SciMedCentral

Medical Journal of Obstetrics and Gynecology

Research Article

Optimizing Birth Outcomes: The Role of Supervised Exercise in Pregnancies With and Without Gestational Diabetes

Nkechi Akinyemi[1], Ericka Biagioni[1], Alex Claiborne[2], Breanna Wisseman[3], Samantha M McDonald[4], James Whiteside[5], James Devente[5], Steven Mouro[5], David Collier[6], Cody Strom[7], Devon Keuhn[6], and Linda E May[1,5]*

[1]*Department of Kinesiology, Human Performance Lab, East Carolina University, USA*

[2]*Department of Kinesiology, Nutrition, and Health, Miami University, USA*

[3]*Department of Kinesiology, University of Rhode Island, Kingston, USA.*

[4]*School of Kinesiology and Recreation, Illinois State University, Normal, USA*

[5]*Department of Obstetrics and Gynecology, East Carolina University, USA*

[6]*Department of Pediatrics, ECU, Greenville, NC, USA*

[7]*Department of Kinesiology and Sports, University of Southern Indiana, USA*

***Corresponding author**

Linda E May, Department of Kinesiology, Human Performance Lab, East Carolina University, Greenville, North Carolina, USA

Submitted: 08 September 2026

Accepted: 23 September 2026

Published: 26 September 2026

ISSN: 2333-6439

Keywords

- Birth Outcomes
- Pregnancies
- Gestational diabetes mellitus
- Pregnant women
- Cesarean delivery

Abstract

Background: Gestational diabetes mellitus (GDM) is associated with adverse birth outcomes, including higher infant adiposity, elevated Ponderal Index (PI), higher weight-to-length ratio, and increased risk of cesarean delivery. Supervised prenatal exercise may improve birth outcomes, potentially mitigating GDM-related complications; however, it remains unclear whether birth outcomes differ between women with and without GDM who participate in a structured, supervised exercise program throughout pregnancy.

Objective: The purpose of this study was to examine differences in birth outcomes between pregnant women with and without GDM who participated in a supervised prenatal exercise program. We hypothesized that women with GDM engaging in supervised exercise would demonstrate similar birth outcomes as exercising women without GDM.

Methods: This is a secondary analysis of a prospective, randomized exercise intervention trial. A total of 370 pregnant women (GDM: n = 22; Non-GDM: n = 348) were enrolled at ≤16 weeks of gestation and participated in supervised exercise (aerobic, resistance, combination, or control group) three times per week until delivery. Exercise variables included total training sessions, weekly frequency, duration, intensity (metabolic equivalents; METs), and total exercise volume (MET-min). Infant birth outcomes were abstracted from medical records and included birth weight, birth length, weight-to-length ratio, infant body mass index (BMI), Ponderal Index, head, chest, and abdominal circumferences, head circumference-to-abdominal circumference ratio (HC:AC), Apgar scores, gestational age at birth, and delivery mode. Between-group differences were assessed using t-tests.

Results: GDM and Non-GDM groups were similar across all birth outcomes (all $p > 0.05$), including birth weight (3.42 ± 0.54 kg vs. 3.42 ± 0.56 kg, $p = 0.99$), infant BMI (14.00 ± 1.76 vs. 14.23 ± 1.81, $p = 0.57$), and Ponderal Index (28.44 ± 4.10 vs. 29.07 ± 3.59, $p = 0.51$). Regression analyses revealed that total pregnancy training sessions are a significant positive predictor of birth weight ($\beta = 0.17$, $p = 0.05$), weight-to-length ratio, infant BMI, and Ponderal Index, while exercise intensity is a significant negative predictor of weight-to-length ratio, infant BMI, and Ponderal Index (all $p < 0.05$). GDM treatment type was not a significant predictor in any model.

Conclusion: Pregnant women with and without GDM who participated in a supervised prenatal exercise program demonstrated similar birth outcomes across all measures, supporting the hypothesis that supervised exercise helps normalize birth outcomes regardless of GDM status. These results add to the body of evidence supporting clinicians' advice that women with gestational diabetes engage in supervised prenatal exercise while considering factors such as training frequency, exercise intensity, and availability of safe resources.

Cite this article: *Akinyemi N, Biagioni E, Claiborne A, Wisseman B, McDonald SM, et al. (2026) Optimizing Birth Outcomes: The Role of Supervised Exercise in Pregnancies With and Without Gestational Diabetes. Med J Obstet Gynecol 14(1): 1201.*

INTRODUCTION

Gestational diabetes mellitus (GDM) is one of the most common medical complications of pregnancy, affecting approximately 6–15% of all pregnancies worldwide and up to 8% of pregnancies in the United States [1,2]. For women with GDM, exercise improves glycemic control, reduces insulin resistance, and decreases the need for pharmacological interventions such as insulin or oral hypoglycemic agents [3,4]. Current guidelines from both the American College of Obstetricians and Gynecologists (ACOG) and the American College of Sports Medicine (ACSM) recommend at least 150 minutes of moderate-intensity physical activity per week throughout pregnancy for all women without contraindications, including those with GDM [5,6]. However, the dose and type of exercise during pregnancy, including training volume and intensity, may differentially influence fetal growth outcomes [7-9]. Emerging evidence suggests that both the number of exercise sessions across pregnancy and the intensity at which exercise is performed may shape infant body composition and proportionality in distinct ways [10-13]. However, these relationships are not fully characterized in populations in GDM and Non-GDM subpopulations participating in a supervised exercise program.

Furthermore, while much of the existing literature previously focused on the effects of exercise on maternal glycemic outcomes among women diagnosed with GDM, much less is known about the effects of exercise on potential differential birth outcomes. Understanding how structured, supervised exercise programs, specifically exercise metrics like frequency and intensity, influence birth outcomes in pregnancies complicated by GDM is clinically relevant, as it can inform individualized prenatal exercise prescriptions and counseling for women diagnosed with GDM. Therefore, the purpose of this study is to examine the influence of exercise metrics from a structured, supervised exercise program on birth outcomes: Birth Weight, infant body mass index (BMI), Ponderal Index, weight-to-length ratio, and delivery mode, in pregnancies with and without GDM.

METHODS

Study Design and Ethical Approval

This study is a secondary analysis of a prospective, randomized exercise intervention trial named ENHANCED (Enhanced Neonatal Health and Neonatal Cardiac Effect Developmentally) (ClinicalTrials.gov Identifiers: NCT03517293). All study protocols were approved by the East Carolina University Institutional Review Board (IRB 16-002153).

Participants were recruited through local obstetric providers and community flyers. Written informed consent and obstetric provider clearance were obtained from each participant before enrollment.

Participants

Pregnant women between 18 and 40 years of age were recruited and enrolled at ≤16 weeks gestation. Inclusion criteria required a singleton pregnancy and a pre-pregnancy body mass index (BMI) between 18.5 and 39.9 kg/m^2. Participants were excluded if they reported current use of alcohol, tobacco, or recreational drugs, or had pre-existing diagnoses of diabetes mellitus, hypertension, or cardiovascular disease. Additional exclusion criteria included comorbidities or medications known to affect fetal growth and well-being. Participants were classified post hoc as GDM (n = 22) or Non-GDM (n = 348) based on clinical diagnosis abstracted from medical records.

Randomization and Exercise Groups

Following physician clearance and baseline testing, participants were randomly assigned using GraphPad software to one of four supervised exercise groups: Aerobic Exercise (AE), Resistance Exercise (RE), Combination Exercise (CE), and Control (CTRL). Target heart rate (HR) zones were established from a submaximal modified Balke treadmill test for participants enrolled before March 2020 [14]. For participants enrolled after March 2020, target HR zones were determined using age- and pre-pregnancy physical activity level-based guidelines per published recommendations, to minimize potential COVID-19 risk [15].

Exercise Intervention

Exercise interventions occurred at two approved exercise facilities at East Carolina University. Training sessions were supervised by trained instructors who abided by guidelines outlined by the ACOG (ACSM) and previously published procedures [5,6]. Briefly, the intervention began at 16 weeks of gestation and continued until delivery. All exercise training sessions included a 5-minute warm-up, a 50-minute exercise period corresponding to the participants' group allocation, and a 5-minute cooldown. Participants in the AE, RE, and CE groups were supervised to maintain their target HR zones equivalent to moderate intensity (60-80% maximal oxygen consumption and a 12-15 rate of perceived exertion [RPE]) using a Polar FS2C HR monitor and Borg scale of perceived exertion [16]. Conversely, participants in the CTRL group completed 50 minutes of low-intensity supervised stretching and breathing sessions three times per week. HR and RPE were monitored to ensure participants stayed below the established moderate-intensity target HR. All sessions were performed three times per week until delivery.

Exercise Training Variables

Maternal exercise training data were obtained from exercise session training logs collected throughout pregnancy. Additional participant information was obtained from prescreening eligibility forms, postpartum questionnaires, and electronic health records. These data included total pregnancy training sessions, weekly exercise frequency (days/week), weekly exercise duration (min/session), average exercise intensity (metabolic equivalents, METs), weekly exercise volume (MET-min/week), and total exercise volume across pregnancy (MET-min). Exercise metrics, including frequency, duration, and intensity, were monitored throughout pregnancy using training logs.

Birth and Infant Outcomes

Delivery and birth outcome data were abstracted from maternal and infant electronic health records. Infant outcomes included: birth weight (kg), birth length (cm), weight-to-length ratio, infant BMI (kg/m^2), Ponderal Index (kg/m^3), head circumference (cm), chest circumference (cm), abdominal circumference (cm), head-to-abdominal circumference ratio (HC:AC), Apgar score at 1 minute, Apgar score at 5 minutes, gestational age at birth (weeks), and delivery mode (cesarean section vs. spontaneous vaginal delivery). Delivery type was further classified as planned cesarean section, spontaneous vaginal delivery, or unplanned cesarean section.

Statistical Analysis

Statistical analyses were performed using JMP (SAS Institute Inc., Cary, NC, USA). Differences in maternal characteristics and birth outcomes between GDM and Non-GDM groups were assessed using t-tests. Normality was assessed for continuous outcomes prior to between-group comparisons. We assessed the normality of Apgar scores at 1 minute and 5 minutes using the Shapiro-Wilk test in JMP. Due to non-normal distribution, 1-minute and 5-minute Apgar scores were compared using the Mann-Whitney U test. All other continuous variables met the assumption of normality and are reported as Mean ± Standard Deviation (SD). Separate multivariable linear regression models were constructed for each continuous infant birth outcome to evaluate whether exercise training characteristics and GDM status were associated with birth outcomes. Predictor variables included total pregnancy training sessions, average exercise intensity, exercise mode, GDM treatment type (Metformin, Glyburide, A1DM, Unknown), maternal age, pre-pregnancy BMI, race, and infant sex. Statistical significance was set at $p \leq 0.05$ for all analyses.

RESULTS

Participant Characteristics

Data from 370 pregnant women were analyzed, including 348 non-GDM and 22 GDM participants. Maternal characteristics were similar between groups for most variables (all $p > 0.05$), except infant sex distribution (68.18% female in GDM vs. 47.32% in Non-GDM; $p = 0.02$; Table 1). Pre-pregnancy BMI, age, exercise training variables, gestational age at birth, and resting heart rate at birth were similar between groups (Table 1).

Table 1: GDM vs. Non-GDM Comparison — Exercisers Only

Measure	Non-GDM (Mean ± SD) n = 348	GDM (Mean ± SD) n = 22	p-value
MATERNAL MEASURES			
Pre-pregnancy BMI (kg/m^2)	26.21 ± 5.25	27.54 ± 6.56	0.26
Age (yrs)	29.97 ± 4.36	31.55 ± 3.84	0.10
Weekly Exercise Volume (MET-min/wk)	511.31 ± 129.16	552.64 ± 103.98	0.24
Average Exercise Intensity (METs)	3.99 ± 0.45	3.96 ± 0.22	0.81
Weekly Exercise Frequency (days/wk)	2.52 ± 0.44	2.62 ± 0.34	0.41
Weekly Exercise Duration (min/session)	129.44 ± 25.31	139.02 ± 23.57	0.17
Total Pregnancy Training Sessions	51.36 ± 14.74	51.79 ± 11.51	0.92
Total Exercise Volume (MET-min)	10,302.58 ± 3,825.57	10,745.21 ± 3,295.43	0.67
Resting HR at Birth (bpm)	123.84 ± 14.00	120.90 ± 7.59	0.35
Race: Asian Black Pacific Islander White	 3.97% 19.55% 0.57% 75.92%	 4.55% 4.55% 0.00% 90.91%	0.26
INFANT MEASURES			
Birth Weight (kg)	3.42 ± 0.54	3.42 ± 0.56	0.99
Birth Length (m)	0.49 ± 0.03	0.49 ± 0.02	0.50
Weight: Length	6.91 ± 0.91	6.98 ± 0.98	0.77
Infant BMI	14.00 ± 1.76	14.23 ± 1.81	0.57
Ponderal Index (kg/m^3)	28.44 ± 4.10	29.07 ± 3.59	0.51
Head Circumference (m)	0.34 ± 0.02	0.34 ± 0.01	0.73
Chest Circumference (m)	0.33 ± 0.02	0.33 ± 0.02	0.68
Abdominal Circumference (m)	0.31 ± 0.03	0.31 ± 0.03	0.95
HC:AC Ratio	1.10 ± 0.08	1.11 ± 0.10	0.75
Apgar Score at 1 min†	8(0,10)	8(3,9)	0.86
Apgar Score at 5 min†	9(4,10)	9(8,9)	0.29
Infant Sex: Female Male	47.32% 52.68%	68.18% 31.82%	0.02
Gestation Length (wks)	39.16 ± 1.96	38.92 ± 1.36	0.57
Delivery: C-Section SVD	24.53% 75.47%	27.27% 72.73%	0.80
Delivery Type: Planned CS SVD Unplanned CS	6.83% 75.47% 7.14%	18.18% 72.73% 9.09%	0.11

Values presented as Mean ± SD unless otherwise noted. † used the Mann-Whitney U test and represented as Median (min, max). Abbreviations: GDM = Gestational Diabetes Mellitus; BMI = Body Mass Index; MET = Metabolic Equivalent of Task; MET-min = MET-minutes; HR = Heart Rate; bpm = beats per minute; HC: AC = Head-to-Abdominal Circumference Ratio; CS = Cesarean Section; SVD = Spontaneous Vaginal Delivery;

Pregnancy and Birth Outcomes

Pregnancy and birth outcomes were similar between GDM and Non-GDM groups for any measure (Table 2). Birth weight was identical between groups (3.42 ± 0.54 kg vs. 3.42 ± 0.56 kg, p = 0.99). Infant BMI (14.00 ± 1.76 vs. 14.23 ± 1.81, p = 0.57), Ponderal Index (28.44 ± 4.10 vs. 29.07 ± 3.59, p = 0.51), and delivery mode (cesarean section: 24.53% vs. 27.27%, p = 0.80) were all comparable between groups with GDM presented first in each comparison. Apgar scores, gestational age at birth, and all circumference measures were also similar.

Regression Analyses

Separate multivariable linear regression models identified significant predictors of several infant birth outcomes (Table 3). The regression model for birth weight was significant (R^2 = 0.10, p = 0.015). Total pregnancy training sessions were positively associated with birth weight (scaled β = 0.17, p = 0.05), while infant sex was also associated with birth weight, with female sex showing a negative association (β = −0.09, p = 0.01) and male sex showing a positive association (β = 0.09, p = 0.01). For weight-to-length ratio (R^2 = 0.09, p = 0.010), exercise intensity was a significant negative predictor (β = −0.56, p = 0.05), while total training sessions were a significant positive predictor (β = 0.34, p = 0.02). For infant BMI (R^2 = 0.06, p = 0.045), total training sessions were a significant positive predictor (β = 1.71, p < 0.01) and exercise intensity was a significant negative predictor (β = −1.26, p = 0.03). For Ponderal Index (R^2 = 0.08, p = 0.039), total training sessions were a significant positive predictor (β = 3.54, p = 0.01) and exercise intensity was a significant negative predictor (β = −3.71, p = 0.04). GDM treatment type was not a significant predictor in any regression model.

DISCUSSION

The purpose of this study was to examine differences in pregnancy and birth outcomes between pregnant women with and without gestational diabetes mellitus participating in a supervised prenatal exercise program. We

Table 2: Non-GDM vs. GDM by Treatment Type

Measure	Non-GDM n=344	GDM-Diet n=8	GDM-Metformin n=8	GDM-Glyburide n=2	GDM-Unknown n=4	p-value
MATERNAL MEASURES						
Prepregnancy BMI (kg/m²)	26.21 ± 5.26	24.71 ± 2.02	31.45 ± 8.61	23.95 ± 4.45	27.15 ± 5.60	0.07
Age (yrs)	29.97 ± 4.36	29.62 ± 3.50	32.00 ± 3.85	31.00 ± 2.83	34.75 ± 3.59	0.16
Weekly Exercise Volume (MET-min/wks)	511.31 ± 129.16	568.33 ± 149.97	533.25 ± 32.99	608.00 ± 76.37	489.00 ± 42.43	0.66
Avg Exercise Intensity (METs)	3.99 ± 0.45	3.93 ± 0.16	3.95 ± 0.38	4.01 ± 0.05	4.06 ± 0.18	0.99
Weekly Exercise Freq (days/wks)	2.52 ± 0.44	2.57 ± 0.37	2.64 ± 0.19	3.02 ± 0.44	2.32 ± 0.02	0.49
Weekly Exercise Duration (min)	129.44 ± 25.31	143.37 ± 32.29	135.40 ± 10.74	151.95 ± 20.86	120.30 ± 5.09	0.44
Total Training Sessions	51.36 ± 14.74	49.33 ± 14.18	54.50 ± 9.04	58.00 ± 16.97	47.50 ± 2.12	0.93
Total Exercise Volume (MET-min)	10,302 ± 3,826	10,612 ± 4,644	10,999 ± 2,458	11,376 ± 3,562	10,006 ± 533	0.99
Gestational Length (wks)	39.16 ± 1.96	38.83 ± 2.03	38.70 ± 1.00	39.80 ± 0.28	39.10 ± 0.43	0.92
Infant Sex: F M	F=47.3% M=52.7%	F=50% M=50%	F=100% M=0%	F=50% M=50%	F=50% M=50%	0.02
INFANT MEASURES						
Birth Weight (kg)	3.42 ± 0.54	3.30 ± 0.64	3.38 ± 0.48	4.40 ± —	3.56 ± 0.39	0.42
Birth Length (m)	0.49 ± 0.03	0.49 ± 0.02	0.49 ± 0.02	0.53 ± —	0.49 ± 0.00	0.53
Weight:Length	6.91 ± 0.91	6.77 ± 1.17	6.88 ± 0.84	8.25 ± —	7.34 ± 0.83	0.56
Infant BMI	14.00 ± 1.76	13.91 ± 2.20	14.05 ± 1.55	15.48 ± —	15.13 ± 1.80	0.75
Ponderal Index	28.44 ± 4.10	28.61 ± 4.27	28.72 ± 3.17	29.04 ± —	31.22 ± 3.87	0.84
Head Circumference (m)	0.34 ± 0.02	0.34 ± 0.02	0.34 ± 0.01	0.36 ± —	0.34 ± 0.00	0.96
Resting HR at Birth (bpm)	123.84 ± 14.00	121.00 ± 3.74	118.75 ± 8.48	120.00 ± —	126.67 ± 13.32	0.81
Chest Circumference (m)	0.33 ± 0.02	0.33 ± 0.01	0.33 ± 0.03	0.36 ± —	0.34 ± 0.02	0.39
Abdominal Circumference (m)	0.31 ± 0.03	0.31 ± 0.01	0.31 ± 0.04	0.33 ± —	0.32 ± 0.03	0.89
HC:AC	1.10 ± 0.08	1.12 ± 0.08	1.11 ± 0.12	1.08 ± —	1.07 ± 0.09	0.86
Apgar Score at 1 min	7.86 ± 1.34	8.38 ± 0.74	7.12 ± 2.03	8.00 ± 1.41	8.00 ± 1.00	0.46
Apgar Score at 5 min	8.75 ± 0.66	9.00 ± 0.00	8.88 ± 0.35	8.50 ± 0.71	9.00 ± 0.00	0.71
Delivery: CS/SVD	24.5%/75.5%	25%/75%	25%/75%	50%/50%	25%/75%	0.90
Delivery Type: Planned CS SVD Unplanned CS	6.8% 75.5% 7.1%	25% 75% 0%	12.5% 75% 12.5%	0% 50% 50%	25% 75% 0%	0.28

Note 1. Values presented as Mean ± SD unless otherwise noted.

Table 3: Regression Analysis of Predictors of Infant Birth Outcomes

Term	Scaled Estimate	Std Error	t Ratio	p-value	95% CI
Response: Birth Weight (kg) | R^2 = 0.100, Adj R^2 = 0.058, p = 0.015					
Significant Predictors					
Total Pregnancy Training Sessions	0.17	0.09	1.98	0.05	0.00, 0.34
Infant Sex: Female	-0.09	0.04	-2.55	0.01	-0.16, -0.02
Infant Sex: Male	0.09	0.04	2.55	0.01	0.02, 0.16
Non-Significant: Intercept, Aerobic, Circuit, Resistance Exercise Groups, Exercise Intensity, GDM Treatment groups					
Response: Weight: Length | R^2 = 0.090, Adj R^2 = 0.057, p = 0.010					
Significant Predictors					
Exercise Intensity	-0.56	0.28	-2.00	0.05	-1.10, -0.01
Total Pregnancy Training Sessions	0.34	0.14	2.42	0.02	0.06, 0.62
Non-Significant: Intercept, Infant Sex, GDM Treatment groups					
Response: Infant BMI | R^2 = 0.063, Adj R^2 = 0.034, p = 0.045					
Significant Predictors					
Total Pregnancy Training Sessions	1.71	0.59	2.89	<0.01	0.54, 2.88
Exercise Intensity (METs)	-1.26	0.57	-2.21	0.03	-2.39, -0.14
Non-Significant: Intercept, Pre-pregnancy BMI, Age, Exercise Groups					
Response: Ponderal Index | R^2 = 0.079, Adj R^2 = 0.041, p = 0.039					
Significant Predictors					
Total Pregnancy Training Sessions	3.54	1.47	2.41	0.01	0.64, 6.44
Exercise Intensity (METs)	-3.71	1.75	-2.12	0.04	-7.16, -0.26
Non-Significant: Intercept, Pre-pregnancy BMI, Age, Race, Weekly Exercise Intensity					

Note. Regression models used scaled estimates to allow comparison across variables of different units. *p < 0.05. Abbreviations: BMI = Body Mass Index; PI = Ponderal Index; MET = Metabolic Equivalent; GDM = Gestational Diabetes Mellitus.

hypothesized that pregnant women with GDM who engage in supervised exercise would have similar pregnancy and birth outcomes as non-GDM exercisers. Consistent with our hypothesis, the primary findings of this study were that: (1) greater total pregnancy training sessions were a significant positive predictor of birth weight, weight-to-length ratio, infant BMI, and Ponderal Index; (2) higher exercise intensity was a significant negative predictor of weight-to-length ratio, infant BMI, and Ponderal Index, suggesting a potential benefit for appropriate infant body size; and (3) GDM and Non-GDM women who participated in supervised exercise throughout pregnancy demonstrated similar birth outcomes across all measures assessed, regardless of GDM status or treatment type.

The first key finding is that greater total pregnancy training sessions were a significant positive predictor of birth weight (β = 0.17, p = 0.05), weight-to-length ratio (β = 0.34, p = 0.02), infant BMI (β = 1.71, p < 0.01), and Ponderal Index (β = 3.54, p = 0.01). Across the study population, a greater number of exercise sessions completed during pregnancy was associated with greater infant birth weight and higher weight-to-length ratios. These associations were observed in the overall study population and should not be interpreted as evidence that exercise further increased birth size among women with GDM. While this association is notable, the precise mechanism by which cumulative exercise sessions influence these specific outcomes is not yet clear [7,17]. Importantly, these findings reflect overall body size measures rather than specific body composition, and it is therefore unknown whether the observed increases represent lean mass, fat mass, or both.

Another key finding is that higher average exercise intensity was a significant negative predictor of weight-to-length ratio (β = −0.56, p = 0.05), infant BMI (β = −1.26, p = 0.03), and Ponderal Index (β = −3.71, p = 0.04). These findings suggest that exercising at higher intensities during pregnancy may be beneficial for appropriate infant body size, as reflected in proportionally lower weight-for-length indices. Higher intensity exercise may improve maternal metabolic efficiency and insulin sensitivity, potentially reducing excess substrate delivery to the fetus while preserving normal length-based growth [3,4,7]. However, as with training volume, the current analyses are limited to composite body size measures and do not capture specific body composition compartments. It therefore remains unknown whether the reduction in weight-for-length indices associated with higher exercise intensity reflects a true reduction in infant adiposity or other tissue changes.

Finally, and most importantly, GDM and Non-GDM women who participated in supervised prenatal exercise demonstrated similar birth outcomes across all measures assessed, including birth weight (3.42 ± 0.56 kg vs. 3.42 ± 0.54 kg, p = 0.99), infant BMI (14.23 ± 1.81 vs. 14.00 ± 1.76, p = 0.57), Ponderal Index (29.07 ± 3.59 vs. 28.44 ± 4.10, p = 0.51), and delivery mode (p = 0.80). Furthermore, GDM treatment type was not a significant predictor in any of the four regression models, indicating that the type of GDM management, whether diet alone, metformin, or glyburide, did not independently influence infant birth outcomes within the context of a supervised exercise program. These findings are particularly meaningful given that GDM is traditionally associated with adverse birth outcomes including higher infant BMI, elevated Ponderal Index, higher weight-to-length ratio, and increased risk of cesarean delivery [18-21]. Despite similar exercise participation across groups (total training sessions: 51.79 ± 11.51 vs. 51.36 ± 14.74, p = 0.92), women with GDM who participated in supervised exercise had birth outcomes similar to their Non-GDM counterparts. This observation is consistent with the possibility that structured exercise may help mitigate expected GDM-associated differences in birth outcomes, although causal inference is limited by the secondary-analysis design and small GDM sample [22].

Strengths and Limitations

This study has several important strengths. The prospective, randomized design of the post-hoc secondary analysis reduces selection bias and ensures well-characterized exercise exposures. Supervision of all exercise sessions ensures intervention fidelity and allows for objective quantification of training variables. The comprehensive set of birth outcome measures, including multiple anthropometric indices, Apgar scores, and delivery data abstracted from medical records, provides a thorough characterization of neonatal health. Significantly, all outcomes were collected as part of the standard operating procedures of a single hospital, ensuring consistency in measurement and data collection and entry. The diverse participant sample, spanning a wide range of BMIs and races, enhances broader generalizability of the findings. A limitation should be considered when interpreting these findings. The GDM sample (n = 22) is considerably smaller than the Non-GDM group (n = 348), which may limit statistical power to detect modest between-group differences [23].

CONCLUSION

In summary, this study examined birth outcomes in pregnant women with and without GDM who participated in a supervised prenatal exercise program. Greater total pregnancy training sessions were a significant positive predictor of birth weight, weight-to-length ratio, infant BMI, and Ponderal Index, while higher exercise intensity was a significant negative predictor of weight-to-length ratio, infant BMI, and Ponderal Index, suggesting a potential benefit for appropriate infant body size. Most notably, GDM and Non-GDM women demonstrated similar birth outcomes across all measures assessed, regardless of GDM status or GDM treatment type.

These findings suggest that supervised exercise during pregnancy leads to similar birth outcomes in women with and without GDM, supporting supervised prenatal exercise as an important clinical strategy for all pregnant women, including those with GDM. Thus, our findings provide additional evidence favoring clinicians' recommendations for supervised prenatal exercise among women diagnosed with gestational diabetes, while emphasizing the importance of considering exercise intensity and training frequency.

REFERENCES

1. Eades CE, Burrows KA, Andreeva R, Stansfield DR, Evans JMM. Prevalence of gestational diabetes in the United States and Canada: a systematic review and meta-analysis. BMC Pregnancy Childbirth. 2024; 24: 200.
2. Xu T. Trends in gestational diabetes mellitus by US state, 2019–2023. Circulation. 2024; 150: 4123308.
3. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, et al. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. Diabetes Care. 2016; 39: 2065-2079.
4. Wang C, Wei Y, Zhang X. The effectiveness of lifestyle changes in glycemic control among pregnant women with gestational diabetes mellitus. Nutrients. 2023; 15: 3993.
5. American College of Obstetricians and Gynecologists. Physical activity and exercise during pregnancy and the postpartum period: ACOG Committee Opinion No. 804. Obstet Gynecol. 2020; 135: e178-e188.
6. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee MI, et al. American College of Sports Medicine position stand: quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults. Med Sci Sports Exerc. 2011; 43: 1334-1359
7. Claiborne A, McDonald SM, Strom C. A narrative review of exercise dose during pregnancy. Birth Defects Res. 2023; 115: 1567-1585.
8. Claiborne A, Wisseman B, Kern K, Steen D, Jevtovic F, McDonald F, et al. Exercise FITT-V during pregnancy: association with birth outcomes. Birth Defects Res. 2024; 116: e2340.
9. Claiborne A, Wisseman B, Kern K, Steen D, Jevtovic F, McDonald F, et al. Exercise during pregnancy dose: influence on preterm birth outcomes. Eur J Obstet Gynecol Reprod Biol. 2024; 300: 190-195.
10. Clapp JF III. The effects of maternal exercise on fetal oxygenation and feto-placental growth. Eur J Obstet Gynecol Reprod Biol. 2003; 110: S80-S85
11. Claiborne A, Jevtovic F, Biagioni EM, Rosa F, Zheng D, Strom C, et al. Exercise FITT-V in pregnancy with obesity: preliminary findings for infant adiposity and intergenerational obesity risk. Physiol Rep. 2026; 14: e70765.
12. Claiborne A, Jevtovic F, Biagioni EM, Rosa F, Zheng D, Strom C, et al. Exercise FITT-V during pregnancy: dose-dependent reduction in infant cellular lipid content and whole-body fat. J Appl Physiol. 2026; 140: 677-685.
13. Claiborne A, Jevtovic F, Zheng D, Strom C, Wisseman B, Newton E, et al. Exercise during pregnancy modulates infant cellular and whole-body adiposity. Physiol Rep. 2024; 12: e70145.
14. Balke B, Ware RW. An experimental study of physical fitness of Air Force personnel. US Armed Forces Med J. 1959; 10: 675-688.

15. Mottola MF, Davenport MH, Ruchat SM, Davies GA, Poitras VJ, Casey E Gray, et al. 2019 Canadian guideline for physical activity throughout pregnancy. Br J Sports Med. 2018; 52: 1339-1346

16. Borg G. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982; 14: 377-381.

17. Bisson M, Lavoie-Guénette J, Tremblay A, Marc I. Physical activity volumes during pregnancy: a systematic review and meta-analysis of observational studies assessing the association with infant's birth weight. Biomed Res Int. 2016; 2016: 5803521.

18. Catalano PM, Shankar K. Obesity and pregnancy: mechanisms of short-term and long-term adverse consequences for mother and child. BMJ. 2017; 356: j1.

19. Nakshine YS, Thute P, Khobrekar MV, Chavhan S. A comprehensive review of gestational diabetes mellitus: impacts on maternal health, fetal development, childhood outcomes, and long-term treatment strategies. Cureus. 2023; 15: e47500.

20. Davenport MH, McCurdy AP, Mottola MF, Barakat R, Weeks A, Slater LG, et al. Impact of prenatal exercise on neonatal and childhood outcomes: a systematic review and meta-analysis. Br J Sports Med. 2018; 52: 1386-1396.

21. Bacchetti P, Leung JM. Sample size calculations in clinical research. Anesthesiology. 2002; 97: 1028-1032.

22. Labonte-Lemoyne E, Curnier D, Ellemberg D. Exercise during pregnancy enhances cerebral maturation in the newborn. Neuroscience. 2017; 341: 202-211.

23. Perales M, Artal R, Lucia A. Exercise during pregnancy. JAMA. 2017; 317: 1113-1114.