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Ethnic heterogeneity in the longitudinal effects of placental vascular blood flow on birthweight

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Abstract

OBJECTIVE—Our goals were: (1) to estimate the longitudinal trends in uterine artery (UtArt) and umbilical artery (UmArt) resistance indices (RIs) in different ethnic strata; (2) to estimate time-dependent changes across gestation in the influence of variation in UtArt and UmArt RI on variation in birthweight in different ethnic strata; and (3) to determine the optimum set of UtArt and UmArt RIs for predicting birthweight in different ethnic strata.

STUDY DESIGN—Analyses were carried out on data collected in a prospective study of 535 multiethnic gravidas recruited from the Cedars-Sinai Medical Center (Los Angeles, CA). Baseline maternal characteristics were recorded at time of entry into the study. UtArt and UmArt RIs were measured on 3 occasions during pregnancy (visit 1, 16–20 weeks' gestation; visit 2, 21–29 weeks' gestation; and visit 3, 30–36 weeks' gestation). The outcome for this study was gestational age-adjusted birthweight (aBW).

RESULTS—The average UtArt and UmArt RI decreased steadily across gestation for all ethnicities. The average UtArt RI at each visit and the average rate of change between visits were not significantly different among the ethnicities. However, the UmArt RI measured at visit 3 and its rate of change in the last trimester were significantly different among the ethnic groups ($P < .02$). After adjustment for traditional risk factors for fetal growth restriction, the magnitude and rate of change of UtArt RI significantly predicted aBW only in Hispanic women, whereas the magnitude and rate of change of UmArt RI predicted aBW only in African American women. The most parsimonious combination of UtArt and UmArt RI measurements at visits 1, 2, and 3 that predicted statistically significant variation in aBW differed by ethnicity.

CONCLUSION—The relationships between aBW and longitudinally collected measures of UtArt and UmArt RI depend on the context defined by ethnicity and time of measurement after adjusting for a parsimoniously selected subset of traditional risk factors.

Keywords

birthweight; Doppler velocimetry; ethnicity; fetal growth; placental vascular resistance

Birthweight is an important indicator of perinatal health that influences an individual's risk for morbidity across the life span. In the United States, large ethnic disparities in birthweight remain a vexing problem.^{1,2} Birthweight is influenced by the establishment of the maternal-fetal vascular interface early in gestation and ongoing placental development during pregnancy.

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³ Accordingly, disordered placentation is associated with fetal growth restriction (FGR).^{4,5} Placentas from pregnancies complicated by FGR are found to have a number of structural abnormalities, including a decrease in villous number, diameter, and surface area, as well as a decrease in arterial number, lumen size, and branching.⁶⁻¹¹ These abnormalities may compromise placental blood flow and nutrient delivery to the developing fetus. We have little knowledge about ethnic variation in the placental vascular development and how this variation may be related to differences in birth outcome.

Doppler velocimetry provides insight into placental vascular development and is an important tool in the clinical management of pregnancies affected by abnormal placental vascular development.¹² Many studies have established that Doppler measures of abnormal uterine and umbilical artery blood flow at individual time points during pregnancy predict the risk of fetal morbidity and mortality.^{6,13-18} However, few studies have adequately documented the relationship between quantitative, time-dependent variation in measures of placental vascular flow and variation in fetal growth. Therefore, little is known about the interpretation of Doppler flow measures at different times during gestation with regard to their effects on clinically important outcomes like birthweight. Even less is known about ethnic differences in these measures and how these differences may be related to ethnic differences in birthweight.

The goals of our study were: (1) to estimate the longitudinal trends in uterine artery (UtArt) and umbilical artery (UmArt) resistance indices (RIs) in different ethnic strata; (2) to estimate the influence of time-dependent variation in changes in UtArt and UmArt RIs across gestation on variation in birthweight in different ethnic strata; and (3) to determine the optimum set of UtArt and UmArt RIs for predicting birthweight in different ethnic strata.

Materials and Methods

Study sample

Data were prospectively collected in a longitudinal study of 688 self-identified non-Hispanic white, African American, Hispanic, and Asian gravidas recruited over a 3-year period in clinics associated with Cedars-Sinai Medical Center in Los Angeles, California. The Institutional Review Board at Cedars-Sinai Medical Center approved this study. Enrolled subjects were 18 years or older, < 20 weeks pregnant with a singleton pregnancy, and intended to deliver at the study hospital. Informed consent was obtained at the initial visit. Subjects with multifetal pregnancies, major structural fetal abnormalities, or prenatally diagnosed aneuploidy were excluded. As shown in the Figure, data analyses were restricted to an initial cohort of 535 eligible non-Hispanic white, African American, and Hispanic subjects who delivered a live infant between 22-44 weeks' gestation. Each analysis was restricted to individuals measured for all relevant variables. Fewer than 10% of women were excluded from any particular analysis because of missing data.

Data collection and variables

Traditional risk factors—Baseline maternal characteristics, including age, height, weight, and self-reports of race (categorized as non-Hispanic white, African American/black, Hispanic, Asian/Pacific Islander, Native American, and other), years of education completed, source of medical payment, marital status, date of last menstrual period (LMP), prepregnancy weight, previous pregnancy history, current pregnancy history, maternal chronic illnesses, medications, alcohol, and cigarette and other drug use were recorded on entry into the study. Maternal prepregnancy body mass index (BMI) was calculated using height and prepregnancy weight. The following 4 maternal BMI categories were defined based on National Heart, Lung, and Blood Institute guidelines¹⁹: (1) < 18.5, (2) 18.5-24.9, (3) 25.0-29.9, and (4) > 30.

At each of the 3 follow-up visits (visit 1, 16-20 weeks' gestation; visit 2, 21-29 weeks' gestation; and visit 3, 30-36 weeks' gestation), Doppler velocimetry was used to measure the RI for the UmArt and the left and right UtArt using an ATL, HDI 3000 ultrasound machine (Philips Medical Systems, Best, the Netherlands). These measurements were obtained by 1 of 5 sonographers at a single site trained by and under the supervision of Dr Hobel, a project investigator. Measurements on the uterine arteries were obtained just proximal to the point at which they crossed the external iliac artery. Each Doppler waveform was measured at least 3 times, and values were excluded if they were more than twice, or less than half, the median of the measurements for an individual. Because there may be laterality differences in UtArt RI, ²⁰ a nested 1-way analysis of variance was used to test the average difference between the left and right UtArt RI. Because there were no significant differences ($P < .05$) between the average measurements on the 2 sides, the values of the left and right UtArt RI for each individual were averaged together for each visit.

Dependent variables—Infant variables, including date of delivery, birthweight, and gender, were collected at delivery. Gestational age (GA) was estimated from the self-reported LMP. For 128 participants, a first-trimester dating ultrasound was available. For 45 of these patients, these 2 measures differed by more than 10 days, so the date determined from the first-trimester ultrasound estimate was used as the actual GA. In all cases, our estimated GA was corroborated by ultrasound estimates at each follow-up visit. Because birthweight varies significantly with GA, the birthweight was regressed onto GA using a third-order polynomial function. The residual values from each fit were used to represent the GA-adjusted birthweight (aBW). These residuals were then used as the dependent variable for the modeling of the contribution of UtArt and UmArt RIs to the prediction of aBW as described below.

Statistical analysis

We used SAS statistical software (v 9.1, SAS Institute, Cary, NC) for all data analyses. We first estimated the mean and SD for the UtArt and UmArt RIs at each visit (RI_1 , RI_2 , and RI_3) as well as the rate of change between visits, defined as $RI_{12} = (RI_2 - RI_1)$ divided by $(GA_2 - GA_1)$, where GA is the gestational age at time of measurement and tested the hypothesis of homogeneity of the means of each among ethnic groups.

We next tested the hypothesis that variation in aBW is not influenced by variation in UmArt or UtArt RI measured at multiple time points in gestation for each ethnic group. We used a standard longitudinal analytic approach²¹ to estimate the effects of variation in repeated measures (RI_1 , RI_2 , RI_3) of a predictor variable (UmArt RI or UtArt RI) on a single outcome (aBW). The definitions of the effects that were considered are given in the following equation.

$$E(aBW) = \beta_0 + (\beta_1) RI_1 + (\beta_2) RI_{12} + (\beta_3) RI_{23} + \sum_i (\beta_i) RF_i$$

In this parameterization, the coefficient for RI_1 defines the effect of increasing the measured resistance by 1 unit at any study visit. This effect describes, for example, a pathophysiological event early in pregnancy that may increase the RI across all visits by uniformly shifting the trajectory upward, resulting in a cumulative effect on aBW. The coefficients for RI_{12} and RI_{23} define how variation in the rate of change of RI in each visit interval may affect variation in aBW. The rightmost summation in the equation defines the covariate effects of the traditional risk factors that may influence aBW.

To determine the most parsimonious combination of covariates for inclusion in the equation, the effects of traditional risk factors for FGR (maternal age at delivery, parity, maternal prepregnancy BMI, maternal smoking during pregnancy, and infant sex) were estimated using a multivariable backward stepwise linear regression procedure done separately for each ethnic

stratum. Variables that were significant predictors of aBW at $P < .1$ were selected for retention at each step.

We next obtained the most parsimonious combination of UmArt and UtArt RI measurements for predicting variation in aBW in each ethnic group after adjustment for variation in the selected traditional risk factors for FGR. The multivariable backward stepwise linear regression method was used to select the optimum combination of UmArt and UtArt RIs measured at different visits that explained the greatest amount of variation in aBW. In these analyses, the selected traditional risk factors (as determined above) for each ethnicity were fixed in each step of the selection procedure. The UmArt and UtArt RIs that were significantly associated with aBW at $P < .1$ were retained in the prediction model.

The analyses were done for women who presented for visit 1; visit 1 and 2; and visit 1, 2, and 3. All women with complete data are included in analyses for visit 1. The sample for the subsequent 2 visits is right censored by deliveries that occur in the interval (ie, preterm deliveries and missed visits). In each analysis, the final model for each ethnic strata represents the optimum combination of UmArt and UtArt RIs measured across visits for predicting aBW adjusted for traditional risk factors for FGR. For univariate analyses, our study was powered to detect a 12.8 g difference in birthweight for a 0.1 unit change in RI in non-Hispanic whites; a 10.6 g difference in African Americans; and a 9.8 g in Hispanics assuming a 10% type I error rate.

Results

Table 1 describes the characteristics of the 535 participants included in our sample; 32.3% of the women were Hispanic, 23.2 % were non-Hispanic white, and 44.5% were African American. These ethnic groups were significantly different for marital status, educational level, and source of payment for medical care associated with pregnancy and delivery. A higher proportion of African American and Hispanic women were in the younger age groups, had BMIs in the overweight and obese range, and were more likely to be multiparous than non-Hispanic white women. African American women had infants with significantly lower average birthweight and were more likely to deliver preterm.

Table 2 gives the average value of the UtArt and UmArt RI for each visit and the average change per day between visits (RI_{12} and RI_{23}). For both arteries, the mean RI decreased steadily from 16-36 weeks. We found that the average values of RI_1 , RI_2 , RI_3 , RI_{12} , and RI_{23} for the UtArt were not significantly different among the ethnicities. However, UmArt RI_3 and RI_{23} were each significantly different among the ethnic groups.

Table 3 presents the results of multivariable analyses of the influence of variation in UtArt and UmArt RI measured at each of the 3 visits on variation in aBW. After adjusting for significant risk factors for FGR in analyses pooled by ethnicity, we found that a 0.1 unit increase in UtArt RI measured at any visit (coefficient of RI_1) decreases aBW by about 140 g, whereas a 0.1 unit increase in UmArt RI measured at any visit predicts an average decrease in aBW of 90 g. A significant decrease in aBW was also associated with an increase of 0.01 unit in the rate of change between visits (coefficients of RI_{12} and RI_{23}) for both UtArt and UmArt RI.

Because of the ethnic differences observed in Table 1 and the heterogeneity of RIs presented in Table 2, the 3 ethnic groups in our sample were analyzed separately. As expected, the set of traditional maternal and fetal risk factors retained in the best fitting regression model differed by ethnicity (see footnote in Table 3). After adjustment for these factors in analyses stratified by ethnicity, a large, statistically significant effect of UtArt RI on aBW is found only in Hispanic women in whom we found that a 0.1 unit increase in UtArt RI measured at any visit decreased aBW by 214 g. Additionally, the influence of UtArt RI_{12} and RI_{23} on aBW was

significantly larger in Hispanic women. After adjustment, a large, significant effect of UmArt RI, was found only in African American women in whom a 0.1 unit increase in UmArt RI measured at any visit decreased average aBW by nearly 170 g. The influence of RI₁₂ and RI₂₃ on aBW was also significantly larger in African American women.

Table 4 presents the results of the multivariable backward regression analyses used to define the most parsimonious combination of UmArt and UtArt RIs in each ethnic group for predicting the variation in aBW adjusted for variation in selected traditional risk factors for FGR (see footnote in Table 4). For all ethnicities seen at visit 1 or visits 1 and 2, UtArt RI measured at different times, but not UmArt RI, was the only significant predictor of aBW. However, for women seen at all 3 visits, optimal prediction of aBW in African-American women was achieved by measurement of only the UmArt RI₃, whereas combined measurement of UtArt RI₂ and UtArt RI₃ best predicted aBW for Hispanic women, and UtArt RI₁ was the best predictor for non-Hispanic white women.

Comment

Little is known about ethnic variation in the placental vascular system and how this variation may be related to differences in birth outcomes such as BW. Our study is among the first to evaluate the relationship between time-dependent variation in quantitative measures of uterine and umbilical artery blood flow and variation in BW in different ethnic strata. We describe time-dependent changes in UtArt and UmArt RI during pregnancy and their influence on variation in aBW in Hispanic, non-Hispanic white and African American women. A strength of our study was the ethnic composition of the cohort. Although the sample size for each of the 3 ethnic groups limited our statistical power, our subsamples were larger than many ethnically pooled studies of the effects of Doppler indices on fetal growth. We found that UtArt and UmArt RI are both strong predictors of aBW, although at different times in gestation in different ethnic strata. However, we note that some of these differences of statistical significance for the effect among the ethnic groups in our study may have been due in part to limited statistical power. Given these caveats, we found that the optimal prediction of aBW by Doppler flow characteristics depends on the context defined by timing of resistance measurements and unmeasured maternal and fetal characteristics indexed by ethnicity.

In our study, ethnicity was determined by self-report of 3 major groups: African American, non-Hispanic white, and Hispanic women. This classification scheme derives from the geographic region of origin of a person's ancestry and suggests a shared genetic heritage.^{22, 23} Although our participants identified themselves as members of a single ethnic group, mixture among different racial groups in the United States makes it difficult to ascribe purely genetic or biologic meaning to differences in ethnic heritage.²² In a multiethnic and multicultural society such as the United States, ethnic identity is a broader construct that defines a context determined by the ever-changing interactions among an array of psychosocial, behavioral, economic, cultural, and other unmeasured factors.^{24,25} Socioeconomic status, racial bias/discrimination, and health behaviors are all correlated with racial and ethnic background and may influence medical care and health outcomes. Our study was not designed to test hypotheses about the interactions among factors that determine ethnic context.

The prospective cohort design of this study is uniquely suited for measuring longitudinal data for the analysis of time-dependence of key variables over the course of gestation. Moreover, this design also ensures that an accurate estimate of gestational age can be determined, from both the date of a woman's LMP and serial ultrasound examinations. However, the identification and recruitment of study participants early in pregnancy inherently limits study participation to a group of women who present for prenatal care and are able to attend multiple

study visits. Women without prenatal care or with late, interrupted, or sporadic care may not have been included.

Time dependence of placental blood flow

We found that the average UtArt and UmArt RI decrease steadily from 16-36 weeks' gestation as reported in previous smaller studies.^{26,27} Although the UtArt RI measured at each visit and its rate of change in the second and third trimester were not significantly different among the ethnic groups considered in our study, the UmArt RI and its rate of change in the third trimester (from visit 2 at 21-29 weeks' gestation to visit 3 at 30-36 weeks' gestation) were significantly different among these groups.

These findings suggest that there may be differences among ethnicities for late pregnancy influences on the maturation of the fetoplacental, but not uteroplacental, vasculature. It is well known that abnormal UmArt flow is associated with fetoplacental vascular pathology.⁶⁻⁸ Previous reports have shown that fetoplacental vascular pathology is associated with UmArt blood flow only late in pregnancy.²⁸ In these studies, pregnancies with abnormal UmArt Dopplers have mean villous profile cross-sectional area and diameter that are significantly smaller than those with normal Dopplers only after 30 weeks' gestation.²⁸

Placental morphology did not differ substantially between the 2 groups before 30 weeks' gestation. Such findings suggest that pathologic changes in the placenta influence variation in UmArt RI relatively late in pregnancy. Our observations of significant differences in third-trimester UmArt RI among ethnic groups suggest that ethnicity-related factors may also influence umbilical artery blood flow relatively late in gestation. However, the histopathologic mechanisms underlying the observed ethnic differences in third-trimester UmArt RI cannot be inferred from our data.

Placental blood flow and birthweight

A significant decrease in aBW was associated with an increase in UtArt and UmArt RI as well as an increase in their rate of change between visits. These results are consistent with previous clinical studies showing that increased impedance to flow in the uterine and umbilical arteries measured during the second trimester are associated with increased risk for FGR.^{18,29,30} However, we found that the influence of time-dependent variation in UtArt and UmArt RI on variation in aBW differs by ethnicity. Increased UtArt RI reduces the aBW of Hispanic infants to a much greater degree than it reduces aBW in the other 2 ethnic groups after adjusting for typical risk factors for FGR. The influence of UmArt RI on aBW also depends on ethnicity. We found that aBW is significantly associated with higher UmArt RI only in African American women. These results suggest that factors indexed by ethnicity act over the course of pregnancy to modify the influence of placental vascular resistance on aBW.

Histopathologic evidence suggests that the relationship of aBW to UtArt and UmArt RI may be mediated by pathological changes in the placenta.³⁰⁻³⁴ In this context, UtArt RI may be influenced by a range of factors³⁵⁻³⁸ that affect placental growth and development early in pregnancy,³⁹ establishing a chain of events that that influences BW later in gestation. Accordingly, we observed that the effect of the rate of change of UtArt RI on aBW becomes smaller as gestation proceeds. In contrast, as noted above, UmArt RI is more strongly influenced by later changes in fetoplacental blood flow.^{33,34} Accordingly, we observed that the effect of the rate of change of UmArt RI on aBW becomes larger as gestation proceeds. Thus, our study suggests that the effect of UtArt and UmArt RI on aBW depends on the timing of these measures and ethnicity of the patient. Although Doppler velocimetry may suggest some potential mechanisms for ethnic differences in birthweight, the likely etiology for these ethnic differences cannot be inferred from the data collected by our study.

Clinical implications

Doppler velocimetry is frequently used in the clinical management of pregnancies affected by abnormal placental vascular development.¹² When multiple Doppler measures are available, the best prediction of aBW utilizes the second-trimester UtArt RI in non-African American women, whereas the best Doppler prediction of aBW in African American women is given by the third-trimester UmArt RI. Although our data and analyses do not provide information on the effect of UmArt and UtArt on BW at different gestational ages, our results do suggest that the optimal utilization of this technique to predict birthweight depends on the type of the measurement (UmArt vs UtArt), the timing of the measurement, and unmeasured characteristics of the mother and her fetus that are indexed by ethnicity. Our study suggests that obstetricians should be aware of the context of the pregnancy defined by the timing of their measures and ethnicity of their patient when making clinical decisions that use measures of UtArt and UmArt RI.

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Figure.
Ascertainment of study cohort

TABLE 1

A description of the general characteristics of the study sample

	Non-Hispanic white 124 (23.2)	Hispanic 173 (32.3)	African American 238 (44.5)
Sample (n, %)			
Maternal characteristics (n, %)			
Maternal age, y, ^{ab}			
< 21	3 (2.4)	23 (13.3)	27 (11.3)
21-30	44 (35.5)	101 (58.4)	143 (60.1)
> 30	77 (62.1)	49 (28.3)	68 (28.6)
Marital status, ^{abc}			
Married	103 (83.1)	94 (54.3)	70 (29.5)
Single	21 (16.9)	79 (45.7)	168 (70.5)
Highest educational level, ^{abc}			
Elementary	0	10 (5.8)	0
High school	24 (19.3)	110 (63.6)	133 (55.9)
College	73 (58.9)	50 (28.9)	97 (40.8)
Postgraduate	27 (21.8)	3 (1.7)	8 (3.3)
Source of payment, ^{abc}			
Government assistance	22 (17.7)	79 (45.7)	150 (63.0)
Private insurance	99 (79.9)	92 (53.2)	87 (36.6)
Self-pay	3 (2.4)	2 (1.1)	1 (0.4)
Parity (n, %), ^{ab}			
Nulliparous	69 (55.7)	63 (36.4)	71 (29.8)
Multiparous	55 (44.3)	110 (63.6)	167 (70.2)
Maternal BMI (n, %) ^{a,b}			
Underweight (< 18.5)	14 (11.3)	8 (4.6)	15 (6.3)
Normal (≥ 18.5, < 25)	81 (65.3)	88 (50.9)	103 (43.3)
Overweight (≥ 25, < 30)	15 (12.1)	44 (25.4)	54 (22.7)
Obese (≥ 30)	14 (11.3)	32 (18.5)	60 (25.2)
Smoking (n, %) ^c			
During pregnancy	22 (17.7)	25 (14.5)	53 (22.3)
Not during pregnancy	102 (82.3)	147 (85.0)	185 (77.7)
Infant characteristics			
Infant sex (n, %)			
Male	61 (49.2)	92 (53.2)	120 (50.4)
Female	63 (50.8)	81 (46.8)	118 (49.6)
Preterm delivery (n, %) ^{b,c}	9 (7.3)	13 (7.5)	34 (14.3)
Gestational age at delivery (mean in days, ± SD) ^b	275.59 (16.3)	274.87 (14.0)	271.91 (17.1)
Birthweight (mean in grams, ± SD) ^{b,c}	3434.60 (569.4)	3370.43 (514.7)	3212.34 (657.7)

Statistically significant differences between ethnicities computed using a χ^2 or Fisher's exact test for categorical variables and the *t* test for continuous variables.

^a*P* < .05 for non-Hispanic white, compared with Hispanic.

^b*P* < .05 for non-Hispanic white, compared with African-American.

^c*P* < .05 for Hispanic, compared with African American.

TABLE 2
Average UtArt and UmArt RI at each study visit and average change per day across study visit intervals

Measure, mean (± SD, n)	RI ₁	RI ₂	RI ₃	RI ₁₂ ^a	RI ₂₃ ^a
Uterine artery					
Ethnicities pooled	0.577 (0.099, 526)	0.505 (0.089, 509)	0.482 (0.082, 455)	-0.0011 (0.0014, 500)	-0.0003 (0.0016, 449)
Non-Hispanic white	0.571 (0.093, 122)	0.501 (0.081, 120)	0.479 (0.073, 103)	-0.0010 (0.0012, 118)	-0.0003 (0.0014, 103)
Hispanic	0.578 (0.103, 170)	0.507 (0.083, 164)	0.487 (0.080, 157)	-0.0011 (0.0015, 161)	-0.0003 (0.0016, 154)
African-American	0.580 (0.100, 234)	0.505 (0.096, 225)	0.479 (0.087, 195)	-0.0011 (0.0013, 221)	-0.0003 (0.0017, 192)
P value ^b	0.69	0.87	0.64	0.82	0.99
Umbilical artery					
Ethnicities pooled	0.747 (0.065, 524)	0.657 (0.071, 508)	0.567 (0.069, 455)	-0.0013 (0.0012, 497)	-0.0016 (0.0014, 448)
Non-Hispanic white	0.748 (0.063, 121)	0.662 (0.062, 119)	0.565 (0.066, 105)	-0.0013 (0.0011, 116)	-0.0017 (0.0014, 104)
Hispanic	0.745 (0.068, 169)	0.651 (0.066, 164)	0.578 (0.066, 156)	-0.0014 (0.0013, 160)	-0.0013 (0.0015, 153)
African-American	0.749 (0.065, 234)	0.658 (0.079, 225)	0.559 (0.073, 194)	-0.0013 (0.0012, 221)	-0.0017 (0.0014, 191)
P value ^b	0.81	0.39	0.04	0.63	0.02

^aRate of change of RI between study visits calculated for each individual as the difference in measurement between visits divided by the gestational age interval in days.

^bSignificance of the effect of ethnicity on RI computed using the *t* test.

TABLE 3

Influence of UtArt and UmArt RI and their rate of change across visit intervals on aBW

	All ethnicities ^a Beta (95% CI)	African American ^b Beta (95% CI)	Hispanic ^c Beta (95% CI)	Non-Hispanic white Beta (95% CI)
UtArt ^d				
RI ₁	-141.6 (-197.7, -85.4) ^e	-83.9 (-169.6-1.8)	-214.0 (-305.3, -122.6) ^e	-86.9 (-224.5-50.7)
RI ₂	-621.2 (-1,031.3, -211.1) ^f	-285.9 (-908.7-337.0)	-1,184.1 (-1,839.8, -528.5) ^e	-65.9 (-1,096.4-964.6)
RI ₂₃	-308.6 (-594.8, -22.4) ^f	-168.3 (-616.6-280.0)	-531.9 (-998.7, -65.0) ^f	-8.9 (-667.1-649.3)
UmArt ^d				
RI ₁	-90.0 (-172.6, -7.4) ^f	-168.9 (-294.6, -43.2) ^f	-49.7 (-189.2-89.8)	-51.8 (-236.1-132.6)
RI ₂	-580.8 (-1,069.4, -92.3) ^f	-998.8 (-1,714.8, -282.7) ^f	-365.9 (-1,199.2-467.3)	-238.2 (-1,404.6-928.2)
RI ₂₃	-621.2 (-944.1, -298.2) ^e	-900.7 (-1,395.6, -405.8) ^e	-438.7 (-1,018.0-140.5)	-582.3 (-1,290.0-125.5)

Significance of effect on aBW was done using an analysis of variance.

CI, confidence interval.

^a Adjusted for sex and parity.

^b Adjusted for sex and maternal BMI.

^c Adjusted for sex, parity, and maternal age.

^d Regression coefficient calculated for the effect of a 0.1 unit change in UtArt and UmArt RI and a 0.01 unit change in RI₁₂ and RI₂₃ on aBW in grams.

^e $P < .001$.

^f $P < .05$.

TABLE 4Backward regression analyses of predictors for aBW in each ethnic stratum^a

	African American ^b Beta (95% CI) (n = 226)	Hispanic ^c Beta (95% CI) (n = 166)	Non-Hispanic white ^d Beta (95% CI) (n = 121)
Visit 1			
UtArt ^e			
RI ₁	-74.8 (-128.5- -21.2) ^f	-76.9 (-135.7- -18.0) ^f	-85.0 (-163.4- -6.6) ^f
UmArt ^e			
RI ₁	—	—	—
Visits 1 and 2	(n = 212)	(n = 158)	(n = 116)
UtArt ^e			
RI ₁	—	—	-101.8 (-181.4- -22.1) ^f
RI ₂	-80.5 (-138.4- -22.7) ^f	-136.5 (-209.5- -63.4) ^g	—
UmArt ^e			
RI ₁	—	—	—
RI ₂	—	—	—
Visits 1, 2, and 3	(n = 178)	(n = 147)	(n = 100)
UtArt ^e			
RI ₁	—	—	-80.8 (-171.5-9.8) ^h
RI ₂	—	-108.8 (-188.8- -28.8) ^f	—
RI ₃	—	-98.2 (-181.0- -15.4) ^f	—
UmArt ^e			
RI ₁	—	—	—
RI ₂	—	—	—
RI ₃	-152.7 (-236.9- -68.4) ^h	—	—

Significance of effect on aBW calculated using an analysis of variance.

CI, confidence interval.

^aVariables with significant effects ($P < .1$) on aBW after completion of the backward elimination procedure are included. A dash denotes a variable that was eliminated at an early step in the backward elimination procedure and does not appear in the final model.^bAdjusted for sex and maternal BMI.^cAdjusted for sex, parity, and maternal age.^dAdjusted for sex.^eRegression coefficient calculated for a 0.1 unit change in UtArt and UmArt RI.^f $P < .05$.^g $P < .001$.^h $P < .10$.