OBSTETRICS

A systematic review and metaanalysis of energy intake and weight gain in pregnancy

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BACKGROUND: Gestational weight gain within the recommended range produces optimal pregnancy outcomes, yet many women exceed the guidelines. Official recommendations to increase energy intake by ∼ 1000 kJ/day in pregnancy may be excessive.

OBJECTIVE: To determine by metaanalysis of relevant studies whether greater increments in energy intake from early to late pregnancy corresponded to greater or excessive gestational weight gain.

DATA SOURCES: We systematically searched electronic databases for observational and intervention studies published from 1990 to the present. The databases included Ovid Medline, Cochrane Library, Excerpta Medica DataBASE (EMBASE), Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Science Direct. In addition we hand-searched reference lists of all identified articles.

STUDY ELIGIBILITY CRITERIA: Studies were included if they reported gestational weight gain and energy intake in early and late gestation in women of any age with a singleton pregnancy. Search also encompassed journals emerging from both developed and developing countries.

STUDY APPRAISAL AND SYNTHESIS METHODS: Studies were individually assessed for quality based on the Quality Criteria Checklist obtained from the Evidence Analysis Manual: Steps in the academy evidence analysis process. Publication bias was plotted by the use of a funnel plot with standard mean difference against standard error. Identified studies were meta-analyzed and stratified by body mass index, study design, dietary methodology, and country status (developed/developing) by the use of a random-effects model.

RESULTS: Of 2487 articles screened, 18 studies met inclusion criteria. On average, women gained 12.0 (2.8) kg (standardized mean difference = 1.306, $P < .0005$) yet reported only a small increment in energy intake that did not reach statistical significance (∼475 kJ/day, standard mean difference = 0.266, $P = .016$). Irrespective of baseline body mass index, study design, dietary methodology, or country status, changes in energy intake were not significantly correlated to the amount of gestational weight gain ($r = 0.321$, $P = .11$).

CONCLUSION: Despite rapid physiologic weight gain, women report little or no change in energy intake during pregnancy. Current recommendations to increase energy intake by ∼ 1000 kJ/day may, therefore, encourage excessive weight gain and adverse pregnancy outcomes.

Key words: energy intake, first trimester, gestational weight gain, pregnancy, third trimester

In developed nations, one third or more of women of childbearing age are overweight or obese.[1-3] Excessive preconception body weight is a recognized risk factor for adverse pregnancy outcomes, including gestational diabetes mellitus, pregnancy-induced hypertension, preeclampsia, and caesarean delivery.[4] Maternal obesity also is linked to increased risk of macrosomia,[3] stillbirth,[5] preterm birth,[6] and congenital malformation.[7] Offspring of overweight and obese women are at increased risk of obesity in childhood and young adulthood, thereby creating an intergenerational vicious cycle.[8-10]

Restricting or optimizing gestational weight gain (GWG) is one of the few interventions that can reduce adverse pregnancy outcomes.[11] The Institute of Medicine (IOM) specifies ranges of desirable weight gain for underweight, normal weight, overweight, and obese pregnant women that have been adopted by other countries[12]; however, many pregnant women gain more than is optimal[13] and find it difficult to lose the excess weight postpregnancy.[14]

A logical assumption is that additional food intake is required to achieve the desirable rate of weight gain in pregnancy. Indeed, mathematical models have been developed to determine the theoretical additional energy costs involved in pregnancy.[15] The cumulative absolute cost for women with a normal body mass index (BMI) and a mean GWG of 12.0 kg has been estimated to be ∼320 MJ, distributed as an additional 0−300 kJ/day in the first trimester, 1000−1500 kJ/day in the second, and 1800−2100 kJ/day in the third.[16] Nonetheless, energy requirements during pregnancy will be influenced by multiple factors, including prepregnancy weight, BMI, maternal age, stage of gestation, rate of GWG, and increases in energy expenditure relating

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to an increase in body mass and, hence, basal metabolic rate (BMR).[17,18]

Despite the theory, recent studies suggest that the current generation of women consume very little additional food energy to sustain a healthy pregnancy. A metaanalysis of 23 studies in well-nourished women reported an average increase of only ~140 kJ/day, that is, a small fraction of the theoretical calculation or current recommendations.[17] It is conceivable that pregnant women now require less energy than earlier generations as the result of reductions in incidental physical activity and increasing sedentariness.[19] Pregnancy guidelines that recommend an additional 2000 kJ/day in the third trimester may result in excessive GWG and adverse pregnancy outcomes.

In this analysis, our objective was to determine whether a greater increment in reported energy intake from early to late pregnancy corresponded to greater or excessive GWG. We systematically searched for observational and randomized controlled trials published during the past 25 years that reported GWG along with energy intake in early and late pregnancy.

Methods

Search strategy

A systematic literature search was undertaken in August to October 2014 by 2 independent student dietitians (J.M. and H.J.). A starting date of 1990 was specified so that the outcomes reflected the current generation of women whose pregnancy advice may have been influenced by the IOM guidelines.[20] We searched Ovid Medline, Cochrane Library, Excerpta Medica DataBASE (EMBASE), Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Science Direct for studies that reported energy intake in early and late pregnancy and GWG in singleton pregnancies in women of any age. Randomized controlled trials (RCTs) and observational, cohort, and longitudinal studies were eligible for inclusion. The following search terms were used: "pregnant" OR "pregnancy" OR "pregnant woman" OR "gestation" OR "maternal" AND "energy intake" OR "macronutrient" OR "dietary fat" OR "dietary proteins" OR "dietary carbohydrate" OR "dietary intake" OR "calorie intake" OR "kilojoule intake" AND "weight gain" OR "body weight" OR "weight change" OR "body mass index" OR "BMI." Hand-searching was conducted to identify additional studies. Studies reported as withdrawn in the database, and retrospective studies that preceded 1990 were excluded.

Study selection

Full-term pregnancy was defined as 37−42 weeks' gestation.[21] Women were classed as underweight, normal, overweight, and obese category according to the IOM criteria. Countries were classified as "developed" or "developing" on the basis of the criteria from the United Nations.[22] In relation to energy intake, early and later pregnancy were defined by time points (t_1 and t_2) at least 12 or more weeks apart, where t_1 <18 weeks and t_2 >30 weeks' gestation (studies reporting data at intervals <12 weeks were excluded). GWG was recorded as the mean ± SD, where data was collected at <18 weeks (t_1) and >34 weeks' gestation (t_2), except in 2 studies,[23,24] where the value was calculated as the difference in weight at the 2 time points and the SD was calculated.[25] Studies published in a language other than English were excluded if a translation was not available. In the RCTs, the control and intervention groups were analyzed as separate groups. Efforts were made to contact authors for additional data regarding their respective studies.

Data extraction

Data were extracted independently by the use of standardized forms in an Excel spreadsheet (Microsoft, Redmond, WA) that collected information on author, title, study type, year published, quality rating, population characteristics (country, age, number of participants, BMI, parity), dietary collection method, weeks' gestation at time of data collection, energy intake at 2 time points (t_1 and t_2), macronutrient intake (g or % energy), weight (t_1 and t_2), and GWG. Data were cross-checked for accuracy and discrepancies resolved through discussion or involvement of a third party (J.C.B.M. or J.C.Y.L.).

Statistical analysis

The primary outcome measures were standardized mean difference (SMD) in energy intake and GWG from early to late pregnancy. Data were meta-analyzed collectively and stratified by developed and developing countries, BMI (underweight, normal, overweight, and obese), study design (observational and RCT), and dietary assessment methodology. A random-effect model assumed heterogeneity among studies. The Mood median test was used to test the equality of medians of SMD for energy intake and weight gain between developed and developing countries. Because of small sample sizes within each BMI group, the median GWG and interquartile range (IQR) were used to assess mean weight gain compared with the IOM recommendations.

To calculate SMDs of mean weight gain between 2 time points ($t_{1\ \text{and}}\ t_2$), a Spearman correlation coefficient of 0.85 was applied.[26] Similarly for the 26 subgroups with reported energy intake at $t_{1\ \text{and}}\ t_2$, a Spearman correlation coefficient of 0.74 was assumed. For the studies that provided a range for weight rather than SD, a value was imputed where $r=0.85$. Analyses were repeated with $r=0.8$ or 0.9 and $r=0.7$ or 0.8 for weight and energy, respectively; however, this did not alter findings. Data were analyzed with the Comprehensive Meta-Analysis (CMA) package, version 2.2 (Biostat, Englewood, NJ), and presented in the form of forest plots. P values of <.01 were considered statistically significant because 7 comparisons were made in this study, including BMI, country's economic status, dietary collection method, study type, energy intake, macronutrient distribution, and GWG. This was achieved using Bonferroni correction, which divides the original $P = .05$ by the number of estimates made, producing a new $P = .007$, which was rounded to .01.

Assessment of risk of bias

Studies were assessed individually at a study level for bias and quality based on the Quality Criteria Checklist obtained