residual	$r=-0.067, P=0.574$	$r=0.120, P=0.311$	$r=-0.061, P=0.610$	$r=-0.098, P=0.409$

* Significantly different from 0 at $P<0.05$.

Regression models linking subject characteristics to the percentage difference between estimated and actual volume of tissue components.

Table VI

<i>Dependent variable</i> Percentage difference	<i>Independent variables</i>					<i>Adjusted R²</i>
	Age, year	Weight, kg	Height, cm	BMI percentile	Sex	
Skeletal muscle (4 cm interval)		−0.009 (0.004)			0.318 (0.146)	0.090
Subcutaneous AT (2 cm interval)				−0.002 (0.001)		0.055
Subcutaneous AT (3 cm interval)				−0.008 (0.002)		0.214
Subcutaneous AT (4 cm interval)				−0.005 (0.002)		0.052
Subcutaneous AT (5 cm interval)		−0.017 (0.005)				0.121
Visceral AT (2 cm interval)				−0.055 (0.012)		0.209
Visceral AT (3 cm interval)				−0.072 (0.027)		0.082
Visceral AT (4 cm interval)				−0.131 (0.035)		0.157
Visceral AT (5 cm interval)		−0.133 (0.053)				0.068
Intermuscular AT (2 cm interval)				−0.027 (0.011)		0.070
Intermuscular AT (3 cm interval)				−0.042 (0.020)		0.044
Intermuscular AT (5 cm interval)			−0.175 (0.048)		4.246 (1.097)	0.183

Values are estimates of regression coefficient and standard error of estimates (SEE) in parentheses. AT: Adipose tissue; Sex: 0 = female; 1 =male. All P<0.05. Models with no independent variables significantly entered the model has been omitted from the Table.