Cross-calibration of fat and lean measurements by dual-energy X-ray absorptiometry to pig carcass analysis in the pediatric body weight range

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ABSTRACT The objective of this study was to cross-calibrate measurements of body composition by dual-energy X-ray absorptiometry (DXA) with chemical analysis of carcasses of pigs in the pediatric range of body weight. Eighteen pigs (25.5 ± 7.0 kg; 9.9–32.8% body fat) were scanned in duplicate by using DXA with a Lunar DPX-L densitometer in the pediatric medium and adult fast-detail scan modes. Pigs were then killed and their carcasses analyzed completely. Carcass lean and fat contents were highly correlated with DXA measurements in both scan modes (Pearson r values > 0.98). For lean mass, the relation between carcass content and DXA measures was not significantly different from the line of identity in the adult mode, but was in the pediatric mode. For fat mass, the relations between carcass content and DXA measures were significantly different from the line of identity in both the adult and pediatric modes. In duplicate scans, the reliability of DXA measures of lean mass and fat mass was excellent in both scan modes. Because neither the adult nor the pediatric scan mode provided accurate measures of fat and lean mass, we derived specific correction factors to improve the measurement of total fat and lean compartments, thereby calibrating the Lunar DPX-L to the laboratory standard of carcass analysis in pigs. Am J Clin Nutr 1996;63:293–8.

KEY WORDS Children, fat mass, bone mass, lean tissue mass

INTRODUCTION Recent advances in body-composition techniques have provided dual-energy X-ray absorptiometry (DXA) for assessment of whole-body as well as regional measurements of bone mass, lean mass, and fat mass (1). This technique is of potential use in the pediatric population in whom prior laboratory techniques have proved either impractical (eg, hydrostatic weighing) or unsafe due to radiation exposure (eg, neutron activation). Since the introduction of DXA, numerous studies have compared this technique with other laboratory-based research methods (2–5). These studies have proved valuable in cross-validating and comparing the individual techniques. A general limitation of many widely used techniques for calculating body composition is the lack of true validation studies in which comparisons with samples of known chemical composition were performed. Most prior techniques were based on the use of known physical properties of body components that were derived from limited cadaver studies.

Several investigators assessed the validity of DXA by performing cross-validations against carcass analyses in a pig model (6–8). Chemical analysis of the carcass is an ideal laboratory standard technique by which to compare DXA because the whole-animal model simulates the various body-composition compartments of a living organism. Because of practical and ethical issues, studies in human carcasses are limited; pigs are often used in these studies because their body fat content is similar to that of humans. One previous study examined the Lunar DPX-L densitometer (Lunar Radiation Corporation, Madison, WI) in animals in the adult range of body weight (35–95 kg) (6). Two other studies examined the Hologic system (Hologic Inc, Waltham, MA) in animals in the infant range of body weight (8), and in animals in the infant to prepubescent weight range (7). None of the previous studies developed correction factors that can be applied to calibrate DXA to carcass analysis as a means of standardizing whole-body composition assessments. Thus, the objective of the present study was to standardize whole-body composition measures with DXA in the pediatric range of body weight against the laboratory standard of carcass analysis in pigs. Having standardized DXA in the pediatric range of body weight, our ultimate objective was to develop new anthropometric equations for estimating body composition in children with DXA as a criterion. The results of this objective are reported separately in a companion paper (9).

METHODS Animals

Eighteen pigs were used in the study. Twelve common pigs (Sus scrofa domestica), ranging in weight from ≈15 to 35 kg

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(≈6–8 wk of age), were obtained from a local supplier. An additional six miniature Yukatan pigs (S. scrofa), ranging in weight from ≈27 to 37 kg (≈6 mo of age), were generously provided by A Tagliaferro at the University of New Hampshire. Animals were housed at the University’s Large Animal Housing Facility, and the research protocol was approved by the University’s Institutional Animal Care and Use Committee. Within 3 d of arrival, each pig was weighed to the nearest 0.01 kg on a metabolic balance and then anesthetized at the animal facility with an intramuscular injection of ketamine hydrochloride (20 mg/kg body wt) and acepromazine (1.1 mg/kg body wt). Food was withheld from the animals for ≥12 h before the study. The animals were then placed in an animal carrier and transported to the Sims Obesity/Nutrition Research Center at the Medical Center Hospital of Vermont (Burlington). At the hospital, an intravenous line was placed in an ear vein and anesthesia was maintained during the DXA scans by a slow drip of pentobarbital.

**DXA scans**

After the intravenous pentobarbital anesthesia line was in place, the animal was positioned prone on the DXA table. Care was taken to not disturb the position of the animal throughout the scans. DXA scans were performed in duplicate in the adult fast-detail mode (version 1.3y) and the pediatric medium mode (version 1.5d) with a Lunar DPX-L densitometer (Lunar Radiation Corporation). The pediatric scan mode uses several parameters that differ from the typical values used in adults. For example, the pediatric medium mode uses a pixel size of 3.6 × 7.2 mm, a tube current of 300 μA, and a collimation of 0.84 mm, compared with the adult fast-detail mode that was also used in this study (pixel size = 4.8 × 4.8 mm, tube current = 150 μA, collimation = 1.68 mm). The order of the scans was chosen at random. All scans were completed within a 2-h period. Reported DXA data are the mean of the duplicate data. The pigs were then killed with an intravenous overdose of pentobarbital and immediately frozen at −20 °C. DXA scans provided the following measures: total fat weight, total lean weight (excluding bone), bone mineral content (in g), and total weight (fat plus lean plus bone).

**Carcass analysis**

The frozen carcasses were transported to the large animal-grinding facility at the Department of Animal Science at Cornell University. This laboratory routinely runs quality-control samples. For protein, standards are provided by the National Forage Testing Association and the National Institute of Standards and Technology. For fat, standard samples are provided by the American Feed Control Officials. In all cases, the measured values are reported to be within ±2% of the standard value at the time our analyses were performed. Each animal was ground once through a large plate followed by seven passes through a 9-mm plate. Four random samples (≈200–300 g, grabbed by hand) of the final pass from each pig were divided into two aluminum pans, weighed, and frozen for transport back to the University of Vermont. The duplicate frozen homogenized samples were then freeze-dried and reweighed to determine the percentage moisture content of the animal. Dried samples were then reground through a 4-mm plate with a Wiley mill. The final dried, ground samples were analyzed in at least quadruplicate for total fat (ether extraction), protein (Kjeldahl nitrogen determination), and ash (8 h at 550 °C) according to methods of the Association of Official Analytical Chemists (10). The mean CV for replicate assays was 4.5% for ash (range: 1.4–11.4%), 2.1% for protein (range: 0.7–5.9%), and 3.8% for fat (range: 1.0–9.2%). All determinations were conducted by the Vermont Agricultural Testing Laboratory of the University of Vermont. Carcass analysis data are presented as the means ± SDs from analysis in the duplicate samples.

**Statistical analysis**

Body composition by carcass analyses was compared with DXA measurements through the use of regression analyses and paired t tests. In the regression analyses, carcass measures were used as the dependent variable and DXA measures as the independent variable. Construction of the regression analyses in this manner allowed us to develop calibration equations for standardizing DXA measures to carcass measures. This approach differs from previous studies that used carcass analysis (6–8), in which regression analysis was performed with DXA data as the dependent variable and carcass data as the independent variable. Reliability was assessed by the CV between duplicate measures and from the intraclass correlation coefficient (11). The discrepancy between carcass analysis and DXA measures was examined as a function of other independent variables through the use of multiple-regression techniques. Data were analyzed with QUATTRO PRO FOR WINDOWS (version 5; Borland Corporation, Scotts Valley, CA) and all statistical analyses were performed with SAS FOR WINDOWS (version 6.08; SAS Institute Inc, Carey, NC). Data are presented as means ± SDs unless stated otherwise.

**RESULTS**

The range of body weight (15.8–35.6 kg) and total carcass fat content (1.7–12.0 kg, or 9.9–33.7% of body mass) of the 18 pigs covered a typical range that might be expected for prepubescent children. The sum of each animal’s moisture, fat, protein, ash contents ranged from a low of 97.1% to a high of 99.2% with a mean of 98.4 ± 0.56%. The remaining 1–3% should be accounted for by glycogen stores and other carbohydrate and nonprotein-nitrogen material. In a two-way analysis of variance, Yukatan pigs were significantly heavier than were common pigs (32.4 ± 2.4 compared with 22.1 ± 1.5 kg, respectively) because of a greater amount of carcass ash (0.98 ± 0.07 compared with 0.67 ± 0.05 kg), fat (9.1 ± 0.7 compared with 2.9 ± 0.5 kg), and lean tissue (22.4 ± 1.6 compared with 18.5 ± 1.1 kg), with no significant effect of sex. The hydration of fat-free mass was significantly higher in common pigs than in Yukatan pigs (77.9 ± 0.27% compared with 73.2 ± 0.39%, respectively).

A summary of the comparison of carcass analysis and DXA measures is given in Table 1. The pediatric medium scan mode accurately measured the sum of fat, lean, and bone tissue (ie, body weight) but the adult scan mode did not. Neither of the DXA scan modes accurately predicted fat mass, lean mass, or bone mass. For example, the adult fast-detail scan mode underestimated fat mass by 1.08 kg, compared with a 0.53-kg overestimate by the pediatric medium mode (see Table 1).
TABLE 1
Comparison of body composition by carcass analysis and dual-energy X-ray absorptiometry (DXA) with two scanning modes

<table>
<thead>
<tr>
<th>Component</th>
<th>Carcass analysis</th>
<th>DXA scanning mode</th>
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<tbody>
<tr>
<td></td>
<td>Adult fast-detail</td>
<td>Pediatric medium</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>25.51 ± 7.03</td>
<td>25.02 ± 6.84&lt;sup&gt;2&lt;/sup&gt;</td>
<td>25.44 ± 6.75</td>
</tr>
<tr>
<td>Lean mass (kg)</td>
<td>19.76 ± 4.23</td>
<td>20.52 ± 4.14&lt;sup&gt;2&lt;/sup&gt;</td>
<td>19.23 ± 3.48&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>4.98 ± 3.34</td>
<td>3.89 ± 3.62&lt;sup&gt;2&lt;/sup&gt;</td>
<td>5.51 ± 3.80&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bone mass (kg)</td>
<td>0.78 ± 0.22</td>
<td>0.60 ± 0.23&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.70 ± 0.25&lt;sup&gt;2&lt;/sup&gt;</td>
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</table>

<sup>1</sup>SEE ± SD.
<sup>2</sup>Significantly different from carcass analysis, P < 0.05 (paired t test).

The correlation coefficients between carcass weight, fat, and lean mass and corresponding DXA measures were highly significant in both scanning modes (> 0.98); however, weaker correlations were seen for the relation between carcass ash content and bone mineral content measured by DXA (Table 2).

A summary of the regression analyses between carcass measures and DXA measures is given in Table 2, and the relations between carcass analyses and DXA measures for each of the components of body composition are shown in Figures 1-4.

For body weight (Figure 1 and Table 2), the regression slopes were significantly different from 1.0 in both scan modes and the intercept was significantly different from 0 in the pediatric mode (-0.98 kg) but not in the adult mode (-0.20 kg). The SEE for body weight were similar for both DXA scan modes (~1% of body weight). For the comparison of carcass ash against bone mineral content (Figure 2 and Table 2), the slopes and intercepts were similar for both scan modes, and significantly different from 1 and 0 respectively, and the SEE was higher in the adult mode (0.13 compared with 0.06 kg, or ~10% compared with 5% of average carcass ash content).

For fat mass (Figure 3 and Table 2), the regression slopes were similar in both scan modes but significantly different from 1.0, and the intercept was not significantly different from 0 in the pediatric mode but was highly significant in the adult mode. The SEE for fat mass was higher in the pediatric mode.

FIGURE 1. Relation between carcass body weight and dual-energy X-ray absorptiometry (DXA) measures with two scan modes (pediatric medium and adult fast-detail). Carcass weight is weight of the animal at the time of DXA measures. DXA weight was derived from the sum of DXA measures of bone mineral content, fat tissue, and lean tissue. The regression lines (solid line, pediatric medium; dotted line, adult fast-detail) are compared with the line of identity (slope = 1, intercept = 0). Regression equations are given in Table 2.

(0.53 compared with 0.31 kg; or 11% compared with 6% of average fat mass). For lean mass (Figure 4 and Table 2), the regression slope was not significantly different from 1.0 in the adult mode but was in the pediatric mode, and the intercept was not significantly different from 0 in the adult mode but was in

TABLE 2
Summary of regression data for comparison of carcass analysis and measurement by dual-energy X-ray absorptiometry

<table>
<thead>
<tr>
<th>Body component and scan mode</th>
<th>Regression slope</th>
<th>Regression intercept</th>
<th>r²</th>
<th>SEE&lt;sup&gt;2&lt;/sup&gt;</th>
<th></th>
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<tbody>
<tr>
<td>Body weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Adult</td>
<td>1.03&lt;sup&gt;2&lt;/sup&gt;</td>
<td>-0.20</td>
<td>&gt;0.99</td>
<td>0.23 (1)</td>
<td></td>
</tr>
<tr>
<td>Pediatric</td>
<td>1.04&lt;sup&gt;2&lt;/sup&gt;</td>
<td>-0.98&lt;sup&gt;2&lt;/sup&gt;</td>
<td>&gt;0.99</td>
<td>0.25 (1)</td>
<td></td>
</tr>
<tr>
<td>Bone mass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Adult</td>
<td>0.80&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.29&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.68</td>
<td>0.13 (17)</td>
<td></td>
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<tr>
<td>Pediatric</td>
<td>0.86&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.17&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.94</td>
<td>0.06 (8)</td>
<td></td>
</tr>
<tr>
<td>Fat mass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>0.92&lt;sup&gt;2&lt;/sup&gt;</td>
<td>1.39&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.99</td>
<td>0.31 (6)</td>
<td></td>
</tr>
<tr>
<td>Pediatric</td>
<td>0.87&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.19</td>
<td>0.98</td>
<td>0.53 (11)</td>
<td></td>
</tr>
<tr>
<td>Lean mass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>1.01</td>
<td>-0.94</td>
<td>0.98</td>
<td>0.64 (3)</td>
<td></td>
</tr>
<tr>
<td>Pediatric</td>
<td>1.20&lt;sup&gt;2&lt;/sup&gt;</td>
<td>-3.30&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.98</td>
<td>0.67 (3)</td>
<td></td>
</tr>
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</table>

<sup>1</sup>Standard error of the estimate, expressed as kg or as a % of mean carcass content.
<sup>2</sup>Slope or intercept significantly different from 1 or 0, respectively.

FIGURE 2. Relation between carcass ash content and dual-energy X-ray absorptiometry (DXA) measures of bone mineral content with two scan modes (pediatric medium and adult fast-detail). The regression lines (solid line, pediatric medium; dotted line, adult fast-detail) are compared with the line of identity (slope = 1, intercept = 0). Regression equations are given in Table 2.
FIGURE 3. Relation between carcass fat mass and dual-energy X-ray absorptiometry (DXA) measurements with two scan modes (pediatric medium and adult fast-detail). The regression lines (solid line, pediatric medium; dotted line, adult fast-detail) are compared with the line of identity (slope = 1, intercept = 0). Regression equations are given in Table 2.

The reliability of both scan modes was determined by performing duplicate scans. As shown in Table 3 the CV for duplicate scans was 2% for bone mass, 4% for fat mass, and 1% for lean tissue mass in both scan modes.

FIGURE 4. Relation between carcass lean mass and dual-energy X-ray absorptiometry (DXA) measurements with two scan modes (pediatric medium and adult fast-detail). The regression lines (solid line, pediatric medium; dotted line, adult fast-detail) are compared with the line of identity (slope = 1, intercept = 0). Regression equations are given in Table 2.

TABLE 3

<table>
<thead>
<tr>
<th>Component of body composition</th>
<th>CV for adult fast-detail mode</th>
<th>CV for pediatric medium mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone</td>
<td>1.9 ± 2.5 (0.8-8.7)</td>
<td>1.8 ± 1.1 (0.3-4.2)</td>
</tr>
<tr>
<td>Fat</td>
<td>3.8 ± 3.6 (0.1-10.9)</td>
<td>4.1 ± 4.2 (0.2-14.5)</td>
</tr>
<tr>
<td>Lean</td>
<td>0.9 ± 1.6 (0-5.7)</td>
<td>1.0 ± 0.9 (0-2.9)</td>
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</table>

\[ \bar{x} \pm SD; range in parentheses; duplicate scans in 18 pigs. Intraclass correlation coefficient was >0.98 in all cases.

DISCUSSION

We examined the validity of the Lunar DPX-L densitometer for whole-body composition with the adult fast-detail and the new pediatric medium scan modes by using carcass analysis in pigs as a standard by which to compare the data. Our data suggest that neither the adult nor the pediatric scan mode provides accurate measures of total body composition in the weight range examined. However, our analysis provides specific regression equations that can be applied easily to improve the accuracy of measurement of total body composition by DXA. Application of these correction factors effectively calibrates the DXA data to the laboratory standard of carcass analysis. These correction factors can only be applied to DXA measures of fat and lean tissue, and not to bone mineral content. The correction factors are not valid for bone because we did not assess bone mineral content in the carcass and instead used the total ash content of the carcass as a proxy indicator of bone mineral content. Furthermore, the correction factors are instrument- and software-specific and cannot be applied to other DXA machines, scan modes, or software versions. The advantage of using this approach is that all subsequent body composition data are effectively expressed relative to a known laboratory standard. This approach relies on a major assumption that the performance of the DXA technique is similar between pigs and humans. Despite this limitation, which is difficult to evaluate, we believe that the approach described is a feasible compromise given the difficulty in identifying a more ideal standard technique.

Although several other studies have examined the validity of DXA through the use of animal models (6–8), ours is the first study to examine exclusively animals in the weight range and body composition expected in prepubescent children. The animals had body weights of 15.8–35.6 kg and fat contents of 9.9–33.7% of body mass, which simulates closely the ranges of body weight and fat mass in prepubescent children (9). To obtain these ranges of body weight and composition with our animal model it was necessary to use both young common pigs and older (≈6 mo) Yukatan miniature pigs because the common pigs were all lean (<20% fat). Inclusion of the six Yukatan pigs allowed us to extend the ranges of body fatness from 20% to 35%, which covered the upper end of the spectrum of body fatness expected in pediatric populations.

Several other studies compared DXA with carcass analysis in pigs. Findings from previous studies as well as those of the present study are summarized in Table 4. Only one of the previous studies examined the validity of the Lunar instrument and this was in larger animals in the adult range of body weight...
(6). Svendsen et al (6) measured body composition with DXA (using a Lunar DPX-L instrument in the adult medium scan mode) in seven larger pigs (35–95 kg body weight, ~10–50% body fat) and subsequently performed chemical analyses of the carcasses. This study showed excellent agreement between the DXA measures of fat mass \( (r = 0.99; \text{SE of the estimate} = 1.9 \text{kg}, \text{or} ~10\% \text{of average fat mass}) \) and fat-free mass \( (r = 0.98; \text{SE of the estimate} = 2.7 \text{kg}, \text{or} ~6.8\% \text{of average lean mass}) \) and chemical analysis. The regression lines relating DXA-derived measures to chemical analysis were not significantly different from the line of identity, demonstrating excellent validity of DXA in larger animals with the Lunar DPX-L and the adult scan mode.

Two studies examined the validity of the Hologic instrument (7, 8). Brunton et al (8) examined the validity of the Hologic QDR-1000/W with pediatric whole-body software against carcass analysis in 10 small (~1.57-kg) and 10 large (~6-kg) piglets. In the small piglets there was excellent agreement between DXA-derived weight and measured weight \( (r = 1.0; \text{not significantly different from the line of identity}) \). There was modest agreement for lean tissue \( (r = 0.92; \text{significantly different from line of identity}) \) and no agreement for fat tissue \( (r = 0.06). \) In the larger piglets, there was good agreement for DXA-derived weight and measured weight \( (r = 1.0), \) lean tissue \( (r = 0.96), \) and fat tissue \( (r = 0.83), \) although in all cases there were departures from a one-to-one relation.

Ellis et al (7) examined the validity of DXA (Hologic QDR-2000; adult scan analysis) in 16 pigs (5–35 kg). For assessment of absolute fat mass, the correlation between DXA-derived body composition and chemical analysis was highly significant \( (r = 0.99) \) and the SE was \(~400\text{g} \). There was a large discrepancy between DXA estimates of body fat and that measured by chemical analysis. The magnitude of the discrepancy was \(~1.16\text{kg for fat mass} = ~20\% \text{ underestimate} \) for one software mode and \(~0.75\text{kg for fat mass} = ~16\% \text{ overestimate} \) for the second software mode, compared with a 0.5-kg overestimate by DXA in this study with the pediatric mode. The regression line between fat mass measured chemically and that determined by DXA significantly deviated from the line of identity.

We examined the data through the use of multivariate analysis to see whether other factors such as body weight, hydration of fat-free mass, sex, or animal breed could explain the discrepancy between DXA measures and carcass analysis. For the adult fast-detail mode, addition of body weight led to small but significant reductions in the SEE for fat mass (from 0.31 to 0.24 kg) and lean mass (from 0.64 to 0.30 kg), yielding the following multivariate equations for estimating carcass fat or lean tissue from DXA fat in the adult fast-detail mode:

\[
\text{Carcass fat} = (0.83 \times \text{DXA fat}) + (0.055 \times \text{body weight}) + 0.34 \text{ kg (1)}
\]

\[
\text{Carcass lean} = (0.78 \times \text{DXA lean}) + (0.16 \times \text{body weight}) - 0.19 \text{ kg (2)}
\]

where SEE equals 0.24 kg and \( R^2 \) equals 0.998 for equation 1 and SEE equals 0.30 kg and \( R^2 \) equals 0.996 for equation 2. Hydration of fat-free mass, sex, or animal breed did not explain any additional variation in the discrepancy between carcass and DXA measures for fat or lean tissue in the adult fast-detail mode. For the pediatric medium mode, addition of body weight led to a small but significant reduction in the SEE for lean mass only (from 0.67 to 0.44 kg), yielding the following multivariate equation for estimating carcass lean tissue from DXA fat in the pediatric medium mode:

\[
\text{Carcass lean} = (0.78 \times \text{DXA lean}) + (0.16 \times \text{body weight}) - 0.19 \text{ kg (2)}
\]

where SEE equals 0.24 kg and \( R^2 \) equals 0.998 for equation 1 and SEE equals 0.30 kg and \( R^2 \) equals 0.996 for equation 2. Hydration of fat-free mass, sex, or animal breed did not explain any additional variation in the discrepancy between carcass and DXA measures for fat or lean tissue in the adult fast-detail mode. For the pediatric medium mode, addition of body weight led to a small but significant reduction in the SEE for lean mass only (from 0.67 to 0.44 kg), yielding the following multivariate equation for estimating carcass lean tissue from DXA fat in the pediatric medium mode:

\[
\text{Carcass lean} = (0.78 \times \text{DXA lean}) + (0.16 \times \text{body weight}) - 0.19 \text{ kg (2)}
\]
Carcass lean = (0.94 × DXA lean) + (0.15 × body weight) − 2.04 kg (3)

where SEE equals 0.44 kg and $R^2$ equals 0.990.

The precision estimates reported in Table 3, which are based on test-retest studies, compare well with other reports. Svendsen et al (6) reported a precision of $\pm 2.5\%$ for both fat and lean tissue in adult pigs compared with values of $\pm 4.6\%$ in adult humans. Ellis et al (7) reported reliabilities of $\pm 2\%$ for fat tissue and $\pm 0.6\%$ for lean tissue in repeat scans in 25-kg pigs. For 6-kg pigs, Brunton et al (8) reported reliabilities of $\pm 3.3\%$ for fat tissue and $\pm 0.6\%$ for lean tissue in repeat scans. Taken together with our reported values of $\pm 4\%$ for fat tissue and $1\%$ for lean tissue, these data suggest excellent reliability of DXA measures of fat and lean tissue. However, the precision estimates described are based on duplicate scans in animals that were performed without removing the animals and replacing them on the scan table. Reliability estimates may be slightly higher in practice in human studies because of variation in subject placement.

In summary, our data show that DXA, in the adult fast-detail or pediatric medium scan mode, yields accurate estimates of body composition for the pediatric range of body weight, provided that software-specific regression equations are applied to calibrate the DXA data to chemical measures of carcasses. Application of the calibration equations should optimize the accuracy of DXA measures of body composition and provides an additional advantage of standardizing the DXA measures to carcass analysis, which is a known laboratory standard. In addition, our data do not provide evidence of any clear advantage, or disadvantage, of using the pediatric medium scan mode for assessment of body composition by DXA for the pediatric range of body weight if the software-specific regression equations are applied. In conclusion, the pediatric medium and adult fast-detail scan modes can be used to estimate whole-body composition in the pediatric range of body weight, and these estimates can be standardized relative to whole-body chemical analysis in pigs by application of the proposed calibration equations.

We thank A Tagliaferro at the University of New Hampshire for providing six miniature Yukatan pigs.

REFERENCES