Larger body size in childhood is correlated with earlier age at menarche; whether birth and infant body size changes are also associated with age at menarche is less clear. The authors contacted female participants enrolled in the New York site of the US National Collaborative Perinatal Project born between 1959 and 1963 ($n = 262$). This racially and ethnically diverse cohort (38% white, 40% African American, and 22% Puerto Rican) was used to investigate whether maternal (body size, pregnancy weight gain, age at menarche, smoking) and birth (birth weight, birth length, placental weight) variables and early infant body size changes were associated with age at menarche even after considering later childhood body size. Higher percentile change in weight from ages 4 months to 1 year was associated with earlier age at menarche even after adjustment for later childhood growth ($b = -0.15$, 95% confidence interval: $-0.27$ to $-0.02$ years per 10-percentile change in weight from ages 4 months to 1 year). The association was in the same direction for all 3 racial/ethnic groups but was largest for the white group. These New York Women's Birth Cohort Adult Follow-up data (2001–2006) suggest that infant weight gain, in addition to childhood weight gain, may be associated with earlier age at menarche.

birth weight; child; growth; infant; menarche

Abbreviations: CI, confidence interval; OR, odds ratio; SES, socioeconomic status.
includes detailed measures of infant growth and is racially and ethnically diverse.

MATERIALS AND METHODS

Study participants

All women who were born at Columbia Presbyterian Medical Center in New York from 1959 to 1963 and participated in the US National Collaborative Perinatal Project until age 7 years were eligible for participation. Of the 841 eligible women, 44% were successfully traced, and 70% of the traced women (n = 262) participated in the adult follow-up: 38% were white, 40% were African American and 22% were Puerto Rican. Of the women we traced, 18 refused to participate, 3 were too ill to participate, and 16 had died. The study was approved by the Internal Review Board at Columbia Medical Center. Refer to Broman (23) for further details on the overall National Collaborative Perinatal Project and to Terry et al. (24) regarding the New York Women’s Birth Cohort Adult Follow-Up Study.

Baseline data were available for all eligible women, and we compared those women who participated with the remaining cohort. Higher family socioeconomic status (SES) at age 7 years, availability of maternal social security number, and white race/ethnicity were statistically significantly associated with a higher probability of tracing. For those traced, race/ethnicity was associated with participation, with African Americans and Puerto Ricans less likely to participate than whites. In addition, higher weight at age 7 years was associated with being less likely to participate (odds ratio (OR) = 0.95, 95% confidence interval (CI): 0.92, 0.99). None of the other maternal characteristics, including age at menarche as well as infant and early childhood growth measures, were associated with participation or with tracing, either overall or within each racial/ethnic subgroup (24).

Perinatal and childhood data

Mothers were enrolled in the National Collaborative Perinatal Project during their second or third trimester. Information on maternal age at menarche and maternal smoking behavior was obtained through self-report at the initial prenatal visit. Information on pregnancy conditions was recorded prospectively at the clinic where mothers received prenatal care, following a uniform protocol. Prospective growth measures for the children in the National Collaborative Perinatal Project were assessed by trained clinical researchers using a standard protocol. Measures included birth weight; birth length; placental weight; and weight and height at ages 4 months, 1 year, and 7 years (23). Because all subjects did not attend the clinic at exactly these time points, and to reduce any potential bias arising from the different measurement times, we interpolated these measurements at the target times using individual cubic interpolation splines (25). No interpolation was needed for birth measurements. Maternal weight gain was calculated from weight measured just prior to birth and reported weight prior to pregnancy. Maternal body mass index was calculated by reported height and weight prior to pregnancy. In addition to the physical measurements, SES was determined from data on maternal and paternal education, occupation, and income at enrollment and when the child was age 7 years (23). Information on income, education, and occupation for the head of household or the main wage earner (most frequently the father) was combined into a continuous SES index, with higher scores indicating higher or more privileged SES (26, 27).

Adult questionnaire data

From 2001 to 2006, we sent follow-up questionnaires to women who were successfully traced to obtain information on age at menarche, adult health, and reproductive events. Participants were asked to recall age at menarche by responding to the following question: How old were you when you had your first menstrual period? The average age of women during adult data collection was 41.8 years (range, 38–46).

Statistical analyses

We examined associations between maternal, infant, and childhood variables and age at menarche, with age at menarche described as both a continuous variable and a binary variable, dichotomized as earlier (≤12 years) and later (>12 years). We first examined univariate associations using correlation coefficients for continuous variables, chi-square tests, and analysis of variance to compare averages between subgroups. We then examined multivariable models using age at menarche as a continuous variable. We also constructed supplemental models that considered age at menarche as a categorized variable using logistic regression modeling the probability of earlier age at menarche (≤12 years) versus later age at menarche (>12 years) (28) and quantile regression methods (29).

Covariates considered in the multivariable models included maternal variables (age at pregnancy, age at menarche, prepregnancy body mass index, weight gain during pregnancy, smoking status, education, occupation), family variables (family SES at age 7 years), and birth variables (gestational age, birth weight, birth order, birth length, placental weight, race/ethnicity). Postnatal growth was characterized as percentile-rank changes over 3 consecutive periods, from birth to age 4 months, from ages 4 months to 1 year, and from ages 1 year to 7 years. Changes in the percentile rank provide a convenient and intuitive way to assess the growth rate while avoiding additional adjustment for age-dependent measurement scales. We developed parsimonious models based on the 10% change in parameter estimate criterion for the growth variables that were statistically significant in the saturated model. In this paper, we present these final models alongside the fully adjusted multivariable model, which includes all prenatal and early-life variables, so the reader can determine the empirical impact of excluding the other prenatal and postnatal variables. The final models were then stratified by race/ethnicity (white, African American, and Puerto Rican as classified at birth) to evaluate whether the magnitude of the effect estimates differed between these groups.

RESULTS

Overall, the mean age at menarche for the cohort was 12.5 years (standard deviation, 1.72), and the median age was
12 years. By race/ethnicity, the means were as follows: whites, 12.53 (standard deviation, 1.79); African Americans, 12.70 (standard deviation, 1.85); and Puerto Ricans, 12.14 (standard deviation, 1.29) (P from analysis of variance = 0.14). Table 1 summarizes descriptive statistics for women who reported earlier age (<12 years) compared with later age (>12 years) at menarche. Women who reported earlier age at menarche were more likely to have a mother with an earlier age at menarche (P = 0.05). The average age at menarche for the mothers was 12.92 (standard deviation, 1.56) years, and the median age was 13.0 years. The correlation between maternal age at menarche and daughter age at menarche was 0.18 (P = 0.005). Figure 1 shows the difference between maternal age at menarche and daughter age at menarche. On average, age of the participants at menarche was 5.0 months earlier than that of their mothers. Higher family SES at age 7 years was associated with later age at menarche (P = 0.01). In addition, women who reported an earlier age at menarche were more likely to be heavier at age 7 years (average weight = 24.7 kg) compared with those who reported a later age at menarche (average weight = 23.2 kg) (P = 0.01). The correlation between weight at age 7 years and age at menarche was −0.17 (P = 0.009). Other characteristics, including birth weight, were not univariably different between the 2 groups.

Table 1. Age at Menarche, by Maternal and Child Demographic Variables, New York Women’s Birth Cohort Adult Follow-up, 2001–2006

<table>
<thead>
<tr>
<th>Variable</th>
<th>Earlier Menarche (≤12 Years; n = 129)</th>
<th>Later Menarche (&gt;12 Years; n = 123)</th>
<th>P Valueb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Value</td>
<td>No. Value</td>
<td></td>
</tr>
<tr>
<td>Prenatal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal prepregnancy body mass index, kg/m²</td>
<td>115 22.57 (3.68)</td>
<td>115 22.44 (3.44)</td>
<td>0.80</td>
</tr>
<tr>
<td>Maternal pregnancy weight gain, kg</td>
<td>120 10.54 (4.99)</td>
<td>118 10.71 (4.94)</td>
<td>0.80</td>
</tr>
<tr>
<td>Maternal age at menarche, years</td>
<td>128 12.73 (1.60)</td>
<td>123 13.12 (1.51)</td>
<td>0.05</td>
</tr>
<tr>
<td>Maternal age at pregnancy, years</td>
<td>128 26.03 (5.80)</td>
<td>123 26.55 (6.09)</td>
<td>0.49</td>
</tr>
<tr>
<td>Maternal education, years</td>
<td>127 10.59 (2.85)</td>
<td>121 11.21 (2.15)</td>
<td>0.06</td>
</tr>
<tr>
<td>Maternal smoking status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsmoker</td>
<td>82 64.57</td>
<td>68 56.20</td>
<td>0.18</td>
</tr>
<tr>
<td>Smoker</td>
<td>45 35.43</td>
<td>53 43.80</td>
<td></td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>48 37.50</td>
<td>48 39.02</td>
<td>0.18</td>
</tr>
<tr>
<td>African American</td>
<td>44 34.38</td>
<td>52 42.28</td>
<td></td>
</tr>
<tr>
<td>Puerto Rican</td>
<td>36 28.13</td>
<td>23 18.70</td>
<td></td>
</tr>
<tr>
<td>Early life</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gestation at delivery, weeks</td>
<td>128 39.43 (2.40)</td>
<td>123 39.41 (2.74)</td>
<td>0.94</td>
</tr>
<tr>
<td>Birth weight, kg</td>
<td>128 3.16 (0.46)</td>
<td>123 3.14 (0.48)</td>
<td>0.79</td>
</tr>
<tr>
<td>Weight at age 4 months, kg</td>
<td>128 6.13 (0.75)</td>
<td>120 6.13 (0.81)</td>
<td>0.99</td>
</tr>
<tr>
<td>Weight at age 1 year, kg</td>
<td>125 9.67 (1.17)</td>
<td>120 9.55 (1.02)</td>
<td>0.39</td>
</tr>
<tr>
<td>Weight at age 7 years, kg</td>
<td>128 24.72 (5.34)</td>
<td>123 23.15 (4.38)</td>
<td>0.01</td>
</tr>
<tr>
<td>Birth length, cm</td>
<td>127 49.96 (2.21)</td>
<td>121 50.06 (2.27)</td>
<td>0.73</td>
</tr>
<tr>
<td>Length at age 4 months, cm</td>
<td>128 61.72 (3.00)</td>
<td>120 61.63 (2.68)</td>
<td>0.80</td>
</tr>
<tr>
<td>Length at age 1 year, cm</td>
<td>124 73.74 (3.08)</td>
<td>122 73.80 (3.13)</td>
<td>0.89</td>
</tr>
<tr>
<td>Height at age 7 years, cm</td>
<td>126 122.13 (5.38)</td>
<td>123 121.28 (4.98)</td>
<td>0.19</td>
</tr>
<tr>
<td>Family SES index at age 7 years</td>
<td>121 50.22 (21.83)</td>
<td>116 57.34 (18.10)</td>
<td>0.01</td>
</tr>
<tr>
<td>Birth order</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not firstborn</td>
<td>74 58.27</td>
<td>77 63.64</td>
<td>0.39</td>
</tr>
<tr>
<td>Firstborn</td>
<td>53 41.73</td>
<td>44 36.36</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: SES, socioeconomic status.

a All values are expressed as mean (standard deviation) or %.

b P value for analysis of variance between 2 groups for continuous variables and for the chi-square test for categorical variables.
in the lowest quartile of weight at age 7 years. The average age at menarche was lower for higher-birth-weight babies only among the girls of lower weight at age 7 years.

Table 3 reports the findings from the linear regression models. Rapid postnatal weight gain from ages 4 months to 1 year and ages 1 year to 7 years was negatively associated with age at menarche ($\beta = -0.03$, 95% CI: $-0.13$, $0.07$ years per 10-percentile increase in weight from birth to age 4 months; $\beta = -0.13$, 95% CI: $-0.24$, $-0.02$ years per 10-percentile increase in weight from ages 4 months to 1 year; $\beta = -0.10$, 95% CI: $-0.19$, $-0.01$ years per 10-percentile increase in weight from ages 1 year to 7 years). After adjustment for other maternal and family variables and for postnatal changes in height, these associations remained fairly consistent, but only rapid weight gain from ages 4 months to 1 year was statistically significant ($\beta = -0.15$, 95% CI: $-0.27$, $-0.02$ years per 10-percentile increase in weight from ages 4 months to 1 year). Later maternal age at menarche and higher SES were positively associated with later age at menarche.

Percentile weight changes in each of the 3 time periods were negatively correlated with each other ($r = -0.16$, $P = 0.01$; $r = -0.26$, $P < 0.0001$; and $r = -0.19$, $P = 0.002$ for percentile weight change from birth to age 4 months and ages 4 months to 1 year, from birth to age 4 months and ages 1 year to 7 years, and from ages 4 months to 1 year and ages 1 year to 7 years, respectively). However, there were no statistically significant interaction effects on age at menarche between percentile weight change in any of the 3 time periods and birth weight ($P = 0.35$). These negative correlations, however, generally resulted in stronger parameter estimates for earlier-period weight percentile measures as later weight measures were added to the model (refer to Table 3). Apart from the growth variables in other time periods, most other variables that we assessed, including placental weight, maternal prepregnancy body mass index, and maternal pregnancy weight gain, did not affect the parameter estimates of the association between weight and height percentile changes and age at menarche. Exclusion of data for 29 babies born preterm did not affect inferences.

We also constructed supplemental models using quantile regression analysis to estimate whether the effects reported in Table 3 were similar across quantiles of age at menarche (data not shown). Overall, we found that the negative association (larger size, earlier menarche) for all measures (birth weight and weight change in each of the postnatal periods) was similar across quantiles. Findings from multivariable logistic regression models for earlier age at menarche ($\leq 12$ years) relative to later age at menarche ($>12$ years) also revealed similar inferences: the association between birth weight and age at menarche was positive; however, it was not statistically significant (OR = $2.59$, 95% CI: $0.79$, $8.53$). Postnatal weight gain during the 3 time periods was also positively associated with earlier age at menarche (OR = $1.10$, 95% CI: $0.98$, $1.24$; OR = $1.16$, 95% CI: $1.02$, $1.33$; and OR = $1.17$, 95% CI: $1.05$, $1.31$ for a 10-percentile increase in weight from birth to age 4 months, ages 4 months to 1 year, and ages 1 year to 7 years, respectively).

As a secondary analysis, we also examined the associations between absolute measures of weight and height at ages 4 months, 1 year, and 7 years and age at menarche (data not shown). These models supported negative associations of birth weight, weight at age 1 year, and weight at age 7 years with age at menarche after adjusting for birth length, postnatal height changes, maternal age at menarche, and family SES at age 7 years. Weight at age 4 months, however, was positively and statistically significantly associated with later age at menarche ($\beta = 0.49$, 95% CI: $0.07$, $0.92$ years per kilogram of weight at age 4 months). There were no statistically significant interactions in the linear

---

**Table 2.** Mean Age at Menarche (Years) by Quartile of Birth Weight and Weight at Age 7 Years, New York Women's Birth Cohort Adult Follow-up, 2001–2006

<table>
<thead>
<tr>
<th>Birth-Weight Quartile, kg</th>
<th>Weight at Age 7 Years, kg</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\leq 20.6$</td>
<td></td>
</tr>
<tr>
<td>2.87–3.15</td>
<td>12.4</td>
<td>12.4</td>
</tr>
<tr>
<td>3.16–3.43</td>
<td>12.6</td>
<td>11.9</td>
</tr>
<tr>
<td>$&gt;3.43$</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Total</td>
<td>12.5</td>
<td>12.5</td>
</tr>
</tbody>
</table>

---

**Figure 1.** Distribution of the difference between mothers' and daughters' age at menarche, New York Women's Birth Cohort Adult Follow-up, 2001–2006.
Table 3. Unadjusted and Adjusted Differences in Mean Age at Menarche According to Birth Weight and Childhood Growth Percentile Using Linear Regression, New York Women’s Birth Cohort Adult Follow-up, 2001–2006

<table>
<thead>
<tr>
<th></th>
<th>Univariablea</th>
<th>Partially Adjustedb</th>
<th>Partially Adjustedc</th>
<th>Partially Adjustedd</th>
<th>Fully Adjustede Saturated Model</th>
<th>Fully Adjustede Parsimonious Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \beta )</td>
<td>95% CI</td>
<td>( \beta )</td>
<td>95% CI</td>
<td>( \beta )</td>
<td>( \beta )</td>
</tr>
<tr>
<td>Birth weight, kg</td>
<td>–0.34</td>
<td>0.80, 0.12</td>
<td>–0.22</td>
<td>0.74, 0.29</td>
<td>–0.37</td>
<td>0.91, 0.17</td>
</tr>
<tr>
<td>Weight change, 0–4 months (10-percentile change)</td>
<td>0.06</td>
<td>0.02, 0.13</td>
<td>0.04</td>
<td>0.04, 0.13</td>
<td>0.02</td>
<td>0.07, 0.11</td>
</tr>
<tr>
<td>Weight change, 4 months–1 year (10-percentile change)</td>
<td>–0.08</td>
<td>0.18, 0.02</td>
<td>–0.09</td>
<td>0.19, 0.01</td>
<td>–0.13</td>
<td>0.24, 0.02</td>
</tr>
<tr>
<td>Weight change, 1–7 years (10-percentile change)</td>
<td>–0.06</td>
<td>0.14, 0.02</td>
<td>–0.10</td>
<td>0.19, 0.01</td>
<td>–0.12</td>
<td>0.23, 0.01</td>
</tr>
<tr>
<td>Birth length, cm</td>
<td>–0.06</td>
<td>0.14, 0.02</td>
<td>–0.08</td>
<td>0.19, 0.02</td>
<td>–0.04</td>
<td>0.13, 0.01</td>
</tr>
<tr>
<td>Height change, 0–4 months (10-percentile change)</td>
<td>0.04</td>
<td>0.09, 0.17</td>
<td>–0.04</td>
<td>0.09, 0.17</td>
<td>0.04</td>
<td>0.04, 0.20</td>
</tr>
<tr>
<td>Height change, 4 months–1 year (10-percentile change)</td>
<td>0.00</td>
<td>0.12, 0.11</td>
<td>–0.04</td>
<td>0.13, 0.01</td>
<td>0.02</td>
<td>0.01, 0.03</td>
</tr>
<tr>
<td>Height change, 1–7 years (10-percentile change)</td>
<td>0.02</td>
<td>0.01, 0.03</td>
<td>0.02</td>
<td>0.01, 0.03</td>
<td>0.17</td>
<td>0.02, 0.32</td>
</tr>
<tr>
<td>Family SES at age 7 years</td>
<td>0.17</td>
<td>0.06, 0.32</td>
<td>0.18</td>
<td>0.05, 0.31</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; SES, socioeconomic status.
a Unadjusted associations.
b Adjusted for percentile change in weight from birth to age 4 months; \( n = 250 \).
c Adjusted for percentile change in weight from birth to age 4 months and ages 4 months to 1 year; \( n = 250 \).
d Adjusted for percentile change in weight from birth to age 4 months, ages 4 months to 1 year, and ages 1 year to 7 years; \( n = 250 \).
e Adjusted for birth weight, percentile change in weight, birth length, percentile change in height, maternal prepregnancy body mass index, maternal smoking status, family SES at age 7 years, maternal age at menarche, maternal weight gain during pregnancy, gestational age, child race, maternal age at pregnancy, maternal education, birth order; \( n = 202 \).
f Adjusted for birth weight, percentile change in weight, birth length, percentile change in height, family SES at age 7 years, maternal age at menarche; \( n = 233 \).

DISCUSSION

Overall, in this racially and ethnically diverse cohort, we observed rapid weight gain from ages 4 months to 1 year was associated with earlier age at menarche, and rapid weight gain from ages 4 months to 1 year and from ages 1 year to 7 years was associated with earlier age at menarche among girls of lower weight at age 7 years. Among those whose weight at age 7 years is below the median, there were no statistically significant differences in the linear model with weight at age 7 years (\( P = 0.19 \)).

Although the stratified linear model stratified by age at menarche was not significant (\( P = 0.64 \)), the model stratified by age at menarche was stronger for the white group regarding the associations between percentage weight gain and negative associations between percentage weight gain and age at menarche. The stratified linear model stratified by age at menarche was also stronger (as measured by percentile change) from ages 4 months to 1 year for the white group regarding the associations between percentage weight gain and age at menarche.

Figure 2 presents the results of this study. The models were performed with and without interaction terms. When interaction terms were included, the results were largely consistent. The results were consistent with the results presented in Table 3. The results were consistent with the results presented in Table 4. The results were consistent with the results presented in Table 4.
of birth weight and birth length (average of 3.15 kg and 50 cm, respectively) were slightly lower than those of other cohorts (15, 17, 19), but, when we performed secondary analyses with the birth-size cutpoints used in these cohorts, our overall inferences did not materially change. For example, using the same cutpoints for birth weight and weight at age 7 years as Cooper et al. (20), we found that those girls in the highest fifth of the birth-weight distribution experienced menarche 6 months earlier than girls in the lowest fifth of the birth-weight distribution. We further assessed the effect of low birth weight on age at menarche. In our cohort, low-birth-weight babies (<2,500 g) were more likely to experience menarche 7.2 months later than babies born weighing 2,500 g or more, although our study included very few low-birth-weight babies (n = 25).

Our mean and median ages at menarche (12.5 years (standard deviation, 1.7) and 12.0 years, respectively) were lower than those in other studies that reported a mean age ranging from 12.6 years to 13.2 years (15, 17–19, 22, 31) and a median of 13.0–13.1 years (16, 20, 21); however, applying the cutpoints for age at menarche used by others did not alter our findings. Except for one study (31), the other studies of birth size and age at menarche were conducted outside of the United States and were more racially and ethnically homogeneous than our cohort.

A more likely explanation for the difference in findings between our studies and the others is that most studies did not adjust for postnatal growth. For example, in 2 separate analyses of the 1946 British Birth Cohort, high birth weight was associated with later and then earlier age at menarche, depending on whether postnatal growth was considered simultaneously in the model (20, 22). However, no information on weight and height changes between birth and age 2 years was available for the 1946 birth cohort. In addition to having prospectively collected information on weight at birth and ages 4 months, 1 year, and 7 years, we were able to examine whether further adjustment for height changes during earlier life; maternal variables, including maternal age at menarche, body size, and pregnancy weight gain;

Table 4. Adjusted Differences in Mean Age at Menarche According to Birth Weight and Childhood Growth Percentile Stratified by Weight at Age 7 Years Using Linear Regression, New York Women’s Birth Cohort Adult Follow-up, 2001–2006

<table>
<thead>
<tr>
<th>Fully Adjusted(^a) Parsimonious Model</th>
<th>Lower Weight at Age 7 Years(^b)</th>
<th>Higher Weight at Age 7 Years(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\beta)</td>
<td>95% CI</td>
</tr>
<tr>
<td>Birth weight, kg</td>
<td>-1.13</td>
<td>-2.71, 0.44</td>
</tr>
<tr>
<td>Weight change, 0–4 months (10-percentile change)</td>
<td>-0.05</td>
<td>-0.29, 0.19</td>
</tr>
<tr>
<td>Weight change, 4 months–1 year (10-percentile change)</td>
<td>-0.17</td>
<td>-0.43, 0.09</td>
</tr>
<tr>
<td>Weight change, 1–7 years (10-percentile change)</td>
<td>-0.20</td>
<td>-0.44, 0.05</td>
</tr>
<tr>
<td>Birth length, cm</td>
<td>0.12</td>
<td>-0.15, 0.40</td>
</tr>
<tr>
<td>Height change, 0–4 months (10-percentile change)</td>
<td>0.13</td>
<td>-0.05, 0.31</td>
</tr>
<tr>
<td>Height change, 4 months–1 year (10-percentile change)</td>
<td>0.19</td>
<td>0.02, 0.36</td>
</tr>
<tr>
<td>Height change, 1–7 years (10-percentile change)</td>
<td>0.09</td>
<td>-0.06, 0.24</td>
</tr>
<tr>
<td>Family SES at age 7 years</td>
<td>0.02</td>
<td>0.01, 0.04</td>
</tr>
<tr>
<td>Maternal age at menarche, years</td>
<td>0.20</td>
<td>0.01, 0.40</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; SES, socioeconomic status.

\(^a\) Adjusted for birth weight, percentile change in weight, birth length, percentile change in height, family SES at age 7 years, maternal age at menarche.

\(^b\) Low weight at age 7 years based on the lower 2 quartiles of the distribution (14.6–22.5 kg).

\(^c\) High weight at age 7 years based on the upper 2 quartiles of the distribution (22.6–51.0 kg).
growth early in life may impact the timing of menses. To a growing body of literature suggesting that body size and between body size and timing of menarche. These findings add growth are needed to understand the complex interplay be-
over time may be explained by the trends in increasing body
independent variables, we were limited to retrospective as-
models.
placental weight; gestation length; and family SES con-
founded our results. Our findings remained after further
adjustment and were also robust to alternative statistical
Although we had detailed prospective data on all of the
independent variables, we were limited to retrospective
assessment of age at menarche because the cohort was fol-
lowed prospectively until age 7 years only. However, age
at menarche has been shown to be reliably reported even
17–40 years later (range of Pearson correlation coefficients
r = 0.60–0.79) (32–38), although reliability was lower when measured by the kappa statistic (33). The reliability
of our retrospective assessment was likely enhanced by ask-
ing women to recall age at menarche in only discrete years.
In our study, recalled age at menarche was positively corre-
lated with maternal age at menarche as well as inversely
correlated with weight and height at age 7 years, consistent
with many other studies (15, 16, 19–22, 31, 39) and support-
ing the overall validity of our measure. Nevertheless, the
measurement error likely influenced our ability to detect
more subtle associations with age at menarche. However,
there is no reason to expect that retrospective assessment
of age at menarche would be differential with respect to ex-
posure; therefore, we would expect the true differences to be
even larger because of this nondifferential misclassification
of the outcome. In addition, in terms of maternal age at
menarche, maternal pregnancy variables, birth size, or any
postnatal height or weight changes, women who partici-
pated in the adult follow-up and therefore had age-at-
menarche data did not differ from those who were not traced
and/or who were traced and did not participate (24).
The main limitation of our study was the sample size,
which limited our overall statistical power. For example,
we were able to detect differences in age at menarche of
10 months or more between racial/ethnic groups. However,
for most of the continuous growth measures, and interactions
between these continuous measures, we had greater statistical
power, particularly in the linear regression model.
Between the late 1960s and 1990, there was a 3-month
decline in age at menarche for US white girls and a 5.5-month decline for US African American girls (40). Comparison of mothers in our cohort, who experienced menarche from 1928 to 1960, with their daughters, who experienced menarche from 1967 to 1979, supports the ac-
cumulating data suggesting a secular decline in age at men-
arche (41–44). Specifically, 50 girls were the same age at
menarche as their mothers, 118 had an earlier age at men-
arche than their mothers, and 84 had a later age at menarche
than their mothers (average difference = 5.0 months).
Some have suggested that the declines in age at menarche
over time may be explained by the trends in increasing body
weight (4, 45, 46). Birth weight has also been increasing in
recent decades (47). Our data support that, in addition to
child body size, early infant growth may be associated with earlier age at menarche. Taken together, these findings sug-
gest that multiple measures of infant and early childhood
growth are needed to understand the complex interplay be-
 tween body size and timing of menarche. These findings add
to a growing body of literature suggesting that body size and
growth early in life may impact the timing of menses.

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