OBSTETRICS

Variations in resting energy expenditure: impact on gestational weight gain

Q4 Ek Berggren, MD; P. O'Tierney-Ginn, PhD; S. Lewis; L. Presley, BA; S. Hauguel De-Mouzon, PhD; P. M. Catalano, MD

BACKGROUND: There are significant variations in gestational weight gain, with many women gaining in excess of the Institute of Medicine guidelines. Unfortunately, efforts to improve appropriate gestational weight gain have had only limited success. To date, interventions have focused primarily on decreasing energy intake and/or increasing physical activity. Maternal resting energy expenditure, which comprises ~60% of total energy expenditure compared with the ~20% that comes from physical activity, may be an important consideration in understanding variations in gestational weight gain.

OBJECTIVE: Our objective was to quantify the changes in resting energy expenditure during pregnancy and their relationship to gestational weight gain and body composition changes among healthy women. We hypothesized that greater gestational weight gain, and fat mass accrual in particular, are inversely related to variations in resting energy expenditure.

STUDY DESIGN: We conducted a secondary analysis of a prospective cohort studied before conception and late pregnancy (34–36 weeks). Body composition (estimated using air densitometry; BodPod) and resting energy expenditure (estimated using indirect calorimetry) were measured. The relationship between the changes in resting energy expenditure and gestational weight gain and the change in fat mass and fat-free mass were quantified. Resting energy expenditure was expressed as kilocalories per kilogram of fat-free mass per day (kilocalories per kilogram of fat-free mass^{-1}/day^{-1}) and kilocalories per day. Correlations are reported as r.

RESULTS: Among 51 women, preconception body mass index was 23.0 (4.7) kg/m^2; gestational weight gain was 12.8 (4.7) kg. Preconception and late pregnancy resting energy expenditure (kilocalories per day) correlated positively with the change in fat-free mass (r = 0.37, P = .008; r = 0.51, P = .001). Late-pregnancy resting energy expenditure (kilocalories per kilogram of fat-free mass^{-1}/day^{-1}) was inversely associated with the change in fat mass (r = −0.34, P = .02) and gestational weight gain (r = −0.29, P = .04). From before pregnancy through late gestation, the increase in resting energy expenditure (kilocalories per day) correlated positively with the change in fat-free mass (r = 0.44, P = .002) and negatively with the change in fat mass (r = −0.27, P = .06).

CONCLUSION: The change in resting energy expenditure from before conception through late gestation correlated positively with changes in fat-free mass but negatively with fat mass accrual. Women with smaller increases in resting energy expenditure across pregnancy had greater gestational weight gain, specifically more adipose tissue. These data suggest that resting energy expenditure is an important factor in gestational weight gain, particularly excess fat mass accrual. Future lifestyle intervention studies need to consider clinically feasible means of estimating resting energy expenditure and, in response, tailor nutrient intake and composition recommendations. Implementing and testing such interventions would be a novel approach to improve compliance with gestational weight gain guidelines.

Key words: body composition, fat mass, gestational weight gain, indirect calorimetry, maternal fat mass, pregnancy, resting energy expenditure

There are wide variations in gestational weight gain in pregnancy. Currently more than half of US women exceed the 2009 Institute of Medicine Guidelines.[1,2] Excess gestational weight gain is associated with adverse short and long-term maternal and neonatal morbidity, especially among normal-weight women.[1,3,4]

The prevailing assumption is that variations in gestational weight gain relate primarily to excess in energy intake and/or decreases in physical activity. Therefore, to improve compliance with the Institute of Medicine Guidelines, as shown in Table 1, multiple lifestyle intervention trials using various diets and increasing physical activity have been conducted.[5-7] Unfortunately, to date, lifestyle intervention trials have had limited success at mitigating excess gestational weight gain or significantly improving maternal or neonatal outcomes.[5]

An important concept in energy balance is that total energy expenditure is composed not only of physical activity (~20%) but also primarily of resting energy expenditure or basal metabolic rate, accounting for approximately 60% of total energy expenditure.[8] The remainder includes the energy required to digest and absorbing food (dietary induced thermogenesis) and facultative thermogenesis (ie, responses to environmental changes in temperature).[8]

Worldwide there are wide variations [T1] in change in total energy expenditure over the course of pregnancy. Estimates of total energy expenditure range from a net savings of 24,000 kcal in women who did not have nutrient supplementation during pregnancy in the Republic of Gambia[9] to a net cost of more than 60,000 kcal in a European population[10] as well as wide variations within populations.[9]

Given its substantial contribution to total energy expenditure, maternal resting energy expenditure may be an important consideration in understanding variations in gestational weight gain. Thus, the aim of this research was

Cite this article as: Berggren E, O'Tierney-Ginn P, Lewis S, et al. Variations in resting energy expenditure: impact on gestational weight gain. Am J Obstet Gynecol 2017;xxx:xx-xx.

0002-9378/$36.00

http://dx.doi.org/10.1016/j.ajog.2017.05.054

Click Video under article title in Contents at **ajog.org**

FLA 5.4.0 DTD ■ YMOB11701_proof ■ 17 June 2017 ■ 10:46 am ■ ce

to determine the changes in resting energy expenditure during pregnancy and the relationship to gestational weight gain and body composition in healthy women. We hypothesized that increases in gestational weight gain and fat mass in particular are inversely related to variations in resting energy expenditure.

Materials and Methods

Study design

This was a secondary analysis of a prospective observational cohort of women who were recruited before a planned pregnancy. The objective of the primary study was to examine the prospective longitudinal changes in maternal carbohydrate metabolism, body composition, and energy expenditure in women with normal glucose tolerance and women developing gestational diabetes. Study procedures before conception and in late pregnancy were part of a larger research protocol, as has been described elsewhere.[10,11]

The primary study procedures were conducted during 2 outpatient visits at Medical Center Hospital of Vermont from 1985 through 1991 and MetroHealth Medical Center, Cleveland, OH, from 1990 through 1998.[10,11] Study visits to the clinical research units were performed at approximately 3 months before conception (median 3, interquartile range [1−7] months) during the follicular phase of the menstrual cycle and in late (33 0/7 to 36 6/7 weeks) pregnancy.

The research protocol was approved by the respective institutional review boards, and written informed consent was obtained from each participant.

Study cohort

Healthy women recruited for the original study were planning a pregnancy, not breast-feeding or using hormonal contraception, nonsmokers, and had no known preexisting metabolic disorders (hypertension, diabetes, hyper- or hypothyroidism). After enrollment and consent, the preconception study visit included collection of maternal demographic data and completion of a 75 g oral glucose tolerance test to confirm absence of preexisting diabetes mellitus.[12] For each visit, women presented after an 8-10 hour overnight fast. Study procedures relevant for the current analysis are described in detail.

TABLE 1
2009 Institute of Medicine guidelines for weight gain in pregnancy

Prepregnancy body mass index	Body mass index, kg/m^2	Total weight gain, lb	Rates of weight gain second and third trimesters, lb/wk (mean range)
Underweight	<18.5	28−40	1 (1−1.3)
Normal weight	18.5−24.9	25−35	1 (0.8−1)
Overweight	25.0−29.9	15−25	0.6 (0.5−0.7)
Obese (all classes)	>30.0	11−20	0.5 (0.4−0.6)

Berggren et al. Energy expenditure and gestational weight gain. Am J Obstet Gynecol 2017.

Study procedures

Two weeks before their preconception visit, women met with a research nutritionist and were instructed to maintain a diet with macronutrient intake of 50% carbohydrate, 20% protein, and 30% fat. This counseling was reinforced as part of routine clinical care once a woman was pregnant, whether she remained normoglycemic or was diagnosed with gestational diabetes at the time of routine third-trimester screening.[13]

For a subset of women, diet and activity information was collected. Dietary intake was collected using a 24 hour recall food frequency questionnaire, reporting total kilocalories per day. Activity was measured using a leisure time activity questionnaire.[14]

Body composition was estimated using hydrodensitometry with correction for residual lung volume.[15] Body fat percentage was calculated according to the equations of Keys and Brozek before conception[16] and Catalano et al[17] in late pregnancy, adjusting for the changes in hydration constant in fat-free mass (FFM) in late pregnancy.

Data are reported as total kilograms, kilograms of fat mass (FM), kilograms of FFM, and percentage body fat (kilograms of FM/kilograms of total body weight × 100). For this analysis, current World Health Organization definitions for body mass index (BMI; kilograms per square meter) and Institute of Medicine Guidelines for gestational weight gain defined, respectively, BMI class (underweight, normal weight, overweight, obese),[18] and gestational weight gain adherence (inadequate, adequate, excess).[1]

Indirect calorimetry was performed after an 8−10 hour overnight fast with a ventilated hood system that was used for continuous collection and mixing of expired air as previously described.[10,11] Briefly, measurements of oxygen consumption and carbon dioxide production were collected over 45 minutes with the participant reclined, usually watching television.

Standard gases were used before and after each procedure to calibrate oxygen (Applied Electrochemistry, Sunnyvale, CA, or Magnos 4G; Hartmann & Braun, Frankfurt, Germany) and infrared carbon dioxide (Applied Electrochemistry, Sunnyvale, CA, or Uras 3G, Hartmann & Braun, Frankfurt, Germany) analyzers.

The coefficient of variation is 2−3% for indirect calorimetry measures. The total volume of expired air was corrected for standard temperature and pressure conditions. Data were collected every 10 seconds, averaged, and reported as a 5 minute average of total resting metabolic rate (kilocalories per minute); data for this analysis were converted to and are reported as kilocalories per day.

Statistical analysis

We described the full cohort, reporting mean and SD for continuous variables and proportions with total n (percentage) for categorical variables and compared the percentage change from preconception to late pregnancy using paired Student *t* tests. We compared adherence to Institute of Medicine gestational weight gain guidelines for

FLA 5.4.0 DTD ■ YMOB11701_proof ■ 17 June 2017 ■ 10:46 am ■ ce