

THE INFLUENCE OF MATERNAL AEROBIC EXERCISE DURING PREGNANCY ON
HEALTH DISPARITIES AND BIRTH OUTCOMES

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Abstract

Health inequities are defined as any apparent disparity in the health of different individuals due to a preventable cause (Penman-Aguilar, Talih, Huang, Moonesinghe, Bouye & Beckles, 2016). Some determinants of health inequities seen in the United States are race, socioeconomic status, and education level (Penman-Aguilar et al., 2016). In pregnancy, these determinants can contribute to adverse maternal, fetal, and neonatal birth outcomes. For example, African American (AA) women are at a higher risk for preterm birth, or delivery before 37 weeks' gestation (Centers for Disease Control and Prevention [CDC], 2018). Preterm birth is important to research because it can cause adverse outcomes such as low birth weights and developmental delays (CDC, 2018). Current research demonstrates the benefits of maternal exercise on birth outcomes such as preterm birth, but fails to investigate the influence of maternal exercise and nutrition on attenuating adverse birth outcomes in AA (Chan, Au Yeung, & Law, 2019). The purpose of this study was to evaluate if supervised exercise training during gestation have similar birth outcome measures in AA and Caucasian infants. In this cross-sectional comparison study, women in the Greenville, North Carolina area are recruited at 16 weeks of pregnancy to participate in weekly exercise. Participants were randomized into 4 groups: aerobic only, combination (aerobic and resistance), resistance only, or non-exercise . Participants completed 150 minutes of moderate intensity weekly exercise from 16 weeks gestational age to delivery. At birth, measures were assessed, including gestational age and birth weight. Standard ANOVAs, multiple t-tests, and logistic regressions were performed to detect differences in measures between the populations. Maternal exercise intervention had similar outcome measures between AA and Caucasians for gestational age. Caucasian and AA infants exposed to maternal exercise had similar measures of gestational age at birth ($p=0.227$). 20% (6/30) of

AA had preterm births relative to 8.5% (8/94) of Caucasians. AA women had significantly ($p < 0.001$) lower birth weights than Caucasian women. These results suggest that maternal exercise has a similar maternal physiological response that benefits African American and Caucasian infants alike regarding gestational. Thus, maternal exercise may be a low cost non-pharmacological way to attenuate adverse birth outcomes in AA women, such as preterm births. Lower birth weights is expected in AA women despite the lower rates of preterm birth. Further research is required to understand birth weight, other birth outcomes, and long term effects.

Keywords: health disparities, pregnancy, exercise, birth outcomes, preterm birth, low birth weight

Table of Contents

| | |
|---|----|
| Introduction | 4 |
| Methods | 5 |
| Study Design | 5 |
| Study Population | 6 |
| Randomization | 7 |
| Exercise Intervention | 7 |
| Maternal Measurements | 8 |
| Neonatal Birth Measures | 9 |
| Statistical Analysis | 9 |
| Results | 9 |
| Participant Recruitment and Retention | 9 |
| Discussion | 14 |
| Strengths and Limitations | 16 |
| Conclusion | 16 |
| References | 18 |
| Additional Documents | |
| IRB Approval Letter | |
| Poster Presentation | |

INTRODUCTION

Health disparities among different populations in the United States often determine various health outcomes that can lead to adverse effects. In particular, certain groups of women are at a greater risk for less favorable maternal and fetal perinatal outcomes (Finch, Frank & Hummer, 2000). Racial disparities among women often lead to adverse birth consequences such as preterm birth and low birth weight that present life-long health problems (Collins, David, Handler, Wall & Andes, 2004). African American women specifically have lower birth weights and are more likely to deliver preterm (Collins et al., 2004). Birth outcomes such as birth weight and body composition are used as indicators of the health and future wellness of the infant. Unfavorable fetal measures can range in severity and onset including low birth weight, preterm delivery, preeclampsia, hypertension, and diabetes. Low birth weights are considered a health problem because it can prevent the proper growth and development of the child (University of Rochester Medical Center [URMC], 2019). Low oxygen levels, inability to maintain body temperature, and increased risk of infections are among a few of the potential complications experienced by children of low birth weights (URMC, 2019).

Preterm birth is the most common cause of low birth weights and can lead to severe health consequences such as developmental delay, vision problems, hearing problems, and genetic diseases (CDC, 2018). Preterm birth and low birth weights are commonly seen among African American women and women of low socioeconomic status (Martinson & Reichman, 2016). The United States ranked second highest among 4 first world countries for low birth weights with 5.8% of the newborn babies weighing under 5.5 pounds (~2.500 kg) (Martinson & Reichman, 2016). Additionally, the Center for Disease Control and Prevention (CDC) reported that in 2016, 14% of African-American women and 9% of white women in the United States delivered prematurely (CDC, 2018). This difference in observed rates presents a noticeable

disparity between African American women and their white counterparts in terms of maternal and fetal health.

Maternal health is considered a major indication to the short and long term health of the child. When predicting birth outcomes, many maternal factors are considered such as weight, family history, anemia, and behavioral risk factors. Monitoring proper care by the mother during pregnancy helps to ensure healthy growth and development of the child. Exercise and nutritional level are two other important dimensions of health that are used in determining the overall well-being of the mother prior to childbirth.

The purpose of this research is to determine if exercise during pregnancy influences birth outcomes (birth weight, gestational age) similarly in African American pregnant women as Caucasian women. Our hypothesis is that there will be similar birth weight and gestational age (decreased preterm birth) in both races that participated in exercise while pregnant; however, there will be differences between races in those that did not exercise while pregnant. These findings will aim to establish a correlation between exercise during pregnancy and lower health disparities in birth outcomes among African American women. Ultimately this information is of high public importance and can help improve neonatal health outcomes, decrease the length of hospital stay after delivery, which will favorably decrease health care costs while increasing quality of life and attenuating health disparities with a low cost easily implementable exercise program.

METHODS

Study Design

This study employed a secondary data analysis using data from a prospective, partially-blinded, four-arm randomized controlled trial. Women were recruited from local obstetric clinics

via brochures, flyers, word-of-mouth and social media. All protocols were approved by the Institutional Review Board at East Carolina University. Each participant read and signed a written informed consent prior to enrollment. Pregnant women were recruited, screened, and enrolled between 13-16 weeks of gestation and participated in the intervention until delivery (~40 weeks' gestation). During the study, each participant completed a screening questionnaire, a submaximal exercise test, a one repetition maximum test, exercise training, and consented for investigators to access electronic health records (EHR).

Study Population

Inclusion criteria for this study were healthy singleton, 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/m², 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) or comorbidities known to affect fetal development (e.g., lupus), 2) were taking medications known to affect fetal development or pregnancy outcomes, or 3) were using tobacco, alcohol, or other recreational drugs. Informed consent was obtained from each participant prior to study enrollment.

Previous activity levels were not designated exclusion criteria, as both active and sedentary lifestyles prior to conception were included. Additional exclusion criteria included pre-existing diabetes, hypertension, other cardiovascular diseases, and comorbidities known to adversely affect fetal growth and well-being such as systemic lupus erythematosus or human immunodeficiency virus (HIV). Participants diagnosed with gestational diabetes mellitus (GDM) remained enrolled in the study and were analyzed separately.

Randomization

Prior to randomization, participants completed a submaximal exercise treadmill test to determine individual target heart rate (THR) ranges for moderate intensity exercise training. Peak oxygen consumption (VO_{2peak}) was estimated via the modified Balke protocol previously validated and replicated by Mottola et al (2006). After completing this test, participants were randomized to an aerobic exercise, resistance exercise, combination (aerobic and resistance) exercise, or non-exercising control group determined via computerized sequencing (GraphPad software).

Exercise Intervention

All groups participated in sessions three times per week for at least 50 minutes per session. Each session, for all groups, began with a 5-minute warm-up and ended with a 5-minute cool-down (treadmill speed ≤ 3.0 mph). For all participants, intensity was monitored with Polar HR monitors during the activity and utilizing previously validated THR in pregnant women as well as a 12-14 on the Borg scale of perceived exertion (RPE), in addition to the “talk test.” The aerobic, resistance, and combination exercise groups participated in individual supervised, moderate-intensity (40-59% VO_{2peak}) exercise sessions, while the non-exercising group attended low-intensity ($<40\%$ VO_{2peak}) stretching sessions. Aerobic exercise was performed using treadmills, elliptical machines, stationary bicycles, rowing and/or stair-stepping equipment. The resistance group performed 12-15 repetitions of 10-12 resistance exercises in a circuit, for 3 sets with rest of 30-60 seconds between sets as needed. Seated isokinetic exercise using Cybex machine exercises targeting all major muscle groups; Light dumbbells and resistance bands were used if participant was unable to lift the minimal load on Cybex machines. Core exercises were done at the end of the session (i.e. seated side bends). The combination group switched between

aerobic and resistance exercises; for this group, resistance exercises consisted of 1 set of 12-15 repetitions of 4 resistance exercises, then 5 minutes of aerobic exercise, then repeated until the end of the exercise session. The non-exercising group attended low-intensity (<40% VO_{2peak}) stretching sessions that focused on standing or sitting stretches of major muscle groups while incorporating breathing techniques. Supervised exercise and stretching/breathing sessions took place at one of two university-affiliated gyms.

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 possible sessions within the participants' gestational period. Participants were considered "exercise adherent" if their attendance was $\geq 80\%$ of possible exercise sessions.

Maternal Measurements

Maternal age, parity, gravida, pre-pregnancy weight and height, gestational diabetes mellitus status (yes or no) were abstracted from various sources including pre-screening eligibility questionnaires as well as electronic health records. Pre-pregnancy BMI was calculated using height (m), measured by stadiometer, and weight (kg) collected from the pre-screening eligibility questionnaire via the following established equation:

$$\text{BMI} = ((\text{weight (kg)}) \div ([\text{height (m)}^2]))$$

BMI classifications were based on ACSM guidelines: 18.5-24.9 was designated as normal, 25.0-29.9 was overweight, and 30.0-34.9 was obese class I. Participant height and weight for each body composition measurement was assessed while in light athletic clothing and without shoes.

Neonatal Birth Measures

Neonatal sex, gestational age in weeks, and birth weight in kilograms, were acquired from EHR. These were the primary outcome measures.

Statistical Analysis

To test between-group differences in maternal and neonatal descriptive characteristics, the 3 exercise groups (aerobic, resistance, combination) were combined into one exercise group and compared to the non-exercise group. Two-sample t-tests between races (African American and Caucasian) and two-way ANOVAs were performed to test for between group differences. ANOVA regression models were performed to determine the main effects of prenatal exercise on neonatal morphometry. Primary birth outcomes were neonatal birth weight, gestational age. Gestational age was also dichotomized into preterm yes (<37 weeks' gestation) and no (≥ 37 weeks' gestation). Pre-pregnancy BMI and neonatal sex were considered potential covariates. Two sets of analyses were performed, 1) intention-to-treat, including all participants with complete data, and 2) per protocol, including 'exercise adherent' participants, defined as those attending $\geq 80\%$ of total possible exercise sessions. Statistical analyses were performed using SAS, version 9.4 (Cary, NC). Statistical significance was determined *a priori* at $p < 0.05$. Per protocol analysis, the statistics were calculated for women adherent to exercise of 80% attendance and above. Participants who did not adhere to the protocol were not included in the statistical analyses.

RESULTS

Participant Recruitment and Retention

Between 2015 and 2018, 188 pregnant women were assessed for eligibility. Of these, 173 were randomized to one of three exercise groups (n=107) or a non-exercising control (n=66). 15

participants did not receive their assigned intervention due to group refusal (n=14) and miscarriage (n=1) and 2 pregnant women were lost-to-follow-up consequent to leaving the geographical area, no time for participation, bedrest or an unknown reason, 1 was excluded for drug use, and 3 had missing data on the EHR. Of the remaining 126 pregnant women (aerobic = 60 and control = 66); of these 126 women, there were 30 African American women and 96 Caucasian women. 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 126 mother: neonate pairs adherent to exercise intervention.

For ITT analysis, descriptive statistics (Table 1) demonstrate women were similar in age regardless of race or exercise group; however, there was a significant difference between races, within exercise group, in pre-pregnancy BMI ($p=0.007$); African American (AA) women had a higher mean pre-pregnancy BMI than Caucasian women. For neonatal descriptive characteristics (Table 1) there were no significant differences between races within exercise group. There was a significant difference between the races, within exercise groups, in mean birth weight ($p=0.021$); AA women had lower birth weights than Caucasian women. There were no differences between the exercise groups for AA or Caucasian women.

| Race | Exercise | Number | Mean Age (Years) | Mean BMI | Mean Gestational Age (Months) | Mean Birth Weight (Kilograms) |
|------------------|----------|--------|------------------|-------------|-------------------------------|-------------------------------|
| African American | No | 19 | 27.63±5.31 | *28.83±5.98 | 38.00±4.11 | *3.069±0.688 |
| | Yes | 11 | 31.36±5.90 | *27.06±5.45 | 38.36±2.99 | *2.969±0.684 |
| Caucasian | No | 47 | 30.09±3.58 | 26.22±5.65 | 39.11±1.71 | 3.439±0.556 |

| | | | | | | |
|--|-----|----|------------|------------|------------|-------------|
| | Yes | 49 | 30.31±3.57 | 24.06±4.41 | 39.24±1.79 | 3.446±0.609 |
|--|-----|----|------------|------------|------------|-------------|

Table 1. Maternal Demographics

Descriptive statistics (table 2) demonstrate that for AA women, 3 delivered prematurely in the aerobic exercise group and 3 delivered prematurely in the non-exercise group. For Caucasian women, 3 delivered prematurely in the exercise group and 5 delivered prematurely in the non-exercise group. There were 6 premature births in the group of AA women and 8 premature births in the group of Caucasian women. 20% of AA women had premature births out of 30 women, but this is not significant enough to predict outcomes for a general population.

| Exercise | Prematurity- African American | | | Prematurity- Caucasian | | |
|---------------|-------------------------------|-----|---------------|------------------------|------|---------------|
| | No | Yes | Total Percent | No | Yes | Total Percent |
| No | 16 | 3 | 63.3% | 41 | 5 | 48.9% |
| Yes | 8 | 3 | 36.7% | 45 | 3 | 51.1% |
| Total Percent | 80% | 20% | – | 91.5% | 8.5% | – |

Table 2. Exercise by Prematurity Stratified by Race

Descriptive statistics (table 3) demonstrates that for women in the exercise group, 2 AA women and 4 Caucasian women delivered neonates with a low birth weight ($w \leq 2.5\text{kg}$). For women in the non-exercise group, 3 AA women and 3 Caucasian women delivered neonates with a low birth weight. There was no significant difference between the exercise groups stratified by race for an observance of low birth weight.

| Exercise | Low Birth Weight- African American | Low Birth Weight- Caucasian |
|----------|------------------------------------|-----------------------------|
|----------|------------------------------------|-----------------------------|

| | | | | | | |
|---------------|--------|--------|---------------|--------|-------|---------------|
| | No | Yes | Total Percent | No | Yes | Total Percent |
| No | 16 | 3 | 63.33% | 41 | 3 | 48.35% |
| Yes | 9 | 2 | 36.67% | 43 | 4 | 51.65% |
| Total Percent | 83.33% | 16.67% | – | 92.31% | 7.69% | – |

Table 3. Exercise by Low Birth Weight Stratified by Race

A binary logistic regression (table 4) was conducted to examine whether race and exercise group (exercise or non-exercise) had a significant effect on the odds of observing a preterm birth. The reference category was no preterm birth. The total amount of AA women analyzed was 30 (11 exercisers, 19 control). The total amount of Caucasian women analyzed was 96 (47 exercisers, 49 control). MET exercise minutes per week and BMI were included as covariates in predicting low birth weight.

| Variable | <i>B</i> | <i>SE</i> | 95.0% CI | χ^2 | <i>p</i> | <i>OR</i> |
|-------------------------------|----------|-----------|---------------|----------|----------|-----------|
| Intercept | 0.67 | 2.18 | [-3.61, 4.95] | 0.09 | .759 | |
| Race | -1.16 | 0.72 | [-2.57, 0.26] | 2.57 | .109 | 0.31 |
| Exercise Group | 0.84 | 0.72 | [-0.57, 2.26] | 1.36 | .244 | 2.32 |
| MET Exercise Minutes Per Week | -0.00 | 0.00 | [-0.00, 0.00] | 1.87 | .171 | 1.00 |
| BMI | -0.07 | 0.07 | [-0.21, 0.07] | 0.97 | .325 | 0.93 |

Table 4. Logistic Regression with Race, Exercise Group, MET Exercise Minutes Per Week, and BMI Predicting Preterm

The overall model was not significant based on an alpha of 0.05, $\chi^2(4) = 5.65, p = .227$, suggesting that race, exercise group, met exercise minutes per week, and BMI did not have a significant effect on the odds of observing the yes category of preterm. McFadden's R-squared was calculated to examine the model fit, where values greater than 0.2 are indicative of models

with excellent fit. The McFadden R-squared value calculated for this model was 0.08. Since the overall model was not significant, the individual predictors were not examined further.

A binary logistic regression (table 5) was conducted to examine whether race and exercise group predicted the likelihood of observing a low birth weight. The reference category was no low birth weight. The total amount of AA women analyzed was 30 (11 exercisers, 19 control). The total amount of Caucasian women analyzed was 91 (47 exercisers, 44 control). MET exercise minutes per week and BMI were included as covariates in predicting low birth weight.

| Variable | <i>B</i> | <i>SE</i> | 95.0% CI | χ^2 | <i>p</i> | <i>OR</i> |
|-------------------------------|----------|-----------|---------------|----------|----------|-----------|
| Intercept | -2.37 | 2.07 | [-6.43, 1.68] | 1.32 | .251 | - |
| Race | -1.20 | 0.74 | [-2.64, 0.25] | 2.62 | .105 | 0.30 |
| MET Exercise Minutes Per Week | -0.00 | 0.00 | [-0.00, 0.00] | 0.44 | .509 | 1.00 |
| BMI | 0.02 | 0.06 | [-0.10, 0.15] | 0.14 | .712 | 1.02 |
| Exercise group | 1.08 | 0.79 | [-0.47, 2.64] | 1.85 | .173 | 2.95 |

Table 5. Logistic Regression with Race, Exercise Group, MET Exercise Minutes Per Week, and BMI Predicting Low Birth Weight

The overall model was not significant based on an alpha of 0.05, $\chi^2(4) = 5.24, p = .264$, suggesting that race, MET exercise minutes per week, BMI, and exercise group did not have a significant effect on the odds of observing the yes category of low birth weight. McFadden's R-squared was calculated to examine the model fit, where values greater than .2 are indicative of models with excellent fit. The McFadden R-squared value calculated for this model was 0.08. Since the overall model was not significant, the individual predictors were not examined further.

DISCUSSION

We hypothesized that there will be similar birth weight and gestational age (decreased preterm birth) in both races that participated in exercise while pregnant; however, there will be differences between races in those that did not exercise while pregnant. We found that when women exercise during pregnancy there are no differences in gestational age among African American and Caucasian women. We also found that AA women were significantly more likely to have a lower birth weight than Caucasian women in similar exercise groups. However, when considering certain covariates that affect exercise such as pre-pregnancy BMI and MET exercise minutes per week, there was not a significant difference between racial groups that exercised. To our knowledge, these findings are unique and of high public health importance.

The finding that exercise during pregnancy eliminates the racial differences in gestational age among African American and Caucasian women has not been reported previously. In similar studies, the effect of moderate intensity exercise training during pregnancy showed that aerobic exercise significantly reduced the likelihood of preterm birth (Chan et al., 2019). The studies were randomized controlled trials that had similar inclusion criteria. Most of the exercise was also aerobic on stationary bicycles, treadmills, ellipticals, but also included dancing and hydrotherapy. However, these studies did not include information on race or consider race as an important covariate. Therefore, our research is significant in that it reports the influence of race on pregnancy and recognizes the racial disparity among African American women. Through exercise, African American women can ameliorate this disparity within gestational age and preterm births.

Our second finding reported on the disparity seen regarding low birth weight. African American women are three times more likely to deliver a low-birth weight baby than Caucasian

women. In the United States alone, 13% of African American women delivered a child with a low birth weight between 2014-2016 (Martin, Hamilton, Osterman, Driscoll, & Drake, (2018). Our second finding supports that African American women have lower birth weights than their Caucasian counterparts between exercise and non-exercise groups. However, our findings have also shown that the mean birth weights for both exercise groups of AA and Caucasian women are significantly higher ($p < .001$) than the value that determines a neonate to be considered at a low birth weight. When considering MET exercise minutes per week and BMI as covariates in predicting low birth weight, race and exercise group did not significantly ($p=0.264$) predict the likelihood of observing a low birth weight. Findings on birth weight should be researched further due to factors that could influence the values observed. The lower birth weights could be a result of body composition and birth length.

In a 2019 systematic review, fifteen studies analyzed the effect of vigorous intensity exercise during pregnancy and specifically the third trimester on birth weight and gestational age (Beetham, Giles, Noetel, Clifton, Jones & Naughton, 2019). The studies included were ten cohort and five randomized controlled trials. They found that there was no significant difference in birth weight between mothers that exercised and those that did not. These studies also found that there was a small but significant increase in length of gestational age before delivery and a small but significant reduction in the risk for prematurity. In comparison, our study was a randomized control trial that looked at the effect of moderate intensity exercise training throughout pregnancy on the same outcomes. Vigorous intensity exercise training requires a level at least 70% maximum heart rate. ACSM guidelines suggests moderate intensity exercise during pregnancy, which is more generalizable to a larger population. Furthermore, the effects of exercise were only considered during the third trimester, whereas our study considered the

effects with exercise starting at the 16th week of gestation until delivery. The results of our study and the others considering vigorous exercise are similar in the sense that they support the hypothesis that exercise during pregnancy is beneficial for the mother and the infant.

Strengths and Limitations

There are several strengths of the current study. First, to the best of our knowledge, this is the first study to evaluate the effects of supervised exercise at recommended levels during pregnancy on racial differences in birth outcomes. The findings of this study, specifically regarding neonatal birth weight and preterm birth, strengthen and extend the growing evidence base for promoting exercise during pregnancy. Second, we employed a prospective, randomized controlled trial study design, providing the strongest evidence for causality. In addition to strengths, we acknowledge several limitations. First, our sample consisted of ‘apparently healthy’ pregnant women reducing the generalizability of our findings to those with complicated pregnancies. Although our sample size was small, this is the first study to evaluate the exercise effects between two racially diverse groups. Third, other important potential covariates including dietary patterns were not included in these analyses, though, research has shown these not to be associated with preterm rates in the AA population.

CONCLUSION

In summary, aerobic exercise during pregnancy is beneficial for prolonging gestational age. Among the women that exercised, there was no difference in gestational age between African American and Caucasian racial groups. This means that there is a lower risk of preterm birth if an African American mother were to exercise throughout her pregnancy. In regards to birth weight, African American women had significantly lower birth weights than Caucasian women. While this does not show that exercise helped to ameliorate this disparity, exercise did

not negatively impact birth weight to put African American women at a greater risk of a lower birth weight. Therefore, this shows that exercise had no impact on this population when considering birth weight.

In regards to public health, this research is important to health promotion in pregnancy. Our data shows that exercise does not increase the risk of delivering preterm or at a low birth weight. Future research needs to be conducted with a larger sample size to determine the exact correlation and to control for other covariates. Although the findings were not significant, the lack of difference between the women of the racial groups who exercised is a good start to understanding the influence of exercise on racial disparities in preterm birth.

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