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# No sustained effects of an intervention to prevent excessive GWG on offspring fat and lean mass at 54 weeks: Yet a greater head circumference persists

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## Summary

**Background:** LIFT (Lifestyle Intervention for Two) trial found that intervening in women with overweight and obesity through promoting healthy diet and physical activity to control gestational weight gain (GWG) resulted in neonates with greater weight, lean mass and head circumference and similar fat mass at birth. Whether these neonate outcomes are sustained at 1-year was the focus of this investigation.

**Methods:** Measures included body composition by PEA POD air displacement plethysmography (ADP) and Echo Infant quantitative magnetic resonance (QMR) and head circumference at birth (n = 169), 14 (n = 136) and 54 weeks (n = 137). Differences in fat and lean mass between lifestyle

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AUTHOR CONTRIBUTIONS

K.W., D.G., and J.C.T. designed this study. D.G. and X.P. were coprincipal investigators of the LIFT trial and were responsible for supervision of data collection. K.W. and J.C.T. were responsible for data analysis. D.G. and K.W. had primary responsibility for final content. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

intervention (LI) and Usual care (UC) groups were examined using ANCOVA adjusting for maternal age and BMI, GWG, offspring sex and age.

**Results:** Compared to UC, LI infants had similar weight (112 ± 131 g; $P$=.40), fat mass (14 ± 80 g; $P$= .86), lean mass (100 ± 63 g; $P$= .12) at 14 weeks and similar weight (168 ± 183 g; $P$= .36), fat mass (148 ± 124 g; $P$=.24), lean mass (117 ± 92 g; $P$= .21) at 54 weeks. Head circumference was greater in LI at 54 weeks (0.46 ± 2.1 cm $P$=.03).

**Conclusions:** Greater lean mass observed at birth in LI offspring was not sustained at 14 and 54 weeks, whereas the greater head circumference in LI offspring persisted at 54 weeks.

### Keywords

fat mass; infant body composition; prenatal intervention

## 1 | INTRODUCTION

The concept of Developmental Origins of Health and Disease (DOHaD) postulates that the maternal environment to which the developing fetus is exposed can influence offspring health and development in childhood and into adulthood.[1,2] Excessive maternal GWG is associated with increased offspring birthweight and subsequent metabolic implications.[3–5] Evidence from meta-analyses and large cohort studies indicates excess GWG as a strong predictor of obesity in offspring later in life[6,7] while other studies have reported no sustained effect.[8] The lack of consensus could be due to differences in study populations and study design. Notably, it remains unclear how much pre-pregnancy BMI, concomitant metabolic disease states or acute postnatal factors confound the association of GWG on offspring obesity (as evidenced by weight or BMI) in studies where these data were not collected.

Pregnancy, therefore, may present as an opportune time to intervene to control excessive GWG thereby promoting a healthier prenatal environment; however, the optimal intervention(s) and associated effect sizes on fetal programming to reduce the risk of offspring obesity remain unknown.[9] Results from randomized behavioural intervention studies that aimed to control excessive GWG have demonstrated no sustained effect on offspring body composition at ages 1, 2.5 and 5 years.[10–13] Differences in study design, timing of intervention and the magnitude of attenuated GWG may have contributed to the lack of sustained effects. More specifically, many of these studies assessed infant body composition using surrogate methods such as skinfold thicknesses, height and weight. By themselves, these approaches are insufficiently sensitive to provide insights on small differences or small changes in lean or fat mass.

LIFT (Lifestyle Intervention for Two) trial reported that women with overweight and obesity engaged in behaviours promoting healthy diet and physical activity to control GWG resulted in neonates with similar FM and greater LM at birth.[14] Offspring body composition was measured by air displacement plethysmography (ADP—PEA POD) and quantitative magnetic resonance (QMR—EchoMRI-Infants) at birth. The primary aim of this study was to investigate whether the greater lean mass (LM) observed at birth in the LIFT intervention offspring persisted at 14 and 54 weeks. A secondary aim was to investigate whether the more readily available skinfold thickness measure of body fat and head circumference at 1 year were related to total LM or fat mass (FM) at 54 weeks.

## 2 | METHODS

### 2.1 | Data collection

**2.1.1 | Population—**Participants were the offspring born to women enrolled in the Lifestyle Intervention for Two (LIFT) in New York City, a randomized controlled trial investigating the effects of a behavioural lifestyle intervention delivered between 2013 and 2015 in the 2nd and 3rd trimesters on maternal GWG and neonatal body composition. Eligibility criteria included age ≥18 years; BMI≥25 at baseline measurement; singleton pregnancy. Gestational age between 9 and 15 weeks was confirmed by dating ultrasound. Women with diabetes mellitus or gestational diabetes mellitus (GDM) as evidenced by a glycosylated haemoglobin greater than 6.5% at study screening were excluded. Details of study design and findings have been published.[14] Between 2014 and 2017, offspring measures were collected after birth (2.9 ± 5.1 days), week 14 (14.8 ± 2.5 weeks) and week 54 (54.8 ± 5.4weeks). Study participants provided written informed consent prior to participation. The study was approved by and conducted in accordance with the Institutional Review Boards at St Luke's-Roosevelt Hospital and Columbia University Irving Medical Center.

**2.1.2 | Anthropometry—**Neonatal and infant study weight, length, head circumference and skinfold thicknesses were measured prior to hospital discharge between 1 and 4 days after birth for term infants (or at 36 weeks post-last menstrual period of preterm infants), 14 weeks and 54 weeks. Weight was measured using a calibrated scale (COSMED USA, Inc.), length using a standardized board (Ellard Instrumentation Ltd.) and head circumference using a tape measure with a tensiometer (Gulick II, model 67020). Small for gestational age (SGA) and large for gestational age (LGA) were determined using WHO guidelines for reference population and ultrasound for gestational age.[15] Birth weight and length were extracted from medical records (Table 1). Skinfold thickness was measured by trained staff in duplicate using the Harpenden skinfold caliper (model HSB-BI) on right side of the body at the following sites: triceps, subscapular, thigh and iliac crest.[17] All assessments were performed in duplicate and when values differed by a specified amount (>0.1 kg for weight, >0.5 cm for length and >0.5 mm for skinfold thickness), a third measurement was taken. The average of the closest two measurements was used in data analyses. Coefficient of variability (CV) of repeated skinfold measures for triceps, subscapular, iliac and thigh in 45 infants at 54 weeks was 2.1%, 2.6%, 2.4% and 0.9%, respectively.

**2.1.3 | Quantitative magnetic resonance—**Quantitative magnetic resonance (QMR) is a non-imaging technique (EchoMRI-Infants) that uses an electromagnetic field to detect the hydrogen atoms of fat, lean tissue and water.[18] Once excited by radio-frequency pulses, these protons have different relaxation times relative to the tissue (fat) or medium (water) in which they are embedded. The processed signal is obtained from the whole body at once. The total water signal by QMR comes from protons primarily found in proteins (lean tissues) and to a lesser degree in fat molecules. The greater absolute value for total water compared to total lean mass for QMR reflects the contribution of water from fat to the total water. The EchoMRI-Infants accommodates infants up to 12 kg that corresponds to approximately 12 months of age. Neonatal body composition was assessed by Infant QMR at birth, 14 and 54 weeks. Reproducibility from data using the EchoMRI-Infants in 14 newborns measured three times showed high precision (CV of 5.3% for FM, 2.5% for LM and 1.6% for total body water [TBW]).[19]

#### 2.1.4 | Air displacement Plethysmography– PEA POD—

The PEA POD body composition system (COSMED USA, Inc.) measures body composition through the measurement of body volume by air displacement plethysmography, as previously described.[14] Infants were undressed and wore a standard tight-fitting hat (Allentown Scientific Associates, Inc, Allentown PA) to minimize air trapped in the hair. Body volume and mass by PEA POD were used to estimate body density using sex specific equations of Fomon[17] from which FM and FFM were derived. The PEA POD accommodates infants up to 8 kg. Body composition was assessed by PEA POD at birth and 14 weeks. Repeated measures on the same day in 29 infants gave CV's of 6.5% for FM and 1.1% for FFM.[19]

### 2.2 | Statistics

For categorical variables, the number and percentage were calculated for each group (lifestyle intervention, LI and usual care, UC). The chi-square test was used to test the null hypothesis that the distributions of baseline categorical variables were equal for the two groups. The groups' means and SDs of the continuous variables were calculated. The Student *t*-test was used to test the null hypothesis that means of the baseline variables were equal for the two groups. The analysis of covariance was used to test the null hypothesis that the adjusted means of the outcome variables were equal for the two groups. The covariates were mother's baseline age, mother's baseline BMI, mother's ethnicity, mother's GWG, offspring sex and offspring age at test. Stepwise regressions methods were performed to identify a minimal subset of independent variables necessary to predict infant QMR FM and LM at 54 weeks using a priori parameters (0.2–0.1). The set of independent variables included in the analysis were gestational age, sex, age at measurement in weeks, ethnicity, total GWG and maternal baseline age, head circumference, individual skin fold sites, weight and length. Only those variables with significance as defined by $P<0.05$ were retained in subsequent regression equations. Final regression equations included head circumference, each of the four individual skinfolds, weight and length as independent variables. Those with missing data were excluded. R-squared and root mean squared error were used to evaluate the models.[20] Statistical analyses were performed using SAS version 9.2 and STATA version 16. Significance was set at $P < 0.05$, two tailed.

## 3 | RESULTS

Births occurred between August 2013 and April 2015. The GWG was 1.79 kg less in the LI group compared with the UC group ($P < 0.003$).[14] The greatest impact of LI on controlling GWG occurred during the second trimester.[14] There were no differences between groups for maternal baseline demographics nor pregnancy information.[14] The incidence of GDM was 10.3% for LI and 6.1% for UC ($P = 0.28$). Mothers who developed GDM were under the care of their obstetrician. Infant birth characteristics are presented in Table 1. Gestational age at birth was 39.4 ± 1.8 weeks.

## 4 | BASELINE

The baseline characteristics of the groups were similar for all demographic variables (Table 1). Compared to UC, LI had greater weight (131 ± 59 g; $P = 0.03$) and head circumference (0.38 ± 0.17 mm; $P = 0.03$) as shown in Table 2. LI had greater FFM (98 ± 45 g; $P = 0.03$) and greater LM (105 ± 38 g; $P = 0.006$) and QMR-total body water (97 ± 40 g; $P = 0.02$). There were no between-groups differences in FM or any site skinfold thickness.

### 4.1 | 14 weeks

Retention at 14 weeks was 89.9% (N = 152). There were no between-group differences observed for any variable.

### 4.2 | 54 weeks

Retention at 54 weeks was 90.2% (n = 177) for anthropometric measures and 82.2% (N = 137) for Infant QMR. There were no other between-group differences with the exception of a greater head circumference in LI (0.46 cm ± 0.21 cm; $P = 0.03$).

### 4.3 | Circumference and skinfold predictors of fat mass at 54 weeks

The most parsimonious model for predicting FM by QMR (Table 3) included 54-week measured head circumference ($P = 0.02$), thigh skinfold, ($P < 0.0001$) triceps skinfold ($P = 0.04$), weight ($P < 0.001$) and length ($P = 0.003$), which explained 72% of the variance ($P < 0.001$, RMSE = 0.38 kg). A second model added FM by QMR after birth ($P < 0.0001$, RMSE = 0.27 kg) that increased the explained variance by 12% ($R^2 = 84\%$). Concurrently measured thigh and triceps skinfolds, and infant body weight had positive relationships with FM, while head circumference and length were negatively associated with FM. There were no significant correlations between thigh or triceps skinfolds with head circumference.

### 4.4 | Circumference and skinfold predictors of lean mass at 54 weeks

The most parsimonious model for predicting LM by QMR (Table 4) included 54-week measures of head circumference ($P < 0.001$), thigh skinfold ($P < 0.001$), weight ($P < 0.001$) and length ($P = 0.002$), which explained 64% of the variance ($P < 0.001$, RMSE 0.35 kg). Thigh skinfold was negatively associated with LM, while weight, head circumference, and length were positively associated with LM.

## 5 | DISCUSSION

This study investigated whether the greater FFM by PEA POD and LM by Infant QMR observed at birth in the intervention group[13] persisted at 14 and 54 weeks postpartum. No between-group differences were observed at 14 or 54 weeks for any fat or lean mass variable. A greater head circumference persisted in the intervention group at 54 weeks.

Our findings of no sustained effects for FM and LM are in agreement with other antenatal randomized lifestyle intervention trials that found no sustained effect on weight-for-length z scores, abdominal circumferences or skinfold thicknesses in the offspring from birth through 1 year.[10–13] Many factors are known to influence body composition and growth during fetal development. Studies that investigated associations of maternal and offspring characteristics with offspring body composition found that maternal pre-pregnancy BMI, trajectory of GWG, and postnatal factors such as breastfeeding, physical activity and other environmental factors may differentially influence body composition outcomes, either directly or through interaction effects.[9–11,16] While randomized interventions implemented in the larger LIFE-Moms Consortium were successful at limiting excessive GWG in the intervention groups, no between-group differences in offspring body composition by skinfold thicknesses were observed at birth or at 1 year.[10] Previous interventions limiting excessive GWG in women with obesity have demonstrated between-group differences in offspring measures of subscapular skinfold thickness at 6 months postpartum[21] and weight for age z-scores at 12 months postpartum.[22] The magnitude of the independent effects of maternal pre-pregnancy BMI on offspring adiposity and the attenuation of excessive GWG on offspring adiposity are unknown. Moreover, it is unclear how early in pregnancy excessive GWG may influence offspring body composition, which would be informative to help guide how early in pregnancy interventions targeting the control of excessive GWG should be initiated. An observational study from the Shanghai Obesity Cohort found that greater GWG in the first trimester was positively associated with childhood adiposity at 5 years of age adjusted for maternal pre-pregnancy BMI and paternal BMI, while third trimester gains were associated with childhood BMI-SD scores for overweight or obesity in the subset of the mothers who had pre-pregnancy BMI > 24.9 (n = 121)[7]. The LIFT intervention was not initiated until 14 weeks gestation, which was beyond the first trimester. The fetal environment in the first trimester, if important for metabolic programming remained undisturbed in our study.

It is well established that head circumference is highly correlated with child length and height under normal nutritional conditions[23] and change in head circumference is used clinically as a marker of optimal growth and development. There is a paucity of data on the mechanisms relating head circumference directly to FM and FFM in the neonate and subsequent implications for metabolic health. To investigate the strongest anthropometric predictors of body composition measures at 54 weeks, the groups were merged. The predictors of greater LM included larger head circumference and a lower thigh skinfold concurrently measured at 54 weeks. The predictors of greater FM included smaller head circumference, greater thigh and triceps skinfolds at 54 weeks, and greater FM at birth. Our study found that head circumference was inversely associated with QMR FM and a positive predictor of QMR lean at 54 weeks. Two recent literature reviews of studies involving prenatal programming and early postnatal growth and nutrition effects on body composition reported an association of birth weight on subsequent lean mass indices as late in life as the seventh decade.[2,9] Persistence of greater head circumference in the intervention group at 54 weeks lends to the importance of measuring early life factors in future GWG interventions. While factors such as GDM and SGA can influence adiposity trajectories, LGA infants are reported to have accelerated lean mass growth during the early postnatal period.[24] The current study covaried for SGA/LGA (n = 16) and GDM development during pregnancy (n =

6), which did not affect outcomes. Thus, the role of prenatal factors in developmental programming and the magnitude of the effect of postnatal factors on lean mass remain an important question requiring further study.

Due to high measurement precision and the existence of the QMR technology for body composition measurements across the lifespan, skinfold equations could be developed with QMR as the criterion measure for populations at different ages including during the first year of life. Triceps and thigh skinfold thicknesses positively predicted FM at 54 weeks. Triceps skinfold reflects upper extremity FM distribution, which along with subscapular skinfold has been used in equations to estimate percent body fat in pediatric populations.[25–27] However, the body fat prediction equations commonly used in neonate and infant populations have not been validated across the entire first year nor have they been validated against different criterion methods.[27,28] Moreover, longitudinal changes in TBW in offspring may confound estimates from skinfold prediction equations.[19] Our findings suggest that thigh skinfold, a marker of lower peripheral fat/adiposity could be an important site to incorporate into skinfold equations. In the current analysis, using stepwise regression, thigh was consistently a significant predictor of FM and LM. Further investigation of childhood body composition using QMR would allow insight on the dynamic role of TBW and FM densities beginning at birth and across the lifespan.[19,29,30] For example, when the model was run to include QMR total water as a predictor of FM, child length was no longer a predictor, and the skinfold predictors were iliac and thigh. Historically, the triceps site is assumed to represent both upper and lower limb adiposity.[25,26] Comparison studies demonstrate wider limits of agreement between skinfold thickness and other two compartment methods, ADP27 and DXA,[31] and a criterion method TBW.[32] Given that the QMR methodology provides estimates of TBW, FM and LM while accommodating offspring at birth through 1 year,[29,30] new skinfold equations for predicting FM should be developed using QMR as the criterion method. These variables may guide site selection across childhood years to produce more robust prediction equations, providing clinicians with information on cross-sectional FM along with rate of FM gain in early life and into childhood.[29,30]

There are limitations to this study. LIFT did not assess variables known to influence post-natal development such as breastfeeding, physical activity, overall dietary intake and other factors. There is much evidence to support measurable albeit unclear effects of breastfeeding and formula-feeding on body composition outcomes,[2,9,33] and we acknowledge this as a limitation to interpretation of the greater head circumference in the intervention group at 54 weeks. Moreover, the generalizability of these findings to the wider pediatric population (external validity) is unknown. Strengths of the study include having precise collection of the primary outcome variables of FM and LM by QMR in a study that was rigorously conducted. The developed models are parsimonious with less than five predictor variables.

## 6 | CONCLUSIONS

The intervention effects that showed greater infant lean mass at birth were not sustained at 14 and 54 weeks of age. Unmeasured early life factors that influence growth and body composition, not limited to nutrition and diet as examples, and not measured in this study, strongly impact post-natal growth and body composition. Future studies investigating the effects of GWG intervention on fetal programming should include the first trimester and the postnatal period. Further consideration should be given to studies involving the development of skinfold equations that more accurately estimate FM throughout the first year of life with consideration to both anatomical measurement site selection and criterion method as evidenced by the consistent observation of thigh skinfold as a predictor. Finally, fetal programming of lean mass remains an important question as evidenced by the persistence of a greater head circumference in the intervention offspring at 54 weeks.

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### What is already known on this subject

- Excessive gestational weight gain (GWG) is associated with higher birth weights and overweight/obesity in later childhood
- The sustained effect of attenuated GWG in women with overweight/obesity on infant body composition remains unknown

**What this study adds**

- There was no sustained effect of lifestyle intervention to control maternal GWG on infant fat and fat-free mass at 54 weeks
- Offspring born to mothers in the lifestyle intervention arm had larger head circumference at birth and the effect remained at 54 weeks
- A larger head circumference was associated with lower infant fat and greater lean mass at 54 weeks.

## TABLE 1

Infant delivery and baseline characteristics[16]

| | Lifestyle intervention (n = 97) | Usual care (n = 99) | *P*-value |
|---|---|---|---|
| **Birth mode** | | | |
| Vaginal | 68 (70%) | 68 (69%) | 0.83 |
| Caesarean | 29 (30%) | 31 (31%) | |
| **Preterm birth** | | | |
| **<31 wk, 6 d** | 2 (2%) | 0 (0%) | 0.17 |
| **32 wk, 0 d-36×, 6 d** | 3 (3%) | 7 (7%) | |
| **Full term birth** | 92 (95%) | 92 (93%) | |
| **Small for gestational age (<10th percentile)** | 8 (8%) | 13 (14%) | 0.26 |
| **Large for gestational age (>90th percentile)** | 10 (10%) | 6 (6%) | 0.28 |
| **Infant sex** | | | |
| Female | 44 (45%) | 46 (46%) | 0.88 |
| Male | 53 (55%) | 53 (54%) | |
| **Gestational age (wk)** | 39.4 (1.9) | 39.4 (1.7) | 0.89 |
| **Birth weight (g)** | 3373 (587) | 3235 (532) | 0.08 |
| **Weight for age z-score** | 0.09 (1.30) | −0.19 (1.23) | 0.13 |
| **Birth length (cm)** | 51.3 (2.7) | 50.6 (2.9) | 0.07 |
| **Length for age z-score** | 0.92 (1.41) | 0.54 (1.55) | 0.07 |

*Note:* Values are n (%) for categorical variables and mean ± SD for continuous variables.

## TABLE 2

Infant anthropometry and body composition measurements at birth, 14 and 54 wk

| | At birth | | | | 14 wk | | | | 54 wk | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **LI N = 97** | **UC N = 99** | **Adj Diff**[a] | ***P* value**[a] | **LI N = 86** | **UC N = 83** | **Adj Diff**[b] | ***P* value**[b] | **LI N = 89** | **UC N = 88** | **Adj Diff**[b] | ***P* value**[b] |
| Age (d) (wk) | 2.86 (5.34) | 3.32 (6.26) | −0.35 (0.70) | 0.62 | 15.0 (2.8) | 15.1 (3.5) | | 0.92 | 58.1 (13.5) | 59.4 (20.2) | | 0.61 |
| **Anthropometry** | | | | | | | | | | | | |
| Study weight (g) (kg) | 3229 (526) | 3108 (500) | 131 (59) | 0.03 * | **N = 86** 6.23 (0.88) | **N = 82** 6.16 (1.04) | 0.11 (0.13) | 0.40 | **N = 89** 9.93 (1.32) | **N = 87** 9.99 (1.79) | 168 (183) | 0.36 |
| Study length (cm) | 49.6 (2.5) | 49.4 (2.3) | 0.3 (0.3) | 0.33 | **N = 86** 61.54 (2.92) | **N = 83** 61.19 (2.99) | 0.45 (0.37) | 0.22 | 76.54 (4.21) | 76.22 (5.19) | 0.70 (0.42) | 0.10 |
| Ponderal index (kg/m$^3$) | 26.2 (1.9) | 25.6 (2.1) | 0.7 (0.3) | 0.02 * | **N = 86** 26.70 (2.62) | **N = 82** 26.75 (2.12) | 0.01 (0.41) | 0.99 | **N = 89** 22.19 (2.39) | **N = 86** 22.37 (2.05) | −0.10 (0.30) | 0.74 |
| Head circumference (cm) | 34.33 (1.52) | 33.97 (1.49) | 0.38 (0.17) | 0.03 * | **N = 84** 40.92 (1.40) | **N = 83** 40.71 (1.62) | 0.19 (0.19) | 0.33 | **N = 88** 46.60 (1.56) | **N = 88** 46.31 (1.76) | 0.46 (0.21) | 0.03 * |
| Skinfolds | **N = 97** | **N = 99** | | | **N = 85** | **N = 83** | | | **N = 89** | **N = 88** | | |
| Triceps (mm) | 4.83 (1.35) | 4.65 (1.11) | 0.20 (0.17) | 0.26 | 9.49 (2.00) | 9.48 (1.83) | 0.06 (0.31) | 0.85 | 10.11 (2.73) | 9.87 (2.57) | 0.47 (0.40) | 0.24 |
| Subscapular (mm) | 4.55 (1.27) | 4.32 (1.17) | 0.25 (0.17) | 0.14 | 8.189 (6.62) | 7.25 (1.83) | 1.14 (0.81) | 0.16 | 6.85 (1.98) | 6.90 (1.93) | 0.14 (0.30) | 0.65 |
| Iliac crest (mm) | 3.97 (0.95) | 3.91 (0.99) | 0.08 (0.13) | 0.54 | 9.68 (2.76) | 9.30 (2.63) | 0.36 (0.44) | 0.41 | 9.25 (3.25) | 9.05 (2.91) | 0.45 (0.48) | 0.36 |
| Thigh (mm) | 5.93 (1.89) | 5.66 (1.57) | 0.29 (0.24) | 0.22 | 17.89 (3.62) | 17.89 (4.79) | 0.08 (0.67) | 0.90 | 17.06 (4.51) | 16.71 (3.82) | 0.60 (0.65) | 0.35 |
| Central[c] (mm) | 8.52 (2.10) | 8.23 (2.01) | 0.33 (0.28) | 0.24 | 17.86 (7.62) | 16.56 (4.07) | 1.50 (1.01) | 0.14 | 16.09 4.88) | 15.95 (4.45) | 0.58 (0.73) | 0.42 |
| Peripheral[d] (mm) | 10.76 (3.09) | 10.32(2.54) | 0.49 (0.39) | 0.21 | 27.38 (5.05) | 27.37 (6.03) | 0.14 (0.89) | 0.87 | 27.17 (6.69) | 26.59 (5.84) | 1.09 (0.96) | 0.26 |
| Sum of skinfolds[e] (mm) | 19.29 (5.03) | 18.55(4.41) | 0.82 (0.65) | 0.20 | 45.25(10.41) | 43.92 (9.29) | 1.64 (1.60) | 0.31 | 43.26 (10.89) | 42.57 (9.64) | 1.66 (1.59) | 0.30 |
| **Body composition** | | | | | | | | | | | | |
| PEA POD | **N = 95** | **N = 96** | | | **N = 70** | **N = 66** | | | – | – | – | |
| Percentage fat (%) | 10.9 (4.34) | 10.10 (3.90) | 0.79 (0.55) | 0.16 | 24.0 (4.7) | 24.7 (4.9) | −0.74 (0.88) | 0.40 | – | – | – | |
| Fat mass (g) | 360 (173) | 324 (157) | 38 (22) | 0.08 | 1493 (436) | 1536 (466) | −28 (83) | 0.74 | – | – | – | |
| Fat-free mass (g) | 2871 (404) | 2786 (405) | 98 (45) | 0.03 * | 4661 (634) | 4588 (586) | 137 (83) | 0.10 | – | – | – | |
| **QMR (g)** | **N = 82** | **N = 87** | | | **N = 80** | **N = 72** | | | **N = 72** | **N = 67** | | |
| Total fat mass (g) | 542 (189) | 509 (179) | 32 (24) | 0.19 | 1759 (450) | 1787 (586) | 14 (80) | 0.86 | 2838 (855) | 2752 (781) | 148 (124) | 0.24 |
| Total lean mass (g) | 2327 (325) | 2211 (314) | 105 (38) | 0.006 ** | 3724 (484) | 3665 (445) | 100 (63) | 0.12 | 5395 (585) | 5306 (563) | 117 (92) | 0.20 |

| | At birth | | | | 14 wk | | | | 54 wk | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **LI N = 97** | **UC N = 99** | **Adj Diff[a]** | ***P* value[a]** | **LI N = 86** | **UC N = 83** | **Adj Diff[b]** | ***P* value[b]** | **LI N = 89** | **UC N = 88** | **Adj Diff[b]** | ***P* value[b]** |
| Total body water (g) | 2452 (334) | 2342 (320) | 97 (40) | 0.02 * | 3802 (471) | 3757 (416) | 86 (62) | 0.17 | 5194 (636) | 5177 (520) | 33 (98) | 0.74 |

[a]Adjusted differences, estimate (SE) and *P* value were obtained using ANCOVA with covariates including mother's baseline age, mother's baseline body mass index, mother's ethnicity, infant's gestational age at birth, infant's age at measurement and infant's sex.

[b]Adjusted differences (14 and 54 wk), estimate (SE) and *P* value were obtained using ANCOVA with covariates including mother's baseline age, mother's baseline body mass index, maternal gestational weight gain, infant's age at measurement and infant's sex.

[c]Central is the sum of subscapular and iliac crest.

[d]Peripheral is the sum of triceps and thigh.

[e]Sum of skinfolds is triceps and subscapular and iliac crest and thigh.

* $P < 0.05$.

** $P < 0.01$.

## TABLE 3

Predictors of infant fat mass (kg) assessed by QMR at age 54 weeks (n = 137)

| | | | 95% CI | | |
|---|---|---|---|---|---|
| | **Coefficient** | **SE** | **Lower** | **Upper** | ***P* value** |
| Weight (kg) | 0.446 | 0.05 | 0.342 | 0.551 | <0.001 |
| Length (cm) | −0.054 | 0.02 | −0.089 | −0.019 | 0.003 |
| Head circumference (cm) | −0.069 | 0.03 | −0.128 | −0.011 | 0.021 |
| Thigh (mm) | 0.050 | 0.01 | 0.029 | 0.072 | <0.001 |
| Triceps (mm) | 0.035 | 0.02 | 0.002 | 0.067 | 0.037 |
| Constant[a] | 4.582 | 1.48 | 1.656 | 7.508 | 0.002 |

Abbreviation: CI, confidence intervals.

[a] R squared = 0.72, RMSE = 0.373kg.

## TABLE 4

Predictors of infant lean mass (kg) assessed by QMR at age 54 weeks (n = 137)

| | | | 95% CI | | |
|---|---|---|---|---|---|
| | Coefficient | SE | Lower | Upper | *P*-value |
| Weight (kg) | 0.205 | 0.05 | 0.109 | 0.301 | <0.001 |
| Length (cm) | 0.052 | 0.02 | 0.019 | 0.084 | 0.002 |
| Head circumference (cm) | 0.109 | 0.03 | 0.055 | 0.164 | <0.001 |
| Thigh (mm) | −0.048 | 0.01 | −0.066 | −0.031 | <0.001 |
| Constant[a] | −4.778 | 1.37 | −7.488 | −2.068 | 0.001 |

Abbreviation: CI, confidence intervals.

[a] R squared = 0.64, RMSE = 0.350kg.