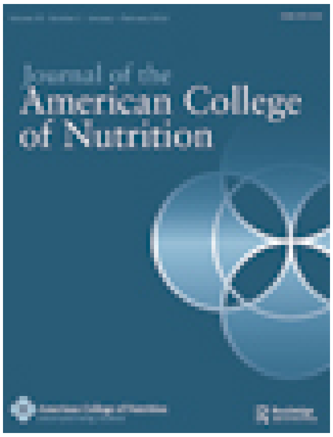

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Body Composition of Newborn Twins: Intrapair Differences

Belinda Koo MA[a], Jocelyn Walters MS[a], Elaine Hockman PhD[c] & Winston Koo MBBS[ab]

[a] Departments of Pediatrics, Obstetrics and Gynecology, University of Tennessee, Memphis, Tennessee (B.K., J.W., W.K.)

[b] Department of Pediatrics, Hutzel Hospital (W.K.), Detroit, Michigan

[c] Computing and Information Technology, Wayne State University (E.H.), Detroit, Michigan

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Original Research

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Belinda Koo, MA, Jocelyn Walters, MS, Elaine Hockman, PhD, Winston Koo, MB BS

Departments of Pediatrics, Obstetrics and Gynecology, University of Tennessee, Memphis, Tennessee (B.K., J.W., W.K.), Department of Pediatrics, Hutzel Hospital (W.K.), Computing and Information Technology, Wayne State University (E.H.), Detroit, Michigan

Key words: body composition, neonates, twins, growth, bone, lean tissue, fat

Objective: To measure body composition in newborn twins and to test the hypothesis that differences in body weights between twins are reflected proportionally by their differences in various components of body composition.

Methods: 48 pairs of newborn twins delivered at a tertiary teaching hospital had dual energy x-ray absorptiometry (DXA) body composition measurement for bone mineral content (BMC), lean and fat mass (LM, FM). Data analyzed with regression and analysis of variance.

Results: Body weight, BMC, LM and FM increased with increased gestational age ($p < 0.001$). The percent difference in BW between each twin pair was significantly correlated with percent difference in BMC, LM, and FM ($p < 0.001$). However, mean ($\pm$ SD) percent difference in body weight (14.3 $\pm$ 10.0%) was significantly lower ($p < 0.001$) than FM (26.0 $\pm$ 15.0%) but was not significantly different from LM (13.4 $\pm$ 9.0%) or BMC (15.9 $\pm$ 11.6%).

Conclusion: In newborn twins, body weight and body composition varies with gestational age. For any twin pair, a difference in body weight was correlated with but not proportional to differences in individual components of body composition.

INTRODUCTION

Discrepant fetal growth in twin pregnancy is well known. It has been defined as the difference in birth weight between twins of greater than 15% [1], 20% [2], 30% [3] or more [4,5]. Its presence is associated with increased risk of perinatal morbidity and mortality [3–6] and long-term physical and intellectual impairment [4]. However, other than standard anthropometric and fetal ultrasound measurements [2,7], there has been no systematic study on the relative contribution of different components of body composition to the body weight of twins.

Information on body composition of twins may contribute to the knowledge on physiological changes during normal and abnormal fetal growth. It also may lead to better postnatal nutritional management of the growth impaired twin if the goal is to achieve body composition similar to the normally grown twin. This study aims to determine the variations in anthropometric and body composition measurements of newborn twins at different gestational ages and to test the hypothesis that differences in body weights between twins are reflected proportionally by differences in various components of body composition, specifically lean body mass, fat mass and bone mineral content.

SUBJECTS AND METHODS

Subjects

Subjects included 48 pairs of twins with birth weights from 976 g to 3135 g and gestation ages from 30 to 40 weeks. Gestational age assessment was based on menstrual and/or ultrasound dating and confirmed by standard physical examination [8]. Seven pairs of twins were $<$33 weeks gestational age, 29 pairs were between 33 and 36 weeks, and 12 pairs were $\geq$37 weeks. In 29 pairs, both twins had birth weights appropriate for gestational age (AGA, between 10th to 90th percentiles) [9]; in one pair, both twins were small for gestational age (SGA, less than 10th percentile); and in 18 pairs, one twin was

Address correspondence to: Dr. Winston Koo, Department of Pediatrics, Hutzel Hospital, 4707 St Antoine Blvd, Detroit, MI 48201. E-mail: wkoo@wayne.edu.

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AGA while the other twin was SGA. There were 23 pairs of twins with a difference in birth weight of greater than 15%. Thirty-seven pairs of twins were African American (38 males and 36 females; 21 pairs were of the same gender), 10 pairs were Caucasian (14 males and 6 females; 8 pairs were of the same gender), and one pair was Asian (1 male and 1 female).

Clinical care of all study subjects was managed by the attending physician, and all infants were clinically well at the time of study. There was no congenital malformation or specific conditions other than that related to multiple fetuses to account for the growth discrepancy within each twin pair. This study was approved by the Institutional Review Board for human subjects at the University of Tennessee-Memphis, and written informed consent was obtained from each subject's parent.

Anthropometric Measurements

Nude weight, length and head circumference of each infant was measured immediately preceding dual energy x-ray absorptiometry (DXA) study. Weight in grams was determined with a digital electronic scale (Air Shields Vickers, Hatboro, PA). The scale was regularly maintained by the hospital Biomedical Instrumentation personnel and calibrated with known standard weights. Recumbent length was the average of two consecutive measurements within 0.4 cm and was determined using a standard length board (Ellard Instrumentation Ltd., Seattle, WA). Head circumference was the average of two consecutive maximum occipitofrontal circumferences within 0.2 cm using a disposable paper tape measure.

DXA measurements

DXA whole body scans were performed at a mean of 3.8 $\pm$ 3.2 (SD) days after birth using a pencil beam densitometer (Hologic QDR 1000/W. Hologic Inc., Waltham, MA). Forty-two pairs of twins were studied on the same day. Six pairs of twins were studied at one to four days apart while awaiting recovery from minor illnesses in one of the twins.

Details of DXA measurements have been reported [10,11]. Briefly, all scans were performed with the subject and a step phantom placed on top of an infant platform with an interposing cotton blanket. Each subject was swaddled in another cotton blanket during scanning. All infants were scanned without sedation or additional restraint. Each scan was judged technically satisfactory if the external calibration step phantom and the skeletal outline of the subject laid within the scan region as shown on the video monitor and if there was no significant movement artifact [11]. Scan analysis was performed using the software developed in conjunction with the manufacturer (Version V5.64P).

Quality control scans were performed daily on a manufacturer-supplied anthropomorphic spine phantom, and the long term ($>$3 years) coefficients of variation for the determination of bone mineral content, bone area and bone mineral density on repeated measurements of spine phantom were $<$0.3% for all parameters. The average annual rate of change for each of these measurements was not significantly different from zero. In our laboratory, the *in vivo* replication of DXA measurements in 50 infants (17 infants were neonates with weights between 1525g and 5128g) was highly significantly correlated (r $\geq$ 0.99 and $p < 0.001$ for all parameters, i.e., bone mineral content, bone area, bone mineral density, lean body mass and total fat mass), and the standard deviation of difference [12] between paired DXA measurements for the same parameters was 3.8%, 2.5%, 2.6%, 2.3% and 7.0%, respectively.

Statistical Analyses

The difference in weight, length and each measured DXA variable (lean body mass, fat mass, bone mineral content, bone area) between each twin pair was expressed as a percentage of the larger twin with the formula [(larger infant—smaller infant)/(larger infant)] $\times$ 100. Bone mineral density was used only as descriptive data and was not analyzed statistically because it is based on bone mineral content divided by area and there are a number of concerns with its use in pediatrics [13].

Regression analysis was used to determine 1) whether the percent difference in birth weights or body composition components listed above was related to gestational age and 2) the change in anthropometric and DXA measurements with increased gestational age for individual infants. Pearson correlation was used to determine the relationship among percent differences in nude weight, lean body mass, fat mass and bone mineral content.

Repeated measure analysis of variance was used to test the premise that the percent difference in nude weight between twins would be equal to the percent difference of each weight component of body composition, namely lean body mass, fat mass and bone mineral content. The dependent variables were percent difference between each twin pair in nude weight, lean body mass, fat mass and bone mineral content, i.e., the four percent differences would be statistically equivalent based on testing our hypothesis with repeated measures analysis of variance. The analysis was controlled for race (African American *vs.* non-African American) and gender (same sex *vs.* different sex). Repeated measures analysis of variance was then repeated with each within-subject factor adjusted for DXA measured area. Orthogonal contrasts using Difference and Helmert methods were used to test for differences among nude weight and body composition variables.

To further explore the relation of gender to differences in weight and body composition, the gender variable was further divided into four categories for each twin pair (i.e., both males, both females, male weighing more than female, female weighing more than male), and the same statistical procedure was repeated. In addition, the Bonferroni test was used for *post hoc* comparison among the four categories of the gender variable. Power was computed for the analyses completed. All statistical tests were performed with SPSS 10.0 (SPSS Inc., Chicago, IL) for windows at an adopted significance level of $p < 0.05$.

RESULTS

There was no significant relation between the magnitudes of intrapair difference in body weight or body composition (lean body mass, fat mass, bone mineral content, bone area) with the gestational age (adjusted $r^2 \leq 0.02$ for all comparisons). Anthropometric and DXA measurements of individual subjects were significantly ($p < 0.001$ for all comparisons) higher with increased gestational age (Figs. 1 and 2). With increasing gestational ages, there was an increase in bone mineral content and fat mass, but a decrease in lean body mass as a percentage of the body weight.

The intrapair percent difference in nude weight was significantly ($p < 0.001$ for all comparisons) correlated with percent difference in each of the body composition components: lean body mass (r = 0.93), bone mineral content (r = 0.75) and fat mass (r = 0.55). However, the percent difference in fat mass

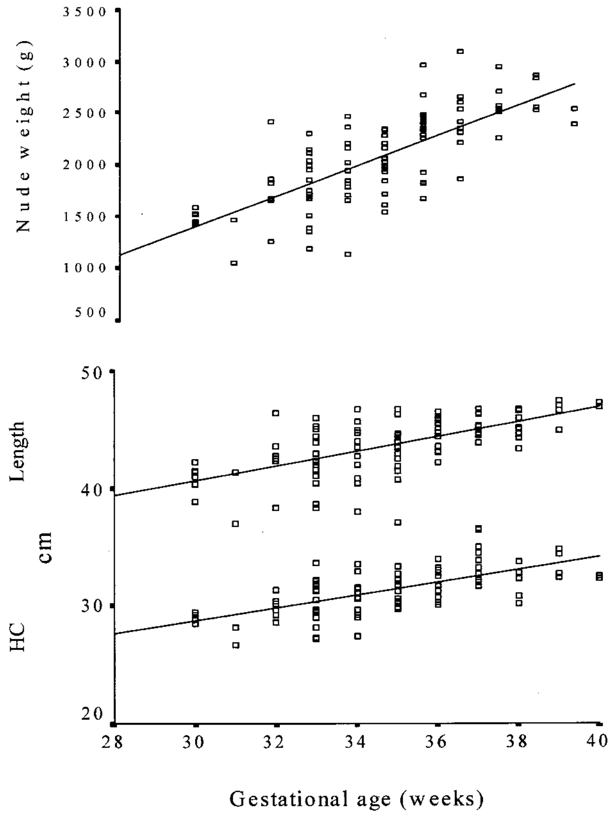

Fig. 1. Scatter plot including mean regression line for anthropometric measurements of all study infants (n = 96) as a function of gestational age (GA) in weeks. Nude weight g = −2736 + 137.97 GA, r = 0.75, $p < 0.001$. Length cm = 21.7 + 0.63 GA, r = 0.65, $p < 0.001$. Head circumference (HC) cm = 12.3 + 0.55 GA, r = 0.64, $p < 0.001$.

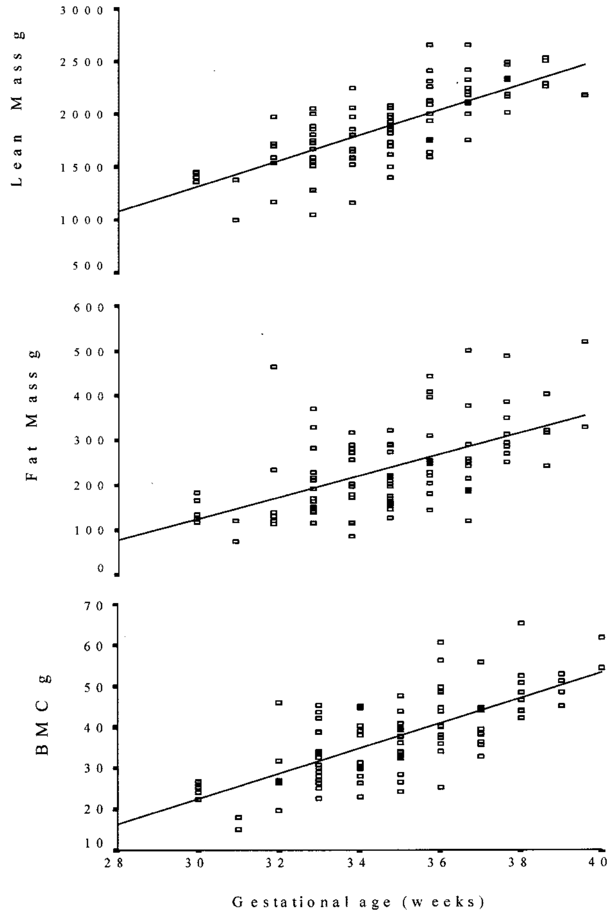

Fig. 2. Scatter plot including mean regression line for body composition measurements of all study infants (n = 96) as a function of gestational age (GA) in weeks. Lean body mass g = −2179 + 116.49 GA, r = 0.76, $p < 0.001$. Fat mass g = −574 + 23.27 GA, r = 0.56, $p < 0.001$. Bone mineral content (BMC) g = −70.3 + 3.09 GA, r = 0.72, $p < 0.001$.

was significantly higher than the percent difference in nude weight, lean body mass and bone mineral content (Table 1).

There was a tendency for an interaction between percent difference in body composition and race ($p = 0.056$, repeated measures analysis of variance) with African American twins having a lower percent difference in lean body mass ($p < 0.05$, repeated measures analysis of variance with contrast). However, the racial effect was no longer present after adjusting each dependent variable by DXA bone area.

There was no gender effect, whether it was categorized as same or different gender pairs, or in the four combinations of gender pairing as described above. In addition, no interaction effect among the dependent variables with race or gender was present in any analyses.

From a prospective aspect with the assumption that, for any twin pregnancy, the larger and presumably normally grown twin has similar body composition to that of a singleton [14,15] and the smaller twin would have discrepant body composition,

Table 1. Percent Difference* in Anthropometric and Dual Energy X-Ray Absorptiometry (DXA) Measurements for the 48 Pairs of Twins

Anthropometric Measurements	Mean ± SD	Range
Study Head Circumference	4.0 ± 3.5	0–16
Study Length	4.3 ± 3.5	0–15.9
Nude weight	14.3 ± 10.0	0.1–42.2
DXA Measurements		
Bone mineral density	7.2 ± 6.0	0–24.2
Bone area	11.2 ± 7.7	0.1–35.1
Lean Body Mass	13.4 ± 9.0	0.1–31.1
Bone mineral content	15.9 ± 11.6	0.4–45.0
Fat Mass	26.0 ± 15.0†	0.2–67.7

* Presented in ascending order for difference in overall mean difference.
† Percent difference in fat mass is higher than that for nude weight, lean and bone mass, $p < 0.001$ repeated measures analysis of variance with contrasts using Helmert and Difference methods.

then a sample size of 40 pairs of twins is expected to detect a minimum of 15% difference in at least one of the body composition components with an α of 0.05 and a power of 0.71, whereas 50 pairs would increase the power to 0.80. *Post hoc* calculation shows that the observed power was >0.90 for all analyses.

DISCUSSION

This study employed the DXA technique because of its ability to simultaneously measure multiple components of body composition and the increasing availability of normal data during infancy [16]. Validation studies for the current version of software have been performed on piglets as small as 886g [10,17,18], and it is generally agreed that DXA measurements better reflect the chemical determination of lean and bone masses compared to fat mass [17,18]. However, the stability and precision of each DXA parameter of body composition measurements in our laboratory indicate that our data provided accurate discriminative power for differences in body composition between subjects; that is, clinically relevant parameters of body composition for the management of growth retarded twins can be determined using this technique.

To our knowledge, this is the first report on the relative contribution of several components of body composition involving soft tissues (fat and lean body mass) and bone in twins. For all infants, the pattern of changes in anthropometric and body composition measurements with increased gestational age are consistent with that reported for normal singleton infants [14,15], specifically, an increase in absolute values for all measurements, but a small decrease in lean body mass as a percentage of total weight.

We used differences in body weight for comparison with differences in body composition because body weight is an accurate and reproducible measurement and is freely available. In addition, we [14,15,19] and others [20,21] have shown that body weight is a major physiological predictor of body composition during infancy. In this study, the data were analyzed as a continuum to better reflect fetal growth rather than arbitrarily defining discrepant fetal growth based on appropriateness of the birth weight for gestational age of each infant or a 15% to 30% difference in body weight. The use of arbitrary grouping may have some value for the prediction of clinical course, but it lacks specificity for use in individual infants. It also ignores errors of measurement with loss of data and loss of power particularly around the cut-off point [22]. The magnitude of differences in body weight and body composition variables (lean body mass, fat mass, bone mineral content and bone area) were not related to gestational age; thus further analysis based on stratification by gestational age would not be justified.

We controlled for race and gender in our data analyses, since race had a small influence on DXA bone mass measurements based on univariate analyses [14] and females had more fat mass and less lean body mass than males [15]. The racial effect showing lower percent difference in lean body mass compared to the differences in fat mass and bone mineral content was statistically insignificant once we controlled for DXA bone area, suggesting that body size is of greater importance in determining body composition. Our data also demonstrated that gender pairing did not have an effect on body composition among twins. This would support the conclusion that growth and body composition within any twin pair are independent of gender.

The lack of detail data on placental anatomy for our subjects limits the interpretation on the role of placental circulation that might account for the altered growth and body composition. The absence of specific conditions such as congenital malformation that affected only one fetus of a twin pair suggest that any adverse in-utero event that may affect growth and body composition could affect both twins, although the susceptibility to adverse events might differ within and between twin pairs. In any case, our data on the differences in body composition among twin pairs are consistent with the reports in singleton infants that body fat is most frequently affected and to the greatest extent by abnormal fetal growth. This appears to be the case whether the fetal growth was impaired [23–25] or was excessive [26]. We have now demonstrated that the deficit in body fat is also greater than the deficit in lean or bone mass in the smaller or growth retarded twin compared to the larger twin. This alteration in body composition appears to be the case in the range of differences in body weights (up to 42%) among the twin pairs studied.

In this study, body weight is disproportionately affected to a greater extent than length or head circumference. This finding supports the presence of asymmetric growth retardation, an indication of nutrient deficiency as the primary cause of growth discrepancy, in contrast to the more uniform decrease in weight, length and head circumference that would be expected from other causes such as chromosome abnormalities or severe intrauterine infection. While a greater intake of energy is usually recommended for growth impaired infants, it is important to note that the difference in body weight is also reflected in differences in lean body mass and bone mineral content. Our findings suggest that an increase in all nutrients with a proportionally greater energy intake is most appropriate for postnatal "catch up" on all components of body composition.

CONCLUSION

Anthropometric and body composition measurements of twins increased with advancing gestational age. However, difference in body weights between neonates for any twin pair is correlated with but is not proportional to differences in individual components of body composition. Lean body mass and bone mass are relatively better preserved than fat mass in the growth impaired twin, and these changes are independent of race or gender.

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