Acute Fetal Response to High-Intensity Interval Training in the Second and Third Trimesters of Pregnancy

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Novelty bullets: points that summarize the key findings in the work:	High-Intensity Interval Training is an enjoyable and effective exercise modality in previously active pregnant women, HIIT does not appear to be associated with any adverse fetal effects in previously active pregnant women
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Acute Fetal Response to High-Intensity Interval Training in the Second and Third Trimesters of Pregnancy

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Abstract

The majority of women do not meet the recommended levels of exercise during their pregnancies, frequently due to a lack of time. High-intensity interval training offers a potential solution, providing an effective, time-efficient exercise modality. This exercise modality has not been studied in pregnancy therefore, the objective of this study was to evaluate fetal response to a high-intensity interval training resistance circuit in the late second and early third trimesters of pregnancy. Fourteen active, healthy women with uncomplicated, singleton pregnancies participated in a high-intensity interval training resistance circuit between 28+0/7 and 32+0/7 weeks. A Borg rating of perceived exertion of 15-17/20 and an estimated heart rate of 80-90% of maternal heart-rate maximum was targeted. Fetal well-being was evaluated continuously with fetal heart-rate tracings and umbilical artery Doppler velocimetry conducted pre-and post-exercise. Fetal heart rate tracings were normal throughout the exercise circuit. Post-exercise, umbilical artery end-diastolic flow was normal and significant decreases were observed in the mean systolic/diastolic ratios, pulsatility indexes and resistance indexes. Therefore, in a small cohort of active pregnant women, a high-intensity interval training resistance circuit in the late second and early third trimesters of pregnancy appears to be a safe exercise modality with no acute, adverse fetal effects but further study is required.

Novelty:

- High-Intensity Interval Training, at an intensity in excess of current recommendations, does not appear to be associated with any adverse fetal effects in previously active pregnant women.
- High-Intensity Interval Training is an enjoyable and effective exercise modality in previously active pregnant women.

Keywords: Pregnancy, High-Intensity Interval Training, Resistance Training, Fetal Response, Physiological Assessment of Performance, Exercise

Introduction

Recommendations for physical activity and exercise during pregnancy and the postpartum period have been updated by the Society of Obstetricians and Gynecologists of Canada (SOGC) in 2018 (Mottola et al., 2018) and the American College of Obstetricians and Gynecologists (ACOG) in 2020 (ACOG, 2020). Despite these recent updates, recommendations remain conservative at 150 minutes/week of moderate-intensity aerobic and strength-conditioning exercises (ACOG, 2020, Mottola et al., 2018). While the safety and health benefits of moderate-intensity exercise during pregnancy have been well established in the literature (Davenport et al., 2019a, Davenport et al., 2018a, Davenport et al., 2018b, Davenport et al., 2018c, Davenport et al., 2018d, Davenport et al., 2019b, Davenport et al., 2018e, Davenport et al., 2019c, Skow et al., 2019), the majority of pregnant women do not meet these targets (Evenson et al., 2004, Gaston and Vamos, 2013). A lack of time has been identified as a prime barrier to exercise in both pregnant (Harrison et al., 2018) and non-pregnant populations (Sukys et al., 2019, El-Gilany et al., 2011). Since there is an inverse relationship between exercise intensity and required exercise duration, a potential solution to this lack of time barrier is High Intensity Interval Training (HIIT).

HIIT is an exercise modality involving repeated bursts of vigorous activity interspersed with periods of active rest (Gibala, 2007). The type of physical activity can vary from traditional aerobic exercises such as running, cycling or swimming to resistance exercises performed in a circuit. It has been studied in a number of non-pregnant patient populations and has been found to be a well-tolerated (Sandstad et al., 2015, Shepherd et al., 2015), time-efficient (Gibala, 2007, Sandstad et al., 2015, Shepherd et al., 2015, Gibala and McGee, 2008, Gibala et al., 2012, Roy, 2013, Talanian et al., 2007, Trapp et al., 2008) method of exercise. HIIT has been found to be as,

or more effective than traditional endurance training at improving cardiovascular and muscular fitness (Gibala, 2007, Sandstad et al., 2015, Shepherd et al., 2015, Gibala and McGee, 2008, Gibala et al., 2012, Roy, 2013, Talanian et al., 2007, Trapp et al., 2008) promoting weight loss (Sandstad et al., 2015, Shepherd et al., 2015, Roy, 2013, Talanian et al., 2007, Trapp et al., 2008, Carpenter et al., 1988), and improving insulin sensitivity (Gibala, 2007, Gibala and McGee, 2008, Gibala et al., 2012, Trapp et al., 2008).

While studies on high-intensity aerobic exercise in pregnancy suggest no adverse fetal effects (Carpenter et al., 1988, Salvesen et al., 2012, Szymanski and Satin, 2012b, Szymanski and Satin, 2012a, Watson et al., 1991) as long as maternal heart rate remains below 90 % of heart rate maximum (Salvesen et al., 2012), to our knowledge, the safety and fetal effects of HIIT has not been investigated in a pregnant population. As such, the objective of this prospective cohort study was to evaluate the acute fetal response to a HIIT resistance circuit in the late second and early third trimesters of pregnancy in previously active women.

Methods

Ethical Considerations

This study was reviewed for ethical compliance by the Queen's University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board prior to initiation (OBGY-320-17). All participants provided informed written consent prior to participation.

Recruitment

Study posters and brochure advertisements were posted in the Fetal Assessment Unit and general obstetrical clinics at Kingston Health Science Centre (KHSC) in Kingston, Ontario,

Canada. They were also distributed to local maternity care providers and fitness facilities so women could self-refer to the study. Interested women were screened for eligibility using the study's inclusion/exclusion criteria and sections B and C of the Physical Activity Readiness Medical Exam for Pregnancy (PARmed-X for Pregnancy) screening questionnaire (Gledhill, 2002).

Participants

Eligible participants included healthy women, age 18 and over with uncomplicated, appropriately grown (Estimated Fetal Weight (EFW) >10% for gestational age), singleton pregnancies between 28+0/ (weeks+ days) and 32+0 gestational age. This gestational age range was selected because the study's primary outcomes, the measures of fetal well-being (NST and umbilical Doppler indices), are generally more informative after 28 weeks gestational age. Furthermore, women in the late second and early third trimesters tend to be more active compared to the late third trimester when increasing physical discomforts may limit exercise. Eligible women were also required to have a pre-pregnancy BMI less than or equal to 35 kg/m² and a normal anatomy ultrasound in their pregnancies. Exclusion criteria included: any absolute or relative contraindication to exercise as per the SOGC clinical practice guideline No 367 (Mottola et al., 2018). See Table 2 for complete list. Current smokers were excluded.

Participants completed self-reported activity questionnaires to quantify their total activity and exercise intensity levels during pregnancy and the preceding six months. A session of exercise was considered equivalent to 20-minutes of moderate-intensity activity (Rating of Perceived Exertion (RPE) of 12-14/20 or "somewhat hard"). Participants were then grouped according to their self-reported activity level. The *moderately active* women engaged in 2-3

sessions/week of exercise while the *highly active* women engaged in 4 or more sessions/week of exercise.

HIIT Resistance Circuit

Data was collected during a single exercise session. Participants completed 3 rounds of a HIIT resistance circuit which consisted of the following exercises; kettlebell swings, chest press with band, goblet squats, double-arm row, reverse lunges and Paloff press (Figure 1). Exercises were performed at a maximal intensity for 20-seconds followed by 60-seconds of active rest consisting of marching on the spot. Two minutes of rest occurred between rounds. Various weighted kettlebells (Element Fitness 10/20/25 lbs. vinyl kettlebell) and resistance tubing (J/Fit Deluxe Resistance Tubing in heavy and x-heavy) provided resistance during the circuit.

Exercise Intensity

Target RPE range during the HIIT resistance circuit was 15-17/20 on the Borg Intensity Scale (Figure 1). This range is the equivalent of “hard” to “very hard” work and approaches the level of work equivalent to the anabolic threshold (Borg, 1982).

A heart rate target range of 80-90% of maternal heart-rate maximum was chosen to meet criteria for “high-intensity” while staying below the suggested safety threshold of 90% of maternal heart rate maximum (Salvesen et al., 2012). Figure 1 lists the age and fitness-based maternal heart rate targets. These targets were extrapolated from previous established targets in pregnancy of age and fitness based heart rate maximums (Mottola et al., 2006).

Outcomes

The primary outcomes of the study were measures of fetal well-being. These included the continuous fetal heart rate tracings and the pre- and post-exercise umbilical artery Doppler indices [systolic/diastolic (S/D) ratio, resistance index (RI) and pulsatility index (PI)].

Secondary outcomes comprised of perinatal outcomes including gestational age at delivery, birthweight, Activity, Pulse, Grimace, Appearance, Respiration (APGAR) scores, complications and Neonatal Intensive Care Unit (NICU) admissions. A 5-point Likert scale subjective questionnaire was also used to assess participants' subjective impression of whether HIIT was an effective or enjoyable exercise modality or a type of exercise they would be willing to participate in again.

Orientation/Testing Sessions

Each participant attended an orientation and testing session at the Perinatal Research Unit (PRU) at KHSC in Kingston, Ontario between April 1, 2019 and December 31, 2019. All sessions were supervised by the primary investigator, JA, and occurred between 1600 and 1900h. The timescale of the study was determined by the availability of the primary investigator, without whom testing was not possible for reasons of health and safety.

During orientation sessions, participants were rescreened to ensure eligibility and informed consent was obtained. Ultrasound EFWs were completed on all participants to exclude any undiagnosed fetal growth restriction. Demographic information and exercise histories were obtained and participants were divided into groups as previously stated. Participants were then

oriented to the HIIT resistance circuit, practiced the movements and determined the level of resistance for each exercise. Testing sessions were scheduled for no later than one week from the date of the orientation session.

Testing sessions commenced with the women resting in the left lateral decubitus position for 5-minutes. A polar H10 heart rate sensor and chest strap were applied for continuous monitoring of maternal heart rate throughout the sessions. Maternal blood pressure (BP) was obtained using an automated BP cuff and the GE Corometrics 250cx Series cardiotocography monitoring system. The pre-exercise measures of fetal wellbeing were completed. All ultrasounds were completed by JK, a certified sonographer at KHSC, using a GE Voluson-I portable ultrasound system. Umbilical artery Doppler indices were obtained 1 cm from the fetal abdomen in the absence of fetal breathing or movement. S/D ratio, RI and PI were then calculated using built-in software. A minimum of three sequential waveforms was utilized for interpretation of the umbilical artery end-diastolic flow. Following the ultrasound measures, a 20-minute, pre-exercise fetal heart rate tracing was obtained using the cardiotocography monitoring system. Fetal monitors remained in place for continuous fetal heart rate monitoring throughout the HIIT circuit. A structured, 5-minute warm up was completed prior to commencement of the HIIT resistance circuit. Total repetitions of each exercise, RPE and maximum fetal and maternal heart rates achieved were recorded after each exercise. During the 60-second active rest periods, fetal monitors were adjusted as required to maintain an adequate tracing. Immediately following completion of the third round, participants returned to the left lateral decubitus resting position and post-exercise measures of fetal wellbeing were repeated while participants completed the subjective questionnaire.

Perinatal data was obtained from electronic birth records after delivery.

Reimbursement:

Participants received \$10 CAD per session to cover the cost of parking at KHSC.

Statistical analysis:

The power analysis was based on the ability to detect a change in the umbilical artery S/D ratio post-exercise. This outcome measure was selected for its ability to be precisely measured, its reproducibility and its use in previous exercise in pregnancy studies (Salvesen et al., 2012, Szymanski and Satin, 2012b, Szymanski and Satin, 2012a, Watson et al., 1991). Eleven to thirteen women per group were required to detect a change from the 50th-75th percentile depending on gestational age with 80% power at the 0.05 level of significance. Due to recruitment difficulties, target sample size was not achieved. For the purposes of the statistical analysis, the *moderately active* and *highly active* groups were combined into a single *active* group with 14 participants.

All data are presented as mean (standard deviation) or count (percent). Paired t-tests were used to analyze the mean change in participant umbilical artery Doppler indices pre-and post-exercise. All tests were two tailed and a p-value <0.05 was used to determine statistical differences. Data were analyzed using SPSS statistical software version 26.0 (IBM Corp., Armonk, NY).

Results**Participant Demographics**

In total, 14 (6 *moderately* and 8 *highly*) active women participated in the study. Mean pre-pregnancy BMI was 23.1 (SD 2.8). Participants were on average 33.4 years of age (SD 2.6),

all had a least a college or university degree, and 9 were nulliparous (Table 1).

Maternal heart rates, RPE, repetitions per exercise and fetal heart rate

Table 3 demonstrates the mean maximum maternal heart rates, RPE, maximum fetal heart rate, and number of repetitions per exercise achieved during each round of the HIIT resistance circuit. Higher maternal heart rates and RPE scores were achieved during the lower body exercises utilizing kettle bells for resistance than during the upper body and core exercises using the resistance bands. Maximum maternal heart rate, repetitions per exercise and RPE tended to increase each circuit. Mean maximum maternal heart rate targets were met during 12/18 exercises and target RPE scores were met during 9/18 exercises. During the 3rd circuit, maternal heart rate and RPE were on target for all exercises.

Fetal heart rate tracings

All fetal heart rate tracings were normal, category 1 tracings before, during and after exercise (Dore and Ehman, 2020).

Umbilical artery Doppler end-diastolic flow

All participants demonstrated normal umbilical artery waveforms and end diastolic flow pre- and post-exercise.

Umbilical artery Doppler indices

There was a statistically significant decrease in all three umbilical artery Doppler indices post-exercise (Table 4). S/D ratio decreased by a mean of 0.35 (SD=0.59, $p=0.048$). RI

decreased by a mean of 0.043 (SD=0.062, $p=0.023$). PI decreased by a mean of 0.13 (SD=0.19, $p=0.021$).

Questionnaire

All participants either “agreed” or “strongly agreed” that the HIIT resistance circuit was enjoyable and an exercise modality they would be willing to participate in again in the future. All but one of the participants either “agreed” or “strongly agreed” that the HIIT resistance circuit was an effective exercise modality.

Perinatal Outcomes

There were no preterm deliveries, NICU admissions or fetal complications amongst study participants. Half of the participants delivered at term between 37+0 and 40+6 weeks and half delivered post-dates at 41+0 weeks or greater (Table 5). Twelve participants delivered vaginally and 2 delivered by cesarean section. All fetuses had a normal birthweight (mean 3507g, SD 391g). Thirteen of the infants had had 1 minute APGAR scores of 9 or greater and all had an APGAR score of 9 or greater at 5 minutes.

Discussion

The current study is unique in that it sought to observe fetal heart rate response in real-time during high-intensity exercise with continuous fetal heart tracings. While the quality of tracings varied, overall interpretable tracings were able to be obtained with adjustments to the fetal monitors between exercises. In active pregnant women, a HIIT resistance circuit in the late second and early third trimesters of pregnancy appears to be well-tolerated with no acute,

adverse fetal effects identified. Encouragingly, significant decreases in mean umbilical artery Doppler indices were observed post-exercise. Umbilical artery Doppler indices represent the amount of impedance encountered in the umbilical artery and act as a surrogate marker of fetal perfusion. The decreases observed post-exercise suggests vasodilation of the umbilical artery and possible improved fetal perfusion. In contrast to the observed findings, hypoxia would result in vasoconstriction and increased Doppler indices. Similar reassuring decreases in Doppler indices were observed by Syzmanski *et al.* (Szymanski and Satin, 2012a) and Santos *et al.* (Santos *et al.*, 2016) in response to “vigorous” and “submaximal” maternal aerobic exercise.

The majority of pregnant women recognize the importance and benefits of physical activity in pregnancy (Harrison *et al.*, 2018). Despite these positive attitudes, less than a quarter of women in Ontario meet recommended levels of exercise during their pregnancies (Gaston and Vamos, 2013). While a lack of time and associated costs are barriers to regular exercise (Evenson *et al.*, 2004, Gaston and Vamos, 2013, Harrison *et al.*, 2018), enjoyment in an activity has been found to be a motivating factor (Aaltonen *et al.*, 2012). One of the key benefits of HIIT-style training is its ability to provide an effective work-out in a time-efficient manner (Gibala, 2007, Sandstad *et al.*, 2015, Shepherd *et al.*, 2015, Gibala and McGee, 2008, Gibala *et al.*, 2012, Roy, 2013, Talanian *et al.*, 2007, Trapp *et al.*, 2008). The active work time in this study was only six-minutes. Additionally, a HIIT resistance circuit, similar to the one in the study, requires few resources and limited physical space, making it an accessible option for woman to do at home. Furthermore, all participants found the HIIT resistance circuit enjoyable and identified it as an exercise modality they would be willing to participate in again. This is consistent with other studies where HIIT-style training has been found to be more enjoyable than traditional aerobic

training in both pregnant (Ong et al., 2016) and non-pregnant populations (Shepherd et al., 2015).

The most recent physical activity and exercise in pregnancy guidelines (Mottola et al., 2018, ACOG, 2020) represent a paradigm shift. Exercise during pregnancy is now prescriptive to minimize adverse pregnancy outcomes such as gestational diabetes, hypertensive disorders of pregnancy and excessive gestational weight gain and to optimize multigenerational health (Mottola et al., 2018). Further study of HIIT in pregnancy is need as it may be a means by which a greater number of busy, expectant mothers may reap the benefits of exercise during pregnancy.

Limitations:

The largest limitation of this study was the small sample size of 14 total participants. This was approximately one third of the original recruitment goal. While combining the data from the *moderately active* and *highly active* cohorts into a single *active* group did allow sufficient sample size for data analysis, the original study design called for a third *sedentary* group. Unfortunately, recruitment of this group was particularly difficult and no conclusions regarding the fetal response to HIIT in inactive pregnant women can be made. In future studies, a longer period of recruitment and utilization of other forms of study advertisement such as social media may help overcome some of the recruitment difficulties that were encountered. Additionally, sedentary individuals may require additional incentives in order to participate in an exercise research study.

The current study only investigated fetal response to a single episode of exercise at a single time point in pregnancy. Across the three rounds of the HIIT resistance circuit, a learning curve was evident with participants consistently meeting RPE and heart rate targets only in the third round. It is anticipated that with more experience, such as with a consistent HIIT exercise

program, women would be able to reliably meet target intensities. Whether fetal response would remain consistent and favourable to such an exercise program requires further investigation as does the maternal health benefits of consistent HIIT-style training throughout an entire pregnancy.

The current study was limited to only healthy, previously active women with uncomplicated pregnancies. Participants were exclusively Caucasian, normal weight and college or university educated. As such, the results cannot be generalized to all pregnant women. Further study regarding the safety of HIIT in a diverse group of women, including sedentary, obese and those with comorbidities, is needed as these groups may benefit the most from exercise during pregnancy.

Conclusion:

In a small cohort of active pregnant women, HIIT appears to be a well-tolerated exercise modality with no acute adverse fetal response. While further research on the safety and potential benefits of this exercise modality during pregnancy is required in all activity levels, HIIT appears to be an enjoyable exercise modality that pregnant women would be willing to participate in.

Contributors JA and GD conceived the project and were responsible for project design and management. JA supervised all orientation and testing sessions. CM was responsible for HIIRT circuit design. JK was responsible for all fetal ultrasounds. LB was responsible for data collection. JP was responsible for data analysis and interpretation. JA, JP and GD were responsible for drafting of the manuscript and critical revisions. All authors read and approved the final manuscript.

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Competing interests None declared

Data sharing: Data is available in a de-identified form upon request from the corresponding author. Data use for additional studies is contingent upon ethics board approval.

Patient consent for publication Not required

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Table 1. Participant Characteristics

N=14		
Age (years), mean $\pm$ SD		33.4 $\pm$ 2.6
Ethnicity, n (%)		
	Caucasian	14 (100.0)
Education, n (%)		
	College/University	8 (57.1)
	Postgraduate Degree	6 (42.9)
Pre-Pregnancy BMI (kg/m²), mean $\pm$ SD		23.1 $\pm$ 2.8
Parity		
	Nulliparous	9 (64.3)
	Parous	5 (35.7)
Estimated Fetal Weight (%), mean $\pm$ SD		51.5 $\pm$ 19.9
	Range	23.1 to 88.5
Antenatal Care Provider, n (%)		
	Obstetrician	6 (42.9)
	Family Doctor	1 (7.1)
	Midwife	7 (50.0)
Activity Level, n (%)		
	Moderately Active	6 (42.9)
	Highly Active	8 (57.1)
Gestational Age at Testing (weeks), mean $\pm$ SD		29.2 $\pm$ 1.1
	Range (weeks+days)	28+3 to 31+2

SD – Standard Deviation, BMI – Body Mass Index

Table 2. SOGC absolute and relative contraindications for exercise in pregnancy (Mottola et al., 2018). Re-used with permission.

Absolute Contraindications	Relative Contraindications
<ul style="list-style-type: none">• Ruptured membranes• Premature labour• Unexplained persistent vaginal bleeding• Placenta Previa after 28 weeks• Preeclampsia• Incompetent cervix• Higher order multiple gestation• Uncontrolled Type 1 diabetes or thyroid disorder• Serious cardiovascular, respiratory or systemic disorder	<ul style="list-style-type: none">• Recurrent pregnancy loss• Gestational hypertension• History of spontaneous preterm birth• Mild/moderate cardiovascular disease• Symptomatic anemia• Malnutrition• Eating disorder• Twin pregnancy after 28 weeks• Other significant medical condition

Table 3: Mean and standard deviation for maximum maternal heart rate (bpm), Rating of Perceived Exertion achieved each exercise, number of repetitions and maximum fetal heart rate (bpm).

Exercise n=14	Circuit 1				Circuit 2				Circuit 3			
	MHR	RPE	REPS	FHR	MHR	RPE	REPS	FHR	MHR	RPE	REPS	FHR
Kettle Bell Swings	139 ± 32.8	12 ± 2.2	13.1 ± 1.2	143 ± 11.5	152 ± 17.4	14 ± 1.3	13.9 ± 1.5	145 ± 11.8	157 ± 16.6	15 ± 1.1	14.6 ± 1.7	146 ± 9.5
Chest Press	129 ± 16.7	12 ± 2.4	17.5 ± 5.6	146 ± 7.5	143 ± 19.3	14 ± 1.9	21.1 ± 6.5	144 ± 10.2	153 ± 17.6	15 ± 1.9	23.1 ± 7.1	152 ± 9.1
Goblet Squats	142 ± 27.5	13 ± 2.0	13.3 ± 2.1	147 ± 14.0	156 ± 16.9	15 ± 1.7	14.4 ± 2.1	150 ± 8.0	162 ± 14.9	16 ± 0.9	15.1 ± 2.6	153 ± 11.4
2-Arm Row	140 ± 16.7	13 ± 2.5	19.9 ± 5.5	139 ± 7.6	152 ± 18.9	14 ± 1.9	23.1 ± 6.5	147 ± 8.2	153 ± 17.6	15 ± 1.9	24.5 ± 5.9	154 ± 7.3
Reverse Lunges	152 ± 15.1	14 ± 1.5	12.5 ± 2.2	147 ± 13.2	159 ± 16.7	16 ± 0.8	14.4 ± 2.7	149 ± 10.3	170 ± 32.5	17 ± 3.3	17.8 ± 2.6	161 ± 8.0
Paloff Press	144 ± 18.4	13 ± 1.9	17.9 ± 6.1	141 ± 10.4	153 ± 16.5	15 ± 1.4	20.1 ± 9.0	149 ± 10.0	152 ± 24.7	15 ± 1.7	22.9 ± 8.6	151 ± 11.1

All data presented as mean ± SD. **Bolded** numbers indicate meeting of exercise intensity targets. MHR - Maternal Heart Rate. RPE – Rating of Perceived Exertion. REPS – number of repetitions per exercise. FHR – Fetal Heart Rate.

Table 4: Mean umbilical artery Doppler indices.

	N=14	P-Value
Systolic/Diastolic Ratio		
Pre	3.05 ± 0.51	
Post	2.71 ± 0.48	
Difference	0.35 ± 0.59	0.048
Resistance Index		
Pre	0.66 ± 0.052	
Post	0.62 ± 0.061	
Difference	0.043 ± 0.062	0.023
Pulsatile Index		
Pre	1.10 ± 0.18	
Post	0.96 ± 0.16	
Difference	0.13 ± 0.19	0.021

All data presented as mean ± SD.

Table 5. Perinatal outcomes.

N=14	
Gestational Age at Delivery, n (%)	
Term (37+0 to 40+6)	7 (50.0)
Post-Dates ($\geq 41+0$)	7 (50.0)
Mode of Delivery, n (%)	
Vaginal	12 (85.7)
Cesarean	2 (14.3)
APGAR Scores, n (%)	
≥ 9 at 1 Minute	13 (92.9)
≥ 9 at 5 Minutes	14 (100.0)
Birth Weight (grams), mean $\pm$ SD	3507 $\pm$ 391

Draft

Figure 1. HIIT Resistance Circuit and Target Exercise Intensities

Exercises of HIIT resistance circuit in order performed demonstrating starting and finishing positions. Measures of exercise intensity including RPE and maternal heart rate targets.

Draft

Exercise 1 – Kettlebell Swings

Exercise 2 – Chest Press

➔

Exercise 6 – Pallof Press

Exercise 3 – Goblet Squats

➔

Exercise 5 – Reverse Lunge

Exercise 4 – Two Arm Row

➔

HIIT Circuit

- ❖ Each exercise performed at maximal intensity for 20 seconds
- ❖ 60 seconds active rest between exercise
- ❖ 3 rounds total
- ❖ 2 minutes rest between rounds

Borg's Rating of Perceived Exertion

6	
7	Very, very light
8	
9	Somewhat light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	hard
16	
17	Very hard
18	
19	Very, very hard
20	

Target RPE is indicated between 15 and 17.

Maternal Age and Fitness-Based Heart Rate Targets (bpm)

Activity Level	Age (years)	
	20-29	30-39
Sedentary	144-162	144-162
Moderately Active	150-170	145-163
Highly Active	160-180	156-176