The Influence of Exercise During Pregnancy on Racial/Ethnic Health Disparities and Birth Outcomes

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Research Article

Keywords: race, health disparities, pregnancy, exercise

Posted Date: December 31st, 2020

DOI: https://doi.org/10.21203/rs.3.rs-126121/v1

Version of Record: A version of this preprint was published on March 26th, 2021. See the published version at https://doi.org/10.1186/s12884-021-03717-5.

# Abstract

Background: Non-Hispanic black (NHB) pregnant women disproportionately experience adverse birth outcomes compared to NH white (NHW) pregnant women. The positive effects of prenatal exercise on maternal and neonatal health may mitigate these disparities. This study evaluated the influence of prenatal exercise on racial/ethnic disparities in gestational age (GA), birthweight (BW), and risks of preterm birth (PTB), cesarean section (CS), and low-birthweight (LBW) neonates.

Methods: This study performed a secondary data analysis using data from a 24-week, two-arm exercise intervention trial (ENHANCED by Mom). Women with singleton pregnancies (<16 weeks), aged 18-40 years, BMI between 18.5-34.99 kg/m^2, and no preexisting health conditions were eligible. The aerobic exercisers (EX) participated in 150 minutes of moderate-intensity weekly exercise while non-exercising controls (CON) attended low-intensity stretching/breathing sessions. Data on GA, PTB (<37 weeks), BW, LBW (< 2.5 kg), and delivery mode were collected. Poisson, median and linear regressions were performed.

Results: Participants with complete data (n=125) were eligible for analyses (EX: n=58, CON: n=67). NHB pregnant women delivered lighter neonates (β=-0.43 kg, 95% CI: -0.68, -0.18, p=0.001). After adjusting for prenatal exercise, racial/ethnic disparities in BW were reduced (β=-0.39 kg, 95% CI: -0.65, -0.13, p=0.004). Prenatal exercise reduced borderline significant racial/ethnic disparities in PTB (p=0.053) and GA (p=0.07) with no effects found for CS and LBW.

Conclusions: The findings of this study demonstrate that prenatal exercise may attenuate the racial/ethnic disparities observed in neonatal BW, and possibly GA and PTB. Larger, diverse samples and inclusion of maternal biomarkers (e.g., cytokines) are encouraged to further evaluate these relationships.

Introduction

Despite recent healthcare reform in the US to minimize racial/ethnic disparities among pregnant women, the prevalence of adverse pregnancy outcomes remains higher among select minority groups, specifically, non-Hispanic (NH) black pregnant women(1). Recent national birth record data shows that 14.1% of NH black women deliver preterm (< 37 weeks of gestation) compared to 9.0% among NH white women. Greater proportions of NH black pregnant women deliver via cesarean section (36.1% vs 30.8%) and deliver more very-low- (2.9% vs 1.0%) & low-birthweight (14.1% vs 6.9%) neonates compared NH white pregnant women(2). These adverse delivery and birth outcomes may negatively affect the health of the neonate at birth. Consequently, consistent evidence shows that the well-being of neonates at birth is a strong indicator of future health trajectory, with poorer well-being at birth predisposing neonates to future health complications including obesity, type 2 diabetes mellitus, respiratory infections, cognitive delays, etc.(3,4). Therefore, it is imperative to explore maternal behaviors that may optimize the maternal-fetal environment leading to the delivery of full-term, healthy-weight neonates; thus, eliminating the racial/ethnic disparities in these adverse maternal and neonatal outcomes.

Over the past two decades, accumulating evidence demonstrates many maternal, fetal and neonatal benefits consequent to participation in recommended levels of exercise during pregnancy(5). Women engaging in at least the recommended American College of Obstetricians and Gynecologists (ACOG) guidelines (6) (>150 minutes per week or 500 MET•min•week^{-1}), experience healthy weight gain(7) and decreased risks of metabolic complications (e.g., gestational diabetes mellitus)(8,9)Moreover, neonates exposed to exercise *in utero* exhibit lower percent body fat(10), increased cardiovascular function(11,12), and enhanced neuromotor skills(13). With regard to delivery and birth outcomes, current evidence suggests that prenatal exercise does not increase the risks of preterm births or delivery of low-birthweight neonates and may lower risk of cesarean sections(14,15). Most of these studies however, did not explore racial/ethnic differences in these outcomes. Limited studies examined these associations among NH black pregnant women and demonstrated a reduction in risk in these outcomes among NHB pregnant women(16,17). However, these studies did not employ rigorous study designs or measures of prenatal exercise. Thus, the effectiveness of prenatal exercise to close the gap in the racial/ethnic disparities in select delivery and birth outcomes between NH black and NH white pregnant women is unclear. As such, the purpose of this study was to determine the effects of a prenatal aerobic moderate-intensity exercise intervention on the association between maternal race/ethnicity and select delivery and birth outcomes between NH black and NH white pregnant women. We hypothesized that for all outcomes, prenatal exercise would reduce the racial/ethnic disparities between NH black and NH white pregnant women and their neonates.

Methods

Study Design

This study employed a secondary data analysis using data from a prospective randomized study (ENHANCED by Mom) focused on the influence of exercise type on infant outcomes throughout pregnancy(18). Women were recruited from local obstetric clinics via brochures, flyers, word-of-mouth and social media in eastern North Carolina. All protocols were approved by the Institutional Review Board at East Carolina University. Each eligible and interested participant read and signed a written informed consent prior to enrollment. Pregnant women were enrolled between 13-16 weeks of gestation and participated in the exercise intervention until delivery.

Study Population

Inclusion criteria for this study were healthy, low-risk pregnancy, defined as follows: 1) singleton pregnancy (<16 weeks of gestation), 2) between 18 and 40 years of age, 3) pre-pregnancy body mass index (BMI) between 18.5 to 34.99 kg/m^2, 4) physician clearance to participate in an exercise program, and 5) able to communicate fluently in English and be contacted via phone or email. Women were excluded from the study if they: 1) had pre-existing medical conditions (e.g., diabetes, hypertension) or conditions known to affect fetal development (e.g., systemic lupus erythematosus), 2) were taking medications known to affect fetal development or pregnancy outcomes, or 3) were using tobacco, alcohol, or other recreational drugs. If an interested participant met these criteria, then the informed consent was obtained prior to study enrollment.

Randomization

Following study enrollment, participants completed a submaximal exercise treadmill test to determine their individual aerobic capacity and calculate their target heart rate (THR) ranges for moderate-intensity aerobic exercise training. Peak oxygen consumption (VO_{2peak}) was estimated via the modified Balke protocol previously validated and replicated for pregnant women by Mottola et al (2006)(19). After completing this test, participants were randomized via computerized sequencing (GraphPad software) to aerobic exercise or a non-exercising comparison group.

Exercise Intervention

Both the aerobic exercise and non-exercising stretching/breathing groups participated in sessions three times per week for at least 50 minutes per session. All participants began each session with a 5-minute warm-up and ended with a 5-minute cool-down. All participants tailored their program, choosing 3 days weekly to attend supervised sessions. All training sessions will be supervised by a trained staff member. Resting heart rate (HR) and blood pressure were assessed before and after each session; HR (Polar FS2C HR monitor) and rating of perceived exertion (RPE) were monitored throughout exercise to maintain appropriate intensity. The aerobic training group exercised on aerobic machines (i.e. treadmill, elliptical, bicycle) meeting the ACOG guidelines of *150 minutes per week of moderate intensity* (40-59% VO_{2peak}; 60-80% aerobic capacity, RPE of 12-14) exercise. The non-exercising control group attended low-intensity (<40% VO_{2peak}) sessions focused on the stretching of major muscle groups while incorporating appropriate breathing techniques. Supervised exercise and stretching/breathing sessions occurred at one of two university-affiliated gyms. HR monitors were worn to ensure that maternal HRs were in the appropriate range. Pregnancy $MET \bullet min \bullet wk^{-1}$(20) were quantified (frequency X duration of session) then multiplied by the MET (metabolic equivalent) level of their assigned group, established by the Compendium for Physical Activity (20). The total for all weeks were summed and averaged for the pregnancy $MET \bullet min \bullet wk^{-1}$ value.

Exercise Adherence

Exercise session attendance was tracked via an electronic record in REDCap and calculated by dividing the number of sessions attended by the total number of potential sessions within the participants' gestational period. Participants were considered "exercise adherent" if their attendance was ≥ 80% of possible exercise sessions.

Maternal Measurements

Maternal demographic and pregnancy-related characteristics including age, gravida, pre-pregnancy weight and height, gestational diabetes mellitus status (yes or no) were abstracted from various sources including pre-screening eligibility questionnaires and electronic health records. Pre-pregnancy BMI was calculated using self-reported height and weight collected from the pre-screening eligibility questionnaire (16 weeks of gestation) via the following established equation: . BMI classifications used were previously established (21):18.5-24.9 kg/m^2 was designated as normal, 25.0-29.9 kg/m^2 was overweight, and 30.0-39.9 kg/m^2 was obese class I and II.

Neonatal Birth Measures

Delivery mode (cesarean section & standard vaginal delivery), gestational age in weeks, and birth weight in kilograms served as the primary outcomes of this study and were acquired from the electronic health records. Preterm birth was defined as a delivery at < 37 weeks of gestation. Low birthweight was defined as a neonate weighing < 2.5 kg at birth. The cut-offs for these outcomes were previously established by medical professionals and research and shown to be associated with poor health outcomes(22). Neonatal circumferences (head & abdominal), length and sex were also collected from electronic health records.

Statistical Analysis

Between-group differences in maternal and neonatal descriptive characteristics were determined via Student's t-tests and Pearson Chi-Square tests. Conditional distributions were evaluated, via residual plots, for the assumptions of linear and Poisson regression and were satisfied. The primary outcomes of this study were: birthweight (kg; continuous), gestational age (weeks; continuous), relative risks of low birthweight (LBW, <2.5 or ≥ 2.5 kg), preterm (<37 or ≥ 37 weeks), and delivery mode (vaginal or cesarean). Following, ANCOVA and Poisson regression models were performed to evaluate the effects of prenatal exercise on the association between race and pregnancy and birth outcomes. The main effects between race and the outcomes of interest were assessed first, followed by the effects of prenatal exercise (MET•min•week^{-1}). Next, the following covariates were considered where appropriate: gestational age, neonatal sex, pre-pregnancy BMI, maternal age, and gravida. Two sets of analyses were performed, 1) intention-to-treat (ITT), including all participants regardless of the exercise dose received and 2) per protocol, restricting the analytical sample to those attending ≥ 80% of total possible exercise sessions. Statistical analyses were performed using SAS, version 9.4 (Cary, NC). Statistical significance was determined *a priori* at p<0.05.

Results

Participant Recruitment and Retention

Between 2015 and 2018, 188 pregnant women were assessed for eligibility. Of these, 173 were randomized to aerobic exercise (n=107) or a non-exercising control (n=66). Fifteen participants did not receive their assigned intervention due to group refusal (n=14, all control) and miscarriage (n=1) and 2 pregnant women were lost-to-follow-up consequent to leaving the geographical area, or no time for participation; 1 was excluded for drug use, and 3 had missing data on their electronic health record. Of the remaining 125 pregnant women (exercise = 58 and control = 67), there were 30 African American women, or Non-Hispanic Black (NHB, 24.0%) and 95 Caucasian women, or Non-Hispanic White (NHW). All women were healthy with no pregnancy complications. For the per protocol analysis, data from 15 mother: neonate pairs were excluded due to 'non-adherence' to the exercise intervention yielding the stated sample of 97 mother: neonate pairs.

For both the ITT and per protocol samples, exercising women tended to be older (only significant for per protocol) with a lower pre-pregnancy BMI than non-exercising controls (Table 1a); there were comparable racial/ethnic compositions between groups (ITT: NHW 17.2% vs 29.9%; per protocol: NHW 13.3% vs 29.9%). No other significant between-group differences were observed. Roughly 20% of women, in both groups, delivered via cesarean section and between 5% to 8% were diagnosed with GDM. A few significant differences were observed between NH white and NH black pregnant women (Table 1b). Regardless of group allocation, average NH black women had obesity and were less physically active than NH white women.

There were no significant between-group differences observed for any neonatal outcomes in both the ITT and per protocol samples (Table 2a). Conversely, significant differences in birth outcomes were found between neonates born to NH white and NH black women (Table 2b). On average, neonates born to NH black women were lighter (3.0 kg vs 3.4 kg; p=0.001) with smaller head (33.0 cm vs 34.3 cm; p=0.01) and abdominal (29.7 cm vs 29.7 cm; p=0.04) circumferences, and were shorter in length (0.48 m vs 0.50 m; p=0.004). No other significant differences were found between infants of NH white and NH black women.

Results for the effects of maternal race on delivery and birth outcomes and the independent effect of prenatal exercise for the ITT analyses are presented in Table 3. Adjusted regressions showed that, after controlling for maternal pre-pregnancy BMI, maternal race was significantly associated with neonatal birthweight, where NH black pregnant women delivered neonates weighing nearly 0.5 kg less (β=-0.43, 95%CI: -0.68, -0.18, p=0.001) than neonates born to NH white pregnant women. Prenatal exercise attenuated this association with reductions observed for the regression coefficient (β: -0.43 vs -0.39 kg), representing a 0.04 kg increase in neonatal birthweight. No other statistically significant associations were found in the ITT sample for the association between maternal race and delivery and birth outcomes or the effects of prenatal exercise on these relationships.

For the per protocol sample, the results for the effects of maternal race on delivery and birth outcomes and independent effects of exercise are shown in Table 4. Similar to the ITT results, maternal race was significantly associated with neonatal birthweight with NH black pregnant women delivering neonates nearly 0.5 kg lighter compared to neonates born to NH white pregnant women (β=-0.41, 95%CI: -0.69, -0.13, p=0.005). Prenatal exercise attenuated this relationship, reducing the differences in neonatal birthweight between NH black and NH white pregnant women by 0.02 kg (β: -0.41 vs -0.39). No other statistically significant effects were found for maternal race and delivery and birth outcomes or the effect of prenatal exercise on these associations.

Discussion

The purpose of this study was to examine the effects of prenatal exercise on the association between maternal race/ethnicity and select delivery and birth outcomes. The major findings of this study were 1) maternal exercise performed through the 2^{nd} and 3^{rd} trimesters of pregnancy partially attenuated the relationship between maternal race/ethnicity and neonatal birthweight, such that the racial/ethnic differences in neonatal birthweight between NH black and NH white pregnant women was reduced, 2) prenatal exercise did not appear to significantly (statistically) affect the relationship between maternal race/ethnicity and gestational age or risks of preterm births, cesarean sections and the delivery of low-birthweight neonates.

A novel aspect of this study was that participation in exercise in the latter two-thirds of pregnancy positively attenuated the relationship between maternal race/ethnicity and neonatal birthweight. Specifically, this study observed that the documented disparities in neonatal birthweight between NH black and NH white women, where NH black women deliver lighter neonates (3.4 kg vs 3.0 kg), was reduced by 0.04 kg. The disparities in neonatal birthweight between NH black and NH white pregnant are attributed to different factors, some of which may be influenced by prenatal exercise. Studies report higher levels of perceived stress(23) and chronic disease risk factors such as hypertension(24), endothelial dysfunction(25), inflammation(26) and obesity etc.(27) among NH black women during pregnancy. These risk factors negatively affect fetal growth and are posited to result in lower-birthweight infants. Importantly, while limited studies exist in the pregnant population, several studies in non-pregnant populations consistently show that chronic exercise reduces perceived stress(28), serum cortisol levels(28), endothelial function(29,30), inflammation(31) and obesity-related health consequences(32). We speculate that these positive effects of exercise may mitigate the negative effects of the aforementioned risk factors during pregnancy on fetal growth, subsequently reducing the disparities in neonatal birthweight between NH black and NH white women, as observed in the present study.

Moreover, another explanation for the decrease in the race/ethnic disparity in neonatal birthweight is the increased cardiac output and decreased peripheral resistance consequent to chronic exercise training. Clapp et al. (1992, 2000, 2002, 2003), Pivarnik et al. (1994) and Jackson et al. (1995) consistently demonstrated positive effects of chronic prenatal exercise on the maternal cardiovascular system, feto-placental growth and increased neonatal birthweight (33–38). Importantly, these cardioavacular adaptations to exercise may augment the naturally occurring changes to the maternal cardiovascular system and placental blood flow and growth(36). With this evidence, we posit that these adaptations enhanced fetal nutrient delivery and increased neonatal birthweight, possibly more so among NH black women during pregnancy. In the present study, we acknowledge the limitation that these hypothesized adaptations of prenatal exercise were not measured. However, no scientific studies, to our knowledge exist in the pregnant population that examine the effects of prenatal exercise on the racial/ethnic disparities in fetal and neonatal growth and the associated physiological factors. As such, these speculations are drawn from the available evidence conducted in pregnant and non-pregnant populations.

Unexpectedly, this study did not observe a significant effect of prenatal exercise on the relationship between maternal race/ethnicity and gestational age or the risks of preterm births, cesarean sections or low-birthweight neonates. While non-statistically significant, the attenuating effects of prenatal exercise on the relationship between maternal race/ethnicity and gestational age (β=-0.67, p=0.07 to β=-0.48, p=0.17) and risk of low-birth infants (RR=2.42, p=0.17 to RR=2.02, p=0.26), were in the hypothesized direction. A potential explanation for these null findings may be the disproportion of NH black pregnant women in the non-exercising control group. Moreover, in this study, NH black pregnant women were less active compared to NH white pregnant women (393.0 vs 163.9 MET•min•week^{-1}) potentially reducing the effect of prenatal exercise on the relationships between maternal race/ethnicity and these adverse outcomes. Another explanation for the null observations is the small proportion of NH black women and lower prevalence of cesarean sections, preterm births and low-birthweight infants precluding our ability to detect an attenuating effect of prenatal exercise. In addition, a larger sample would allow for the evaluation of a potential moderating effect of prenatal exercise on the maternal racial/ethnic disparities in these outcomes, providing information on possible differential effects among various minority groups.

Strengths and Limitations

There are several strengths of the present study. First, to the best of our knowledge, this is the first study to evaluate the effects of recommended levels of maternal exercise during the 2nd and 3rd trimesters of pregnancy on racial/ethnic disparities in delivery and birth outcomes. Our findings show a potentially, positive effect of prenatal exercise, which appeared to reduce the disparities in neonatal birthweight between NH black and NH white women. This finding extends the growing evidence base for the documented benefits of prenatal exercise, emphasizing the important of exercise throughout pregnancy. Second, this study used data from a previously conducted a prospective, supervised exercise intervention study increasing the robustness of our exercise exposure. In addition to the strengths of this study, we acknowledge some limitations. First, our sample included a small proportion of NH black women, which increased the difficulty of detecting the effects of prenatal exercise on the previously documented disparities in delivery and birth outcomes assessed in this study. Second, we were unable able to determine the effects of exercise mode which parallel the original study as the very small proportion of NH black women present in the four groups would have led to an imprecise estimation of the effects of prenatal exercise on the outcomes of interest. Third, this sample of pregnant women were considered ‘apparently healthy’ presenting with no chronic diseases, as such these findings cannot extend to women with complicated pregnancies.

Conclusion

Based on these findings, prenatal exercise may decrease the likelihood of NH Black women delivering with more adverse outcomes. Specifically, prenatal exercise may reduce the racial/ethnic disparities in neonatal birthweight, possibly increasing the birthweight among NH Black women. Importantly, birthweight is a predictor of future health trajectories of neonates. Prenatal exercise did not exert measurable attenuating effects on gestational age or risks of preterm birth and low-birthweight neonates, although associations were in the hypothesized direction. Further research is neededto elucidate the effects of prenatal exercise on the racial/ethnic disparities in birth outcomes, specifically studies requiring larger, racial/ethnic diverse samples, measurements of metabolic biomarkers, and more comprehensive analyses to examine potential underlying mechanisms.

Declarations

Funding: This study was funded, in part, by the American Heart Association (AHA grant #15GRNT24470029) and by ECU internal funds.

Conflicts of Interest/Competing Interests: The authors declare no conflicts of interest.

Ethics Approval: All aspects of this study were performed in accordance with the Declaration of Helinski and approved by East Carolina University Institutional Review Board (IRB# 12-002524).

Consent to Participate: Written informed consent was obtained from all participants as well as a clearance letter from their obstetric provider prior to participating in the study.

Availability of Data and Material: De-identified data is available upon request to the lead PI, Dr. Linda May, mayl@ecu.edu.

Code Availability: Upon request

Authors' Contributions: MJR assisted with data collection, interpretation, and writing the manuscript; SMM and CJ assisted with data collection, analysis, interpretation, as well as writing and editing the manuscript; CI assisted with oversight of the obstetric population throughout the study as well as data interpretation and editing the manuscript; EN assisted with oversight of the obstetric population throughout the study as well as data interpretation and editing the manuscript; DK and DC assisted with oversight of the pediatric population as well as data interpretation and editing the manuscript; NB and AM assisted with the data interpretation and editing of the manuscirpt; LEM oversaw the study design, data collection, data analysis, data interpretation, and participated in the writing and editing of the manuscript.

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Tables

Table 1a. Maternal Descriptive, Pregnancy and Delivery Outcomes by Intervention Group and Exercise Adherence

Characteristics	Intention-to-Treat			Per Protocol (≥ 80% adherence)		
	Aerobic (n=58)	Control (n=67)	p-value	Aerobic (n=30)	Control (n=67)	p-value
Demographics						
Age (yr.)	30.7 (4.0)	29.4 (4.3)	0.11	31.7 (3.2)	29.4 (4.3)	0.01
Race/Ethnicity						
NH Black (%)	17.2	29.9	0.10	13.3	29.9	0.13
Pre-Pregnancy BMI	24.7 (4.8)	27.0 (5.8)	0.02	23.4 (3.5)	27.0 (5.8)	0.0003
Pregnancy						
Gravida	1.5 (1.0, 5.0)	1.0 (1.0, 6.0)	0.81	1.0 (1.0, 4.0)	1.0 (1.0, 6.0)	0.69
GDM (%)	5.3	7.6	0.72	6.7	7.6	1.00
Delivery						
Cesarean (%)	21.1	24.6	0.64	20.0	24.6	0.79

Note: Means (SD), medians (range) and proportions are reported and Student's t-test, Wilcoxon Rank Sum tests and Fisher's Exact tests were performed, respectively. NH = Non-Hispanic; BMI = body mass index; GDM = gestational diabetes mellitus.

Table 1b. Maternal Descriptive, Pregnancy and Delivery Outcomes by Maternal Race

Characteristics	Non-Hispanic White (n=95)	Non-Hispanic Black (n=30)	p-value
Demographics			
Age (yr.)	30.2 (3.5)	29.3 (5.8)	0.29
Pre-Pregnancy BMI	25.2 (5.2)	28.5 (5.7)	0.004
Activity Level	393.0 (0.0, 1225.0)	163.9 (0.0, 942.0)	0.002
Pregnancy			
Gravida	1.0 (1.0, 5.0)	2.0 (1.0, 6.0)	0.34
GDM (%)	7.5	3.3	0.42
Delivery			
Cesarean Section (%)	21.7	26.7	0.62

Note: Means (SD), medians (range) and proportions are reported and Student's t-test, Wilcoxon Rank Sum tests and Fisher's Exact tests were performed, respectively. BMI = body mass index (kg/m^2); GDM = gestational diabetes mellitus.

Table 2a. Neonatal Characteristics and Birth Outcomes (mean or median, SD or range) by Intervention Group and Exercise Adherence

Characteristics	Intention-to-Treat			Per Protocol (≥ 80% adherence)		
	Aerobic (n=58)	Control (n=67)	p-value	Aerobic (n=30)	Control (n=67)	p-value
Sex						
Male (%)	50.0	45.6	0.68	50.0	45.6	0.83
Length of Gestation (weeks)	39.6 (30.5, 41.9)	39.3 (23.7, 41.3)	0.53	39.7 (34.0, 41.9)	39.3 (23.7, 41.3)	0.39
Preterm (%)	13.3	12.1	1.00	13.3	12.1	1.00
Size at Birth						
Birthweight (kg)	3.4 (0.7)	3.3 (0.6)	0.63	3.3 (0.7)	3.3 (0.6)	0.96
Low Birthweight (%)	13.3	9.0	0.49	13.3	9.0	0.49
Birth Length (m)	0.50 (0.35, 0.56)	0.50 (44.5, 0.54)	0.46	0.49 (0.35, 0.53)	0.49 (0.03)	0.45
Head Circumference (cm)	34.5 (26.0, 38.1)	33.7 (28.0, 45.0)	0.32	34.5 (28.5, 38.1)	33.7 (28.0, 45.0)	0.46
Abdominal Circumference (cm)	31.5 (23.5, 35.6)	31.0 (22.0, 37.5)	0.49	31.1 (23.5, 35.6)	31.0 (22.0, 37.5)	0.78

Note: Means (SD), medians (range), and proportions are reported and student's t-test, Wilcoxon Rank Sum, Fisher's exact tests were performed, respectively.

Table 2b. Neonatal Birth Outcomes and Characteristics (mean or median, SD or range) by Maternal Race

Characteristics	Non-Hispanic White (n=95)	Non-Hispanic Black (n=30)	p-value
Sex			
Male (%)	48.9	40.0	0.41
Length of Gestation (weeks)	39.5 (34.0, 41.9)	39.1 (23.7, 41.3)	0.14
Preterm (%)	8.5	20.0	0.10
Size at Birth			
Birthweight (kg)	3.4 (0.6)	3.0 (0.7)	0.001
Low Birthweight (%)	8.4	16.7	0.30
Birth Length (m)	0.50 (0.35, 0.56)	0.48 (0.39, 0.56)	0.004
Head Circumference (cm)	34.3 (28.5, 45.0)	33.0 (26.0, 36.0)	0.01
Abdominal Circumference (cm)	31.8 (23.5, 36.0)	29.7 (22.0, 37.5)	0.04

Note: Means (SD), medians (range) and proportions are reported and Student's t-test, Wilcoxon Rank Sum tests and Fisher's Exact tests were performed, respectively.

Table 3. Intention-to-Treat: Linear, Median and Poisson Regression Coefficients (β, 95%CI, p-value) for the Effects of Prenatal Exercise on Race and Delivery and Birth Outcomes.

Characteristics	Model (Race + covariate[s])			Adjusted (Model 1 + Exercise)		
	β or RR**	**95%CI**	**p-value**	**β or RR****	**95%CI**	**p-value**
Delivery						
Gestational Age¥	-0.67	-1.40, 0.06	0.07	-0.48	-1.2, 0.22	0.18
Preterm (%)**	2.33	0.99, 8.94	0.053	2.23	0.70, 7.04	0.17
Cesarean Section (%)**	1.04	0.72, 1.50	0.83	1.04	0.71, 1.53	0.84
Birth Outcomes						
Birthweight (kg) €	-0.43	-0.68, -0.18	0.001	-0.39	-0.65, -0.13	0.004
Low Birthweight (%)**	2.24	0.71, 7.05	0.17	2.02	0.59, 6.86	0.26

Note: Model-specific covariates included 1) gestational age: pre-pregnancy BMI, MET•min•week^{-1}; 2) preterm: pre-pregnancy BMI, MET•min•week^{-1}; 3) cesarean section: MET•min•week^{-1}; 4) birthweight:

MET•min•week^{-1}; and 5) low birthweight: MET•min•week^{-1}. ¥ Median regression was performed and the respective βs were reported. * Poisson regression was performed, and the respective relative risks are reported. € Linear regression was performed and the respective βs were reported.

Table 4. Per Protocol: Linear, Median and Poisson Regression Coefficients (β, 95%CI, p-value) for the Effects of Prenatal Exercise on Race and Delivery and Birth Outcomes.

Characteristics	**Model (Race + covariate[s])**			**Adjusted (Model 1 + Exercise)**		
	β or RR**	**95%CI**	**p-value**	**β**	**95%CI**	**p-value**
Delivery						
Gestational Age¥	-0.73	-1.55, 0.09	0.08	-0.69	-1.5, 0.14	0.11
Preterm (%) **	2.14	0.68, 6.75	0.19	1.98	0.58, 6.76	0.27
Cesarean Section (%) **	1.11	0.74, 1.67	0.60	1.12	0.73, 1.73	0.61
Birth Outcomes						
Birthweight (kg)€	-0.41	-0.69, -0.13	0.005	-0.39	-0.69, -0.09	0.01
Low Birthweight (%) **	2.40	0.64, 8.94	0.19	2.20	0.53, 9.13	0.29

Note: Model-specific covariates included 1) gestational age: pre-pregnancy BMI, MET•min•week^{-1}; 2) preterm: pre-pregnancy BMI, MET•min•week^{-1}; 3) cesarean section: MET•min•week^{-1}; 4) birthweight: MET•min•week^{-1}; and 5) low birthweight: MET•min•week^{-1}. ¥ Median regression was performed and the respective βs were reported. * Poisson regression was performed, and the respective relative risks are reported. € Linear regression was performed and the respective βs were reported.