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Longitudinal Study of Growth and Adiposity in Parous Compared With Nulligravid Adolescents

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Abstract

Objective—To examine the impact of pregnancy on adolescent growth and adiposity relative to nulligravidas of similar maturation stage.

Design—Prospective cohort study.

Setting—The multicenter National Heart, Lung and Blood Growth and Health Study with annual examinations from 1987-1988 through 1996-1997.

Participants—One thousand eight hundred ninety girls (983 black and 907 white) aged 9 to 10 years at enrollment.

Main Exposure—Self-reported number of pregnancies and births during adolescence and young adulthood (age, 15-19 years): 311 primiparas (17%), 84 multiparas (4%), 196 nulliparous gravidas (10%), and 1299 nulligravidas (69%).

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Outcome Measures—Estimated race-specific changes in body weight, height, body mass index, waist circumference, hip circumference, waist to hip ratio, and percent body fat, defined as the difference between baseline and measurements 9 to 10 years later.

Results—Thirty-one percent of black and 10% of white girls gave birth during adolescence and young adulthood. We found evidence of race by pregnancy interactions ($P < .10$) for changes in weight, body mass index, hip circumference, and percent body fat. Black primiparas and multiparas, respectively, had smaller decrements in waist to hip ratio (0.019 and 0.023) and greater increments in weight (3.6 and 6.0 kg), body mass index (1.3 and 2.3), waist circumference (3.5 and 5.2 cm), hip circumference (2.1 and 4.0 cm), and percent body fat (3.4% and 4.6%) than black nulligravidas after adjustment for baseline measurements, age, study center, family income, parental education, age at menarche, hours of television and video viewing, and height at visit 9 or 10 in weight models ($P < .01$). White primiparas had borderline greater increments in waist circumference (2.4 cm) and percent body fat (0.9%) and smaller decrements in waist to hip ratio (0.017) than white nulligravidas ($P < .05$). Height did not differ by pregnancy status.

Conclusions—Women who give birth during adolescence and young adulthood have substantially greater increments in overall and central adiposity than adolescents who do not experience pregnancy independent of other known correlates of weight gain.

Pregnancy promotes development of obesity and worsens metabolic risk factors in adult women.[1-4] Pregnancy during adolescence, a period of growth and fat accumulation in females, may exacerbate these risks[5] by contributing to excess weight gain and increased central adiposity, especially among growing adolescents. [6] Greater gestational weight gain and postpartum weight retention than adults are characteristic of pregnant adolescents.[7-10] Studies have shown that after 28 weeks' gestation, growing adolescents continued to accrue fat, whereas nongrowing adolescents and adult gravidas mobilized fat stores.[6,11] Growing adolescents also retained more weight postpartum than adults.[11] What is not clear from these studies is to what extent pregnancy influences adolescent growth and changes in body composition relative to non-gravid adolescents of similar maturation stage. In 464 Brazilian adolescent girls aged 15 to 19 years, those who became pregnant (n=74 [16%]) had greater gains in weight and body mass index (BMI) and smaller increments in stature than nulligravidas within the same 4-year interval.[12] Thus, pregnancy may influence gains in adiposity and stature apart from secular trends and maturation differences.

Pregnancy has been associated with development of overweight in both adults[3,4] and adolescents.[5] Girls who become pregnant during adolescence have earlier physical maturation and different sociodemo-graphic characteristics.[9,13,14] Both younger age at menarche (<12 years) and shorter interval from menarche to first birth (<8 years) have been associated with increased risk of overweight after pregnancy during adulthood, indicating that timing of reproductive maturation stage may influence postpartum weight retention. [15] Therefore, the timing of pregnancy in relation to maturation may play an important role in determining adiposity and future health.

To our knowledge, no study has examined differences in growth and adiposity among pregnant vs nonpregnant adolescent girls from the same population based on anthropometric measurements obtained prior to menarche. We sought to evaluate the impact of pregnancy during adolescence on growth and adiposity in the National Heart, Lung and Blood Institute Growth and Health Study (NGHS) sample of black and white girls who were followed up annually for 10 years since they were aged 9 to 10 years. In this large prospective cohort, we examined growth and adiposity changes in adolescent and young adult females from before to after pregnancy relative to nulligravidas of the same age within the same study population and time.

METHODS

PARTICIPANTS AND STUDY DESIGN

The NGHS is a multicenter, longitudinal, observational study of the development of obesity in black and white girls during adolescence and the relationship between obesity and cardiovascular disease risk factors during a 10-year period.[16,17] The NGHS was designed to examine the association between behavioral, psychosocial, and environmental attributes to risk factors for cardiovascular disease in a cohort of black girls and white girls followed up from childhood to age 18 to 19 years as previously described.[16] The study was undertaken by 3 clinical centers: University of California at Berkeley, University of Cincinnati Medical Center and Children's Hospital Medical Center, and Westat Inc, Rockville, Maryland. The Maryland Medical Research Institute served as the coordinating center. The institutional review board at each participating study center approved the study. Written informed consent was obtained from participants and their parents or guardians for all study procedures.

The University of California at Berkeley used census sampling to recruit participants from all public and parochial schools in west Contra Costa County, California. The University of Cincinnati Medical Center and Cincinnati Children's Hospital Medical Center recruited participants from Ohio public and parochial schools that were racially and socioeconomically representative of the greater Cincinnatiarea. Westat Inc recruited participants from Group Health Association, a health maintenance organization in Washington, DC. As previously reported,[16] 81% of eligible girls at the University of California and Westat sites and 74% of those at the Cincinnati site were enrolled in the study between January 1987 and May 1988. Girls aged 9 and 10 years were the primary focus of the study; however, their parents and guardians were also interviewed and enrolled. Recruitment, data collection methodology, and the determination of race have been previously described.[16-18] In 1987-1988, 2379 girls (1213 black and 1166 white) and their families were enrolled. In 1996-1997, the girls in NGHS were aged 18 to 19 years, and the retention rate was 88% of the original cohort.

Of 2094 girls examined in 1987-1988 and again up to 1996-1997, 471 reported 1 or more births, 224 reported 1 or more pregnancies but no births, 84 were missing reproductive history, and 1315 girls reported no pregnancies. We selected NGHS participants who reported pregnancies and those with incomplete or uncertain information on reproductive history (n=779) for the NGHS pregnancy study from 2002 to 2005 in which telephone interviews were done to confirm when pregnancies and births occurred. We also requested permission to collect information from pregnancy medical records and to obtain copies of their children's birth certificates. We also used data (ie, birth dates of their infants) collected from an ancillary study of 2054 participants, NGHS Wave II (1998-2001), to ascertain whether additional unreported births had occurred during the study period.[19] For parous adolescents, NGHS visits were scheduled at least 4 months post partum.

Of the 779 participants who were eligible for the pregnancy study, 694 (89%) were located and agreed to provide additional information on pregnancies and births reported during the study. Among 84 participants with missing or incomplete reproductive history, 56 were contacted and provided information on pregnancies from 1987 to 1997: 52 were never pregnant, 4 had been pregnant but had no births, and 1 had given birth. Of 223 participants who reported pregnancies but no births, 185 confirmed that they had been pregnant and 1 reported that she had given birth. Among 387 girls who had given birth, we abstracted pregnancy medical records for 1 or more deliveries during NGHS for 345 participants. Some participants may have been reluctant to disclose pregnancies during adolescence, but we were able to confirm previous pregnancies by querying participants when they were in their 20s. These pregnancy data from the interviews and medical records were combined with existing data to determine reproductive history during NGHS.

For this analysis, we selected 1890 girls who attended a visit in the ninth or tenth year of the study and had complete data on growth as well as pregnancies (79% of the original NGHS cohort). This sample included 395 (309 black and 86 white) girls with 1 or more births, 196 girls with 1 or more pregnancies and no births, and 1299 girls who were never pregnant during the 10-year study period. Subjects not included were similar in age and BMI at baseline to those included, but were more likely to be black and their parents' were more likely to have a high school education or less and lower family income ($P < .001$).

OUTCOME MEASURE AND MAIN EXPOSURE

Growth and Adiposity—Anthropometric measurements, including weight, height, and skinfold thickness, were obtained from all participants at baseline (1987-1988) and annually during the 10-year follow-up as previously described.[16] Waist and hip circumferences were measured annually starting with the second study visit in 1988-1989. Weight and height measurements were used to calculate BMI (weight in kilograms divided by height in meters squared). Weight was measured to the nearest 0.1 kg with calibrated electronic scales, with the participant wearing only a paper hospital gown or a large NGHS standard t-shirt. Two weight measurements were obtained and a third was taken if the first 2 differed by more than 0.3 kg. Height was measured in duplicate to the nearest 0.1 cm with the participant in socks, using custom-made portable stadiometers. A third measurement was taken if the first 2 were more than 0.5 cm apart. Waist and hip circumferences were measured to the nearest 0.1 cm. The waist was measured at the umbilicus or the narrowest point between the rib cage and the iliac crest after normal expiration, and hip circumference was measured at the maximal circumference below the waist. A third measurement was taken if the first 2 differed by more than 1 cm. Certified personnel measured skinfolds (triceps, subscapular, and suprailiac) in duplicate to the nearest millimeter on the right side of the participant using a caliper. A third set of measurements were taken if the first 2 differed by 1.0 mm or more. The sum of the subscapular and triceps skinfolds was used to estimate percent body fat using an equation based on race, pubertal stage, age, and interactions as described by Morrison et al.[20] The average of the 2 measurements or the closest 2 of 3 measurements were used for the analysis. Waist to hip ratio (WHR) was calculated as waist circumference divided by hip circumference. Waist circumference and WHR were examined as measures of central obesity.

Pregnancy Group—Girls were asked if they had ever been pregnant or were currently pregnant, the number of times they had been pregnant, and the number of births they had had from visit 6 (age, 14-15 years) through visit 10 (age, 18-19 years). Birth dates of their infants were collected starting at visit 6. A birth was defined as a live or still birth, an abortion, or a fetal death for any pregnancy that lasted 20 weeks or longer and occurred after the NGHS baseline examination and at least 4 months before the year 10 visit. A pregnancy that did not end in a birth was defined as any pregnancy that ended in a spontaneous or therapeutic abortion, ectopic or molar pregnancy, or miscarriage with less than 20 weeks' gestation after the NGHS baseline examination and at least 4 months before the year 10 visit. Ancillary studies conducted after 1998 collected data on the number of pregnancies and births.

Girls were classified into 1 of 4 pregnancy groups: 1 birth (primiparas); 2 or more births (multiparas); pregnant and 0 births (nulliparous gravidas); and never pregnant (nulligravidas). Among the parous girls, we calculated the age at their first birth based on the birth date of their first child or self-reported age at first birth and classified them as younger than 16 years or 16 years or older at first birth.

OTHER MEASURES

Age at Menarche and Hormonal Contraceptives—At annual examinations, girls were asked if they had started their menstrual cycles. Thus, age at menarche was determined from

the girls' declaration. Questions about oral contraceptive use were asked annually since visit 3 (age, 11-12 years). Questions on Norplant (levonorgestrel; Leiras Oy Pharmaceuticals, Turku, Finland) and Depo-Provera (medroxyprogesterone; Pfizer, New York, New York) were added to the questionnaires at visits 9 and 10 (age, 17-19 years) when the contraceptive products came on the market. We categorized girls as never-users, past users, or current users of hormonal contraceptives for the last NGHS visit. Current users were classified by type of hormonal contraceptives, either oral or Norplant/Depo-Provera.

Demographic, Familial, and Lifestyle Attributes—Parents and guardians provided information on race, age, family composition, maximum parental education, employment status, and household income at the baseline examination. Girls provided information on dietary intake and physical activity patterns on an annual basis. Methods for collecting dietary intake and physical activity information were validated using actual observed eating and activity behavior and have been previously described.[21] Briefly, the 3-day food record was selected since it was found to be more accurate than 24-hour recall or 5-day food-frequency methodologies.[22] The Nutrition Coordinating Center at the University of Minnesota coded the food records, including number of meals and snacks, and analyzed them for nutrients using version 11 of the Nutrition Coordinating Center nutrient database. A description of this database and methodologies used to determine sources of nutrients and frequency of nutrient update are described elsewhere.[16] The nutrition questionnaire also asked girls to report their frequency of eating fast food and dieting to lose weight.

Physical activity was self-reported from the questionnaire and a 3-day diary. The first method measured each girl's perception of her activity level. The participants were asked to respond to the statement, "I am physically active, that means I get lots of exercise," by choosing 1 of 3 responses: "never or almost never," "sometimes," or "usually or always." Self-perception of physical activity responses were dichotomized, with the "never or almost never" response as the reference group, and the "sometimes" and "usually or always" responses combined to form another group. To measure sedentary behavior, the girls were asked to report the number of hours of television or videos they watched per week. The methodology of collecting physical activity data and quantifying the scores has been previously described.[23]

STATISTICAL ANALYSIS

Preliminary analyses involved description of the baseline characteristics of the girls and their parents by race and by pregnancy group. χ^2 Tests were used to assess associations of racial groups with baseline family demographic variables (education and income), study center, girl's age, pregnancy group, and hormonal contraceptive use. Multiple linear regression methods were used to assess differences in baseline characteristics (height, weight, BMI, waist circumference, hip circumference, WHR, percent body fat, age at menarche, dietary intake, and physical inactivity [hours per week spent watching television or videos]) by race and pregnancy groups. We also examined follow-up characteristics at age 18 to 19 years (height, weight, BMI, waist circumference, hip circumference, WHR, percent body fat, and age at menarche) by pregnancy groups within each race. Overall differences among these groups were evaluated by a comparison of mean values using *F* statistics from analysis of variance. Bivariate associations between baseline characteristics and each outcome were examined for each race group separately. Statistical significance was defined as $P < .05$ (2-sided). However, we selected a procedure-wise error rate of 5%, which resulted in defining statistical significance as $P < .0165$ for each pairwise comparison among the pregnancy groups.

Covariates that were evaluated as potential confounders based on a priori hypotheses included race, baseline measurements, age at menarche, parental education, household income, and lifestyle behaviors (baseline physical activity and dietary patterns). Covariates were not

included as potential cofounders if the coefficients for 1 or more of the pregnancy groups were altered by less than 10% when the covariate was added to the model. Differences in mean changes in each anthropometric measure were examined in multiple linear regression models by age-at-first-birth groups (<16 or ≥16 years) for primiparas and multiparas combined. Effect modification by race within the pregnancy group associations for each measure was evaluated by introduction of appropriate cross-product terms into the models (significance was set at $P < .10$). Adjusted leasts-square means were obtained from race-specific linear regression models for all dependent variables.

RESULTS

At baseline, race groups differed significantly by family income, parental education, and anthropometric measurements (Table 1). Specifically, black girls came from households with lower incomes; were taller with higher body weights; had larger measures of waist circumference, hip circumference, and percent body fat; consumed more dietary fat; and watched more hours per week of television and/or videos. Black girls also reached menarche at an earlier age (Table 2). By the end of follow-up (age, 18-19 years), young black women were more likely to have been pregnant and given birth, to be past or current users of hormonal contraceptives, to be overweight or obese, to be more centrally obese, and to have higher percent body fat and BMIs than young white women (Table 2). Overall, 43% of black girls (n=423) and 19% of white girls (n=168) became pregnant during the study period, and of these, 73% of black girls (n=309) and 51% of white girls (n=86) gave birth. Black girls were more likely to bear more than 1 child during adolescence. There were 237 black primiparas (77%) and 72 black multiparas (23%) compared with 74 white primiparas (86%) and 12 white multiparas (14%).

Among white girls (Table 3), pregnancy groups were similar at baseline in mean height, body weight, BMI, waist circumference, hip circumference, and WHR. However, black girls who became pregnant but did not give birth (nulliparous gravidas) or who gave birth during adolescence (primiparas and multiparas) had lower BMI, body weight ($P < .05$), and percent body fat ($P < .001$) at age 9 to 10 years and smaller waist circumferences at age 10 to 11 years than black girls who did not become pregnant (nulligravidas). At the end of follow-up (age, 18-19 years), both primiparous and multiparous adolescent girls (black and white) were heavier, shorter in stature, more centrally obese, and had a higher percent body fat than nulligravidas (all $P < .05$), though height did not differ among pregnancy group in black girls (Table 3). White girls who became pregnant (gravidas and paras) reached menarche earlier ($P < .001$) than white nulligravidas (Table 3). In black girls, age at menarche did not differ by pregnancy group. Use of hormonal contraceptives at age 18 to 19 years was more likely in primiparas or multiparas than nulligravidas; 24% vs 9% were past users and 52% vs 25% were current users, respectively ($P < .001$).

Overall, 28% of young white women and 49% of young black women were considered overweight or obese (BMI ≥ 25) at age 18 to 19 years ($P < .001$). Among adolescent pregnancy groups, 27% of white nulligravidas, 24% of nulliparous white gravidas, and 40% of white paras were overweight or obese at age 18 to 19 years ($P = .02$). Forty-seven percent of black nulligravidas, 36% of nulliparous black gravidas, and 57% of black paras were overweight or obese at age 18 to 19 years ($P < .001$).

Race-specific unadjusted and adjusted means for changes in growth and adiposity measures (from age 9-10 years to age 18-19 years) by pregnancy groups (Table 4) were similar in black and white girls, except for BMI, hip circumference, and percent body fat (race interaction, $P < .10$, all). Among black girls, primiparas and multiparas, respectively, group differences measured from age 9-10 years to 18-19 years included greater increments in body weight (3.6

and 6.0 kg), BMI (1.3 and 2.3), waist circumference (3.5 and 5.2 cm), hip circumference (2.1 and 4.0 cm), and percent body fat (3.4% and 4.6%); smaller decrements in WHR (0.019 and 0.023) (all $P < .0165$; for multiple comparisons); and similar height increments (0 and −0.3 cm) compared with nulligravidas. We found a trend for larger increments in anthropometric measurements with increasing number of births in black girls, but differences between primiparas and multiparas did not reach statistical significance.

Compared with white nulligravidas, gravida and nulliparous white girls had significantly smaller increments in body weight, BMI, hip circumference, and percent body fat ($P < .01$), and white primiparas had greater gains in mean waist circumference (2.4 cm) and percent body fat (0.9%) ($P < .05$). This did not reach statistical significance ($P < .0165$) when adjusted for multiple comparisons, but smaller decrements in WHR (0.017) were found in white primiparas relative to white nulligravidas ($P < .01$).

Within each race group, growth indices varied by age at first birth (Table 5). Compared with girls who gave birth after age 16 years, black parous girls (primiparas and multiparas combined) who gave birth before age 16 years had borderline greater increments in BMI (1.2; $P = .08$) and nonsignificant greater increments in body weight (2.9 kg) and percent body fat (2.0%) in adjusted models. No differences in changes in anthropometric measures were found among white girls, of whom only 12 girls aged younger than 16 years gave birth. There was no evidence of effect modification by race in the association of age at first birth with changes in anthropometric measures (all $P > .10$; except weight, $P = .10$). However, black girls who gave birth before age 16 years reached menarche earlier (11.6 vs 12.2 years, $P < .01$) than those who gave birth after age 16 years. Age at menarche did not differ in parous white girls (11.8 vs 12.0 years, $P = .85$).

COMMENT

Our findings show that childbearing during adolescence is associated with greater deposition of overall and central adiposity, though there was little difference in attained stature in both races. The evidence in black girls was stronger than in white girls, presumably owing to fewer white girls becoming pregnant. Larger waist circumference and WHR were associated with 1 or more births vs no pregnancies in both races. Increments in body weight, body size, and percent body fat were greater for parous than never-pregnant black girls. These pregnancy differences were less apparent in white girls, though those who had a pregnancy but did not give birth were thinner. Initial BMI, percent body fat, and other anthropometric measures at ages 9 to 11 years were similar for white girls irrespective of adolescent pregnancies. However, black girls who gave birth were thinner and had lower overall and central adiposity at these ages than nulligravidas.

Pregnancy during adolescence may alter normal growth processes and increase the risk of becoming overweight or obese.[5] Previous studies lacked a reference group of nongravid adolescent girls. Therefore, greater weight gain in adolescents compared with adults may partially reflect underlying secular trends and growth during adolescence. One study found that 74 pregnant Brazilian girls aged 15 to 19 years[12] had greater weight gain (2 kg) and lower stature (−0.5 cm) than 390 nongravid girls. Our study found similar changes for white multiparas. However, black primiparas and multiparas, respectively, had greater gains in body weight (3.6 and 6.0 kg) and little difference in stature (0 and −0.3 cm) vs nulligravidas.

Despite being thinner at ages 9 to 10 years, parous black girls in our study accumulated more fat overall and centrally than nulligravidas at ages 18 to 19 years. These findings are consistent with prior studies that report that pregnant adolescents, particularly young, growing pregnant adolescents,[11] tend to accrue more subcutaneous fat in central locations than adult women.[5,6]

The prevalence of overweight and obesity was greater at ages 18 to 19 years among girls in the NGHS who had previously given birth vs those who were never pregnant, an additional 13% of white girls and 11% of black girls. This finding is consistent with that of a previous study of pregnant adolescents that reported that prevalence of obesity increased from 5.7% before pregnancy to 15.7% at 6 months' post partum.[24] In the United States in 1996, 17% of girls younger than 16 years and 25% of girls aged 16 to 19 years were overweight prior to pregnancy,[25] compared with 13% of adolescent girls overall aged 12 to 17 years.[26] We observed a trend for increasing adiposity with the number of births. This may be related to initiation of childbearing at a young age, rather than cumulative effects of births. We found some evidence of a greater increment in BMI associated with giving birth before age 16 years ($P = .08$) vs at age 16 years or older, even after adjusting for differences in age at menarche among black girls. Younger age at first birth may influence gains in body size and differences in fat distribution because of younger age at menarche, which may have been a factor in the larger gains in adiposity observed in black girls who became pregnant during adolescence. Differences in physical maturation and the overall pattern of growth have been reported between black and white adolescent girls.[17,27] Black girls reach menarche earlier and have greater peak velocities and smaller growth increments in late adolescence than white girls.[17] Pregnancy-related gains in adiposity appear to be greater for adolescents than in adult women. In a 10-year follow-up, the Coronary Artery Risk Development in Young Adults Study observed 1-kg and 2-cm greater increases in weight and waist circumference, respectively, in primiparas compared with nulliparas (black and white) who were not overweight before pregnancy.[2] Among white women aged 25 to 45 years in the National Health and Nutrition Examination Survey Epidemiologic Follow-up Study, a 1-kg greater weight gain was associated with 1 birth compared with no births during the 10-year study period.[4] The Black Women's Health Study prospectively examined childbearing and weight gain during 4 years of follow-up and found that primiparas gained 1 kg more than nulliparas.[28] These studies in adult women indicate that modest parity-associated weight gain occurs primarily after the first birth and is not cumulative with the number of births.

Limitations of this study include the small number of white girls who became pregnant and had births, variable time intervals from enrollment until the deliveries, earlier maturation among white girls, and the tendency of taller stature in black girls who became pregnant. We adjusted for age at menarche, baseline measurements, and other covariates to minimize these differences, but they may still be influential. Dietary intake had little impact on our findings. Another limitation is the potential underreporting of pregnancies that ended in miscarriage or abortions during adolescence, which would bias our findings in black girls toward the null.

This study has several strengths, including the large, community-based sample of adolescent girls, with an internal comparison group of never-pregnant girls, to evaluate the direct effects of pregnancy on adolescent growth independent of secular trends and maturation (age at menarche) and prospectively collected data relying on anthropometric indices measured before and after pregnancies. Our findings are potentially important because adolescence has been identified as one of the critical periods of development that set the stage for the onset of obesity later in life.[29] Continued slow growth in stature has been observed for American girls through age 18 years in longitudinal studies of incremental growth.[27,30] At least 50% of white adolescent girls have not attained adult height by the chronological age of 17 years.[30] Prospective studies have found that adiposity gains during adolescence may be associated with a greater risk of overweight and obesity in adulthood.[31,32] For the adolescent female, maturation is accompanied by body fat mass increases of 17% to 24% as well as changes in the location of fat stores.[33] The excessive fat deposition during adolescence may signal the onset and persistence of obesity[34] and elevated insulin, lipid, and blood pressure levels into young adulthood.[35] Earlier age at a first birth (<20 years) has been associated with increased rates of coronary heart disease in women.[36] Thus, the influence of gestational weight gain on

changes in growth and adiposity during adolescence is an important aspect for future investigation.

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Table 1

Baseline Characteristics and Age at Menarche by Race

Baseline Characteristic	Mean (SD)		*P* Value
	Black Girls Aged 9-10 y (n=983)	White Girls Aged 9-10 y (n=907)	
Annual household income, No. (%), $			
<20 000	443 (45.1)	141 (15.6)	
20 000-50 000	393 (40.0)	446 (49.2)	<.001
>50 000	147 (15.0)	320 (35.3)	
Parental education, No. (%)			
≤HS	293 (29.8)	164 (18.1)	
Post-HS/some college	478 (48.6)	277 (30.5)	<.001
≥4 y of college	212 (21.6)	466 (51.4)	
Study center, No. (%)			
Berkeley, California	369 (37.5)	351 (38.7)	
Cincinnati, Ohio	339 (34.5)	304 (33.5)	.86
Washington, DC	275 (28.0)	252 (27.8)	
Height, cm	143.0 (7.8)	139.5 (7.0)	<.001
Weight, kg	39.5 (10.7)	35.1 (8.5)	<.001
Body mass index[a]	19.1 (4.1)	17.9 (3.3)	<.001
Waist circumference, cm[b]	66.5 (9.4)	63.3 (8.1)	<.001
Hip circumference, cm[b]	83.2 (10.4)	79.1 (8.5)	<.001
Waist to hip ratio[b]	0.80 (0.045)	0.80 (0.044)	.94
Body fat %	21.5 (8.9)	20.6 (7.3)	.01
Dietary intake, total kcal	1973 (457)	1810 (333)	.12
Total fat intake, % kcal	36.1 (3.3)	33.0 (3.8)	<.001
Fiber intake, g/d	11.3 (3.2)	11.9 (3.1)	.054
Television/video watching, h/wk	38.3 (14.1)	20.1 (12.0)	<.001
Age at menarche, y	12.0 (1.2)	12.7 (1.2)	<.001

Abbreviation: HS, high school.

[a] Calculated as weight in kilograms divided by height in meters squared.

[b] First measurement was at the second study visit (age, 10-11 years).

Table 2

Pregnancy Groups, Hormonal Contraceptive Use, and Anthropometric Characteristics at Ages 18 to 19 Years by Race

Characteristic	Mean (SD)		*P* Value
	Black Women (n=983)	White Women (n=907)	
Pregnancy group, No. (%)			
Nulligravidas	560 (57.0)	739 (81.5)	
Nulliparous gravidas	114 (11.6)	82 (9.0)	<.001
Parous	309 (31.4)	86 (9.5)	
Births in paras, No. (%)			
1 Birth	237 (76.7)	74 (86.0)	
≥ 2 Births	72 (23.3)	12 (14.0)	
Age at first birth, No. (%), y			
<16	61 (19.7)	13 (14.1)	
≥16	248 (80.3)	73 (85.9)	.95
Hormonal contraceptive use at age 18-20 y, No. (%)			
Never	503 (51.2)	503 (55.5)	
Past	163 (16.6)	95 (10.5)	
Current oral	191 (19.4)	263 (29.0)	<.001
Current Depo-Provera[a] or Norplant[b]	126 (12.8)	46 (5.0)	
Height, cm	163.8 (6.2)	165.2 (6.3)	<.001
Weight, kg	72.3 (15.1)	65.3 (20.7)	<.001
Body mass index[c]	26.9 (7.4)	23.9 (5.3)	<.001
Waist circumference, cm	79.0 (14.1)	74.5 (11.0)	<.001
Hip circumference, cm	104.1 (13.8)	100.3 (10.1)	<.001
Waist to hip ratio	0.76 (0.056)	0.74 (0.050)	<.001
Body fat %	33.5 (13.6)	28.8 (10.1)	<.001
Body size, No. (%)			
Obese[d]	258 (26.3)	117 (12.9)	
Overweight[e]	221 (22.5)	138 (15.2)	<.001
Normal[f]	504 (51.3)	652 (71.9)	

[a] Medroxyprogesterone. Manufactured by Pfizer, New York, New York.

[b] Levonorgestrel. Manufactured by Leiras Oy Pharmaceuticals, Turku, Finland.

[c] Calculated as weight in kilograms divided by height in meters squared.

[d] Body mass index of 30 or greater.

[e] Body mass index 25 to 29.9.

[f] Body mass index less than 25.

Table 3

Unadjusted Baseline and Follow-up Characteristics Among Pregnancy Groups for White and Black Females

Characteristics by Race	Mean (SD)				*P* Value
	Nulligravidas	Nulliparous Gravidas	Primiparas	Multiparas	
At Baseline, Age 9-10 y[a]					
White girls					
No. of participants	739	82	74	12	
Height, cm	139.5 (6.9)	140.6 (7.4)	139.2 (6.8)	137.0 (9.5)	.31
Weight, kg	34.9 (8.5)	36.4 (9.3)	35.8 (7.9)	35.6 (8.0)	.39
Body mass index[b]	17.8 (3.2)	18.3 (3.6)	18.4 (3.2)	18.7 (2.7)	.21
Waist circumference, cm[c]	63.1 (8.1)	63.6 (8.7)	64.9 (8.1)	66.1 (7.2)	.21
Hip circumference, cm[c]	78.9 (8.5)	80.0 (9.1)	80.8 (8.6)	79.7 (8.3)	.20
Waist to hip ratio[c]	0.80 (0.044)	0.79 (0.048)	0.80 (0.042)	0.83 (0.040)	.07
Body fat %	20.5 (7.3)	20.7 (7.3)	21.0 (7.1)	20.8 (6.5)	.95
Black girls					
No. of participants	560	114	237	82	
Height, cm	143.0 (8.1)	143.6 (7.6)	142.4 (7.1)	144.2 (8.0)	.26
Weight, kg	40.3 (11.6)	39.0 (10.5)	37.8 (8.5)	39.8 (10.5)	.03
Body mass index[b]	19.5 (4.3)	18.7 (3.9)	18.5 (3.3)	18.9 (4.0)	.01
Waist circumference, cm[c]	67.2 (10.0)	65.5 (9.2)	65.3 (8.1)	66.7 (8.8)	.04
Hip circumference, cm[c]	83.8 (10.8)	82.5 (10.2)	81.8 (8.9)	84.1 (11.1)	.08
Waist to hip ratio[c]	0.80 (0.046)	0.79 (0.045)	0.80 (0.044)	0.79 (0.039)	.13
Body fat %	22.5 (9.5)	19.9 (8.0)	20.4 (7.9)	19.7 (8.6)	<.001
At Follow-up, Age 18-19 y[d]					
White women					
No. of participants	739	82	74	12	
Height, cm	165.7 (6.1)	164.0 (6.8)	162.9 (6.0)	159.8 (7.9)	<.001
Weight, kg	65.3 (15.0)	62.5 (15.1)	68.9 (15.8)	64.3 (13.3)	.06
Body mass index[b]	23.7 (5.2)	23.2 (5.2)	26.0 (6.0)	25.2 (4.8)	.002

Characteristics by Race	Mean (SD)				*P* Value
	Nulligravidas	Nulliparous Gravidas	Primiparas	Multiparas	
Waist circumference, cm	74.2 (10.9)	72.8 (11.0)	79.6 (11.3)	78.4 (9.4)	<.001
Hip circumference, cm	100.2 (9.9)	98.3 (10.2)	103.6 (11.2)	99.1 (10.2)	<.01
Waist to hip ratio	0.74 (0.050)	0.74 (0.043)	0.76 (0.044)	0.77 (0.054)	<.001
Body fat %	28.5 (9.9)	27.2 (10.7)	32.4 (11.4)	31.8 (9.3)	.005
Age at menarche, y	12.8 (1.2)	12.6 (1.2)	12.2 (1.1)	12.1 (0.6)	<.001
Black women					
No. of participants	560	114	237	82	
Height, cm	164.0 (6.2)	164.7 (6.2)	163.2 (6.3)	163.3 (6.0)	.13
Weight, kg	72.4 (21.5)	68.9 (18.3)	72.4 (19.3)	77.4 (22.0)	.06
Body mass index[b]	26.9 (7.7)	25.4 (6.5)	27.1 (6.8)	29.0 (8.1)	.01
Waist circumference, cm	78.6 (14.9)	75.6 (12.2)	80.0 (13.1)	83.6 (12.9)	.001
Hip circumference, cm	104.0 (14.3)	102.2 (12.1)	104.2 (12.9)	108.1 (15.3)	.04
Waist to hip ratio	0.75 (0.056)	0.74 (0.049)	0.77 (0.054)	0.77 (0.054)	<.001
Body fat %	33.0 (13.6)	31.4 (12.5)	34.9 (13.7)	36.2 (14.2)	.03
Age at menarche, y	12.0 (1.1)	12.0 (1.1)	12.1 (1.2)	12.0 (1.1)	.70

[a] Race by pregnancy group interaction: height, *P* = .43; weight, *P* = .04; hip circumference, *P* = .02; body mass index, *P* = .005; waist circumference, *P* = .01; and waist to hip ratio, *P* = .05.

[b] Calculated as weight in kilograms divided by height in meters squared.

[c] First measurement was at the second study visit (age, 10-11 years).

[d] Race by pregnancy group interaction: height, *P* = .002; weight, *P* = .35; body mass index, *P* = .16; hip circumference, *P* = .13; waist circumference, *P* = .24; waist to hip ratio, *P* = .04; percent body fat, *P* = .75; and age at menarche, *P* = .001.

Table 4

Multivariable-Adjusted Mean Changes in Anthropometric Measures Among Pregnancy Groups by Race[a]

	Mean Change (95% Confidence Interval)							
	Pregnancy Group				Group Differences		*P* Value[b]	
Growth and Adiposity Indices by Race	Nulligravidas[c]	Nulliparous Gravidas[d]	Primiparas[e]	Multiparas[f]	Primiparas vs Nulligravidas	Multiparas vs Nulligravidas	Overall	Race Interaction
Height, cm								
Black	22.3 (20.0 to 22.6)	23.1 (22.3 to 23.9)	22.3 (21.8 to 22.8)	22.0 (21.0 to 23.0)	0 (−0.6 to 0.6)	−0.3 (−1.3 to 0.7)	.17	.13
White	24.2 (24.1 to 24.7)	23.5 (22.6 to 24.4)	24.3 (23.3 to 25.3)	23.1 (20.8 to 25.4)	0.1 (−0.9 to 1.1)	−1.1 (−3.4 to 1.2)	.36	
Weight, kg								
Black	31.3 (30.3 to 32.3)	30.3 (28.1 to 32.5)	34.9 (33.3 to 36.5)[g]	37.3 (34.5 to 40.1)[g]	3.6 (1.9 to 5.3)[g]	6.0 (3.3 to 8.7)[g]	<.001	.06
White	31.0 (30.0 to 32.0)	27.3 (24.9 to 29.7)[h]	32.7 (30.1 to 35.3)	29.4 (23.0 to 35.8)	1.7 (−1.0 to 4.4)	− 1.6 (−7.9 to 4.7)	<.01	
Body mass index[i]								
Black	6.8 (6.4 to 7.2)	6.5 (5.7 to 7.3)	8.1 (7.5 to 8.7)[g]	9.1 (8.1 to 10.1)[g]	1.3 (0.7 to 1.9)[g]	−2.3 (1.3 to 3.3)[g]	<.001	.08
White	6.8 (6.4 to 7.2)	5.3 (4.3 to 6.3)[g]	7.4 (6.4 to 8.4)	6.1 (3.7 to 8.5)	0.6 (−0.4 to 1.6)	−0.6 (−2.9 to 1.7)	<.001	
Waist circumference, cm[j]								
Black	11.0 (10.2 to 11.8	10.3 (8.9 to 11.7)	14.4 (13.4 to 15.4)[g]	16.2 (14.2 to 18.2)[g]	3.5 (2.3 to 4.7)[g]	5.2 (3.2 to 7.2)[g]	<.001	.24
White	11.6 (10.8 to 12.4)	10.0 (8.2 to 11.8)	14.0 (12.2 to 15.8)[k]	12.4 (8.0 to 16.8)	2.4 (0.4 to 4.4)[k]	0.8 (−3.6 to 5.2)	<.01	
Hip circumference,cm[j]								
Black	20.6 (20.0 to 21.2)	20.3 (19.9 to 21.7)	22.7 (21.7 to 23.7)[g]	24.6 (22.8 to 26.4)[g]	2.1 (0.9 to 3.3)[g]	4.0 (2.1 to 5.9)[g]	<.001	.02
White	21.0 (20.4 to 21.6)	18.5 (16.9 to 20.1)[h]	22.1 (20.3 to 23.9)	19.2 (15.0 to 23.4)	1.1 (−0.8 to 3.0)	− 1.9 (−6.2 to 2.4)	.01	
Waist to hip ratio[j]								
Black	−0.057 (−0.061 to −0.053)	−0.060 (−0.068 to −0.052)	−0.037 (−0.042 to −0.031)[g]	0.033 (−0.043 to −0.023)[g]	0.019 (0.013 to 0.025)[g]	0.023 (0.013 to 0.033)[g]	<.001	.62
White	−0.053 (−0.057 to −0.049)	−0.049 (−0.057 to −0.041)	−0.036 (−0.046 to −0.026)[g]	−0.034 (−0.056 to −0.013)	0.017 (0.007 to 0.027)[h]	0.020	<.01 (−0.004 to 0.044)	
Body fat %								
Black	9.5 (8.7 to 10.3)	10.4 (8.8 to 12.0)	12.9 (11.7 to 14.1)[g]	14.0 (12.0 to 16.0)[g]	3.4 (2.1 to 4.7)[g]	4.6 (2.5 to 6.7)[g]	<.001	.003
White	9.5 (8.7 to 10.3)	6.5 (4.7 to 8.3)[h]	10.4 (8.4 to 12.4)	10.0 (5.2 to 14.8)	0.9 (−1.2 to 3.0)	0.4 (−4.4 to 5.2)	<.01	

[a] Adjusted for baseline measurement, age, study center, family income, parental education, age at menarche, hours of television/video watching at baseline, and height at visits 9 or 10 for change in weight.

[b] Significance level for multiple comparisons is $P < .0165$.

[c] n = 503 black females; n = 739 white females.

[d] n = 114 black females; n = 82 white females.

[e] n = 237 black females; n = 74 white females.

[f] n = 72 black females; n = 12 white females.

[g] $P < .001$, pairwise comparison of pregnancy group with referent, nulligravidas.

[h] $P < .01$, pairwise comparison of pregnancy group with referent, nulligravidas.

[i] Calculated as weight in kilograms divided by height in meters squared.

[j] First measurement was at the second study visit (age, 10-11 years).

[k] $P < .05$, pairwise comparison of pregnancy group with referent nulligravidas.

Table 5

Multivariable-Adjusted Changes in Anthropometric Characteristics by Age at First Birth[a]

Characteristic	Mean Change (SE)		Difference in Means (95% CI)[b]
	<16 y at First Birth	≥16 y at First Birth	
Black Females			
No. of participants	61	248	
Height, cm	20.1 (0.6)	20.6 (0.3)	−0.6 (−1.9 to 0.6)
Weight, kg	36.8 (1.9)	33.9 (1.1)	2.9 (−0.8 to 6.6)
Body mass index[c]	9.8 (0.7)	8.6 (0.4)	1.2 (0 to 2.5)
Waist circumference, cm	15.9 (1.2)	14.8 (0.7)	1.1 (−1.4 to 3.4)
Hip circumference, cm	23.8 (1.3)	22.2 (0.7)	1.6 (−0.9 to 4.1)
Waist to hip ratio	−0.031 (0.006)	−0.032 (0.003)	0.001 (−0.1 to 0.01)
Body fat %	16.0 (1.4)	14.0 (0.8)	2.0 (−0.8 to 4.8)
White Females			
No. of participants	12	73	
Height, cm	21.7 (1.3)	22.7 (0.6)	−1.0 (−3.6 to 1.6)
Weight, kg	29.5 (3.8)	33.9 (1.7)	−4.4 (−12.3 to 3.5)
Body mass index[c]	6.9 (1.3)	8.1 (0.6)	−1.3 (−3.8 to 1.6)
Waist circumference, cm	13.0 (2.4)	14.9 (1.1)	−1.9 (−3.3 to 6.9)
Hip circumference, cm	21.1 (2.6)	23.2 (1.1)	−2.1 (−7.5 to 3.2)
Waist to hip ratio	−0.041 (0.012)	−0.035 (0.005)	0.006 (−0.2 to 0)
Body fat %	10.3 (2.9)	11.4 (1.3)	−1.1 (−7.1 to 4.9)

Abbreviations: CI, confidence error; SE, standard error.

[a] Adjusted for baseline measurement, age, family income, study site, parental education, age at menarche, and height at baseline and end of follow-up for change in weight model. Race interaction: change in weight, $P = .10$; change in height, $P = .76$; change in body mass index, $P = .14$; change in waist circumference, $P = .31$; change in hip circumference, $P = .22$; change in waist to hip ratio, $P = .18$; change in percent body fat, $P = .36$.

[b] Not all age group differences in mean changes are statistically significant.

[c] Calculated as weight in kilograms divided by height in meters squared.