Adolescents with Adequate Birth Weight Newborns Diminish Energy Expenditure and Cease Growth

Esther Casanueva,* María Emilia Roselló-Soberón, Luz María De-Regil, María del Carmen Argüelles, and María Isabel Céspedes

Public Health Research Branch, Instituto Nacional de Perinatología, Isidro Espinosa de los Reyes, 11000, Mexico City, Mexico

Abstract

Maternal energy requirements increase during pregnancy but the magnitude of this increment is unknown among adolescents. We determined the effects of maternal age and weight status on adjustments in gestational weight gain, resting energy expenditure (REE), and growth among adolescents. Weight, and growth rates of pregnant adolescents (PA) ≤17 y of age during late pregnancy were compared with changes in nonpregnant adolescents (NPA) over a 5-mo period. REE was also measured monthly in the PA group. Paired t-tests and general linear models for repeated measures were used for the analysis; height was included as a confounding variable. Weight, height, and BMI of the PA and NPA women did not differ at baseline. During the follow-up period, NPA grew 0.94 ± 0.30 cm; growth rate was greater in adolescents ≤14 y of age (P < 0.001) than in the older subjects. No growth occurred in the PA group. REE tended to increase linearly between wk 20 and 36 wk of gestation (P = 0.164); the net change in women >14 y (25%) tended (P = 0.164) to be greater than that of younger adolescents (7%). The mean increment of REE from wk 20 to wk 36 was 230 ± 60 kcal/d (962 ± 236 kJ/d) and the smallest increase occurred in women with BMI <20 (P = 0.010). Women with BMI ≥20 had a decrease in REE/kg that was greater than that of normal weight (BMI 20–25) or overweight (BMI ≥25) women (within subject, P = 0.010; between subject, P = 0.001). In conclusion, PA appear to adjust their resting energy needs by ceasing growth. J. Nutr. 136: 2498–2501, 2006.

Introduction

According to the Food and Agriculture Organization, World Health Organization, and the United Nations University Expert Committee, additional energy is required to support metabolic demands and fetal growth during pregnancy to deliver infants with adequate weight at term and to maintain maternal weight, body composition, and physical activity at levels necessary for good health and well-being (1). Butte and King (2) estimated that women who gain 12 kg during pregnancy need an additional 321 MJ (76,705 kcal) to achieve good fetal outcomes and to store the 3–4 kg of fat necessary to support lactation. However, studies carried out in Thailand, Philippines, Gambia, and some European countries indicate that insufficient energy intake during pregnancy is compensated by decreasing physical activity and diminishing fat deposition to exhibit good reproductive performance (3–6). These adjustments among populations are also related to pregestational maternal fat stores (7); in general, the net change in resting energy expenditure (REE)1 in thin women is lower than in those with normal weight.

Pregnant adolescents have twice the risk of delivering a preterm infant with a low birth weight or of having obstetric complications (8). Actually, teens gaining similar amounts of weight as mature women tend to have smaller babies (9–11). A reduction in placental nutrient flow and maternal-fetal competition for nutrients are 2 of several mechanisms that may explain intrauterine growth retardation (12,13). Nevertheless, there is still not enough information that allows elucidating energy metabolism adaptations in teen pregnancies to achieve good fetal outcomes. Therefore, the purpose of this study was to determine the effect of maternal age and BMI on gestational weight gain, REE, and linear growth among adolescents under 17 y who had adequate pregnancy outcomes (weight at birth >2500 g and gestational age ≥37 wk).

Subjects and Methods

Of the 120 adolescents invited to participate, 60 were pregnant (PA) and 60 were nonpregnant (NPA). The inclusion criteria for the PA were that they had to be ≤17 y of age and free of chronic diseases. Additionally, they were required to provide an accurate date of their last menstrual period, have a singleton pregnancy, be ≥20 wk pregnant, and be receiving prenatal care at the Instituto Nacional de Perinatología (INPer) in Mexico City. Women were excluded if they developed hypertension or diabetes during gestation, had preterm birth, or a low birth

1 Abbreviations used: INPer, Instituto Nacional de Perinatología; NPA, nonpregnant adolescents; PA, pregnant adolescents; REE, resting energy expenditure.

* To whom correspondence should be addressed. E-mail: casanuev@servidor.unam.mx.
weight infant (<2500 g). The NPA were healthy students recruited from a public school near INPer and were individually matched to PA by socioeconomic level, chronological age, menarche age, and BMI.

Baseline information on socioeconomic status was recorded using the scale of the Asociación Mexicana de Agencias de Estudios de Mercado (Mexican Association of Marketing and Opinion Research), in which purchasing power is classed into 6 categories (14). The study protocol was reviewed and approved by INPer’s Research and Ethics Committees, and informed consent of the PA and NPA and their parents or caregivers was obtained.

**Anthropometric measurements.** Height was measured using an anthropometer with an accuracy of 1 mm (SECA 208); Maternal and neonatal weight was measured with an electronic scale accurate to 0.1 g (TANITA 1582); women wore a gown of known weight and no shoes or jewelry. All measurements were done in duplicate on the same day and by personnel trained according to standard techniques (15) with a CV <1%. PA were studied at 4-wk intervals between 20 and 36 wk of gestation and at 1-mo postpartum. Body weight was measured monthly. Height was recorded at the beginning of the study and at 1-mo postpartum to avoid the influence of the increased curvature of the spine typical of advanced pregnancy. Self-reported maternal weight before pregnancy and height at the wk 20 of gestation were used to calculate pregestational BMI.

Weight and height of NPA were measured at the school on 2 occasions 5 mo apart, which is comparable to measurements at 20 wk of gestation and 1-mo postpartum in the PA group.

**Gestational age.** Gestational age was estimated from the date of the last menstrual period and from characteristics of the newborn using the Capurro method (16). Participants were excluded from the study if estimates derived from the 2 methods differed by more than 2 wk.

**REE.** REE was measured in PA by indirect calorimetry, using a metabolic cart (Life Energy Systems MCM/TWO). Measurements were conducted on women in a semi-Fowler’s position after a 30-min rest period. The determination was performed between 0800 and 0900, after at least 10 h of fasting. Women were instructed to consume their usual diet the day before the test and to abstain from excessive exercise. When oxygen consumption had stabilized, VO2 and the VCO2 were measured and used to calculate REE according to Weir’s equation (17).

**Statistical analysis.** Differences between the growth rates and general characteristics of the PA and NPA were evaluated with Student’s *t* test for independent samples. In the PA group, general linear models for repeated measures were used (SPSS version 11.0) to evaluate longitudinal changes in body weight, REE (kcal/d), and REE [kcal/(kg · d)] at 20, 24, 28, 32, and 36 wk of pregnancy. The PA group was divided by age (≥14 y and <14 y) or BMI (≥20, 20–24.9, and ≥25) to evaluate their effects on weight, height, and REE changes. Height as a continuous variable was consistent with the low to middle class range. The age, height, and weight of the PA did not differ from that of the NPA (Table 1). The women were ~15 y of age, 154 cm tall, and weighed ~51 kg.

Infant birth weight were 3089 ± 413 g; none of the infants were born preterm or with low birth weight.

**Weight gain.** The PA gained 10.10 ± 4.6 (range: 5–23) kg between 20 and 36 wk (Table 2). There was a significant, linear increase in gestational weight gain between 20 and 36 wk gestation after adjusting by height. The amount of weight gained was related to the period of gestation and pregestational BMI (F = 55.93; *P* < 0.001) but not to age. The interaction between these 2 factors on weight gain was not significant. There was no association between maternal weight gain and newborn’s weight. The NPA gained 0.46 ± 0.10 kg and their BMI did not change during the study.

**Linear growth.** None of the PA grew during the follow-up period (Table 1), whereas the NPA grew 0.94 ± 0.30 cm during the 5-mo study period (*P* < 0.001; range, 0–2.3 cm). Among the NPA who grew, the younger teens (≤14 y) increased in height 0.5 ± 0.07 cm more than older ones (*P* < 0.02).

**Energy expenditure.** The mean increment of REE from wk 20 to 36 was 230 ± 30 kcal/d (962 ± 126 kJ/d); the net changes at the 25th, 50th, and 75th percentiles were 94, 174, and 333 kcal/d (393, 728, and 1393 kJ/d). REE tended to increase between 20 and 36 wk (*P* = 0.062); the interaction between gestational age and chronological age was significant after adjusting by height. When the PA was stratified into adolescents <14 y of age (*n* = 13) and those ≥14 y (*n* = 38), there were no differences at 20, 24, or 28 wk gestation (Table 2). However, at 32 wk, the REE of the 2 groups began to diverge, and at 36 wk gestation, the REE of PA > 14 y was ~10% higher than in the younger adolescents (*P* = 0.001). The REE of adolescents ≤14 y old increased by 7% during the last one-half of pregnancy, whereas it increased by 25% in adolescents >14 y relative to their baseline (*P* = 0.164). Although there was a significant difference in total REE (kcal/d) between adolescents ≤14 y of age and those >14 y (Table 2), age did not affect the pattern of change in REE/(kg · d). There was no association between REE and infant birth weight.

The net increase in REE was higher in women with pregestational BMI above 25 [213 kcal/d (891kJ/d)] than that of women with BMI below 20 [150 kcal/d (627kJ/d)]. The REE expressed as kcal/(kg · d) increased throughout pregnancy and was modified by pregestational BMI (gestational age · BMI, *F* = 2.06; *P* = 0.041). The differences between subjects stratified by BMI also were significant (*F* = 7.086; *P* = 0.002) (Fig. 1). In the

### TABLE 1 Characteristics of the study groups1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>PA</th>
<th>NPA</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>15.3 ± 1.1</td>
<td>15.3 ± 1.0</td>
<td>13–17</td>
</tr>
<tr>
<td>Gynecological age, y</td>
<td>3.6 ± 1.4</td>
<td>3.5 ± 1.3</td>
<td>1–8</td>
</tr>
<tr>
<td>Literacy, y</td>
<td>8.7 ± 1.3</td>
<td>9.0 ± 1.4</td>
<td>8–11</td>
</tr>
<tr>
<td>Height, cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>155.3 ± 0.42</td>
<td>154.8 ± 4.5</td>
<td>147–169</td>
</tr>
<tr>
<td>Final</td>
<td>155.3 ± 0.42</td>
<td>155.7 ± 4.5*</td>
<td>147–170</td>
</tr>
<tr>
<td>Pregestational wt, kg</td>
<td>51.5 ± 0.1</td>
<td>52.2 ± 10.5</td>
<td>46–70</td>
</tr>
<tr>
<td>BMI, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>25.4</td>
<td>25.6</td>
<td>16.9–19.8</td>
</tr>
<tr>
<td>20–24.9</td>
<td>62.7</td>
<td>58.1</td>
<td>20–24.9</td>
</tr>
<tr>
<td>≥25</td>
<td>11.8</td>
<td>16.2</td>
<td>25.1–27.7</td>
</tr>
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</table>

1 Values are mean ± SD. *Different from initial height (paired *t* test, *P* < 0.001).
thin women with BMI <20, REE · kg$^{-1}$.d$^{-1}$ decreased between 20 and 28 wk of gestation and did not change thereafter, although it remained higher than that of women with a greater BMI ($P = 0.01$). In normal (BMI 20–25) or overweight (BMI ≥25) women, REE/(kg · d) increased between 32 and 36 wk gestation.

### Discussion

Between wk 20 and 36 of gestation, adolescents gained 10.10 ± 4.6 kg, equivalent to 0.63 kg/wk. The Institute of Medicine recommends a weight gain of 0.4 kg/wk during trimesters 2 and 3 of pregnancy for women with normal BMI before pregnancy (18). The available literature indicates that adolescents should gain more weight than adults to bear infants with comparable birth weight (19). Our study confirms this: PA gained 50% more weight than adults to bear infants with comparable birth weight (18). The Institute of Medicine recommends a weight gain of 0.4 kg/wk during trimesters 2 and 3 of pregnancy for women with normal BMI before pregnancy (18). Our study confirms this: PA gained 50% more weight than adults to bear infants with comparable birth weight (19).

The cost of adaptation to the energy demands of pregnancy was expressed as a cessation of longitudinal growth. A check in growth rate can have long-term consequences because 20% of adult height is reached during adolescence (1); however, catch-up growth after pregnancy remains possible in this group.

Our findings are consistent with those of Scholl et al. (13), who found that teenagers that continued to grow during pregnancy gave birth to smaller infants. It would be tenuous to ascribe the cessation of growth observed in our study to factors other than pregnancy because the PA group had adequate weight gain and were compared with a matched control group that grew 0.94 cm. Moreover, the sample size was large enough to encompass variation in growth patterns between individuals.

In other studies, the adaptive cost of gestation was reflected in the weight of the newborn (7, 25). In contrast, the weight of all infants in our study was adequate at birth, even those delivered by adolescents ≤14 y old. Nonetheless, the amount of weight gained can be excessive and predispose women to future obesity; it was expressed as a cessation of longitudinal growth. A check in growth rate can have long-term consequences because 20% of adult height is reached during adolescence (1); however, catch-up growth after pregnancy remains possible in this group.

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recently reported that adolescents have significantly greater risk of developing postpartum obesity (26). We do not have information about fat deposition but we have previously demonstrated, in a similar population, that adolescents deposit less fat during pregnancy than adults (27). Therefore, it is likely probable that the teens of the present study followed the same pattern.

In summary, pregnant adolescents gaining 50% more weight than recommended have good fetal outcomes. However, these achievements are a consequence of metabolic adaptations that are expressed as a reduced REE especially in those very young and with a BMI <20, as well as a cessation of longitudinal growth. It is clear that data are still insufficient to establish energy and weight gain recommendations for appropriate physiological responses (REE), good fetal outcomes, and maintenance of maternal linear growth for this age group. The results of this study also indicate that it is necessary to evaluate the body composition and height of pregnant adolescents during pregnancy and postpartum y 1 to establish if growth is resumed without a modification of body composition.

**Acknowledgment**

We thank Dr. Janet King for her perceptive and helpful comments.

**Literature Cited**