

# Exercise During Pregnancy

## Fetal Responses to Current Public Health Guidelines

Linda M. Szymanski, MD, PhD, and Andrew J. Satin, MD

**OBJECTIVE:** To evaluate acute fetal responses to individually prescribed exercise according to existing guidelines (U.S. Department of Health and Human Services) in active and inactive pregnant women.

**METHODS:** Forty-five healthy pregnant women (15 non-exercisers, 15 regularly active, 15 highly active) were tested between 28 0/7 and 32 6/7 weeks of gestation. After a treadmill test to volitional fatigue, target heart rates were calculated for two subsequent 30-minute treadmill sessions: 1) moderate intensity (40–59% heart rate reserve); and 2) vigorous intensity (60–84%). All women performed the moderate test; only active women performed the vigorous test. Fetal well-being measures included umbilical artery Dopplers, fetal heart tracing and rate, and biophysical profile. Measures were obtained at rest and immediately postexercise.

**RESULTS:** Groups were similar in age, body mass index, and gestational age. Maternal resting heart rate in the highly active group ( $61.6 \pm 7.2$  beats per minute [bpm]) was significantly lower than the nonexercise ( $79.0 \pm 11.6$  bpm) and regularly active ( $71.9 \pm 7.4$  bpm) groups ( $P < .001$ ). Treadmill time was longer in highly active ( $22.3 \pm 2.9$  minutes) than regularly active ( $16.6 \pm 3.4$ ) and nonexercise ( $12.1 \pm 3.6$ ) groups ( $P < .001$ ), reflecting higher fitness. With moderate exercise, all umbilical artery

Doppler indices were similar pre-exercise and postexercise among groups. With vigorous exercise, Dopplers were similar in regularly and highly active women with statistically significant decreases postexercise ( $P < .05$ ). The group  $\times$  time interaction was not significant. Postexercise fetal heart tracings met criteria for reactivity within 20 minutes after all tests. Biophysical profile scores were reassuring.

**CONCLUSION:** This study supports existing guidelines indicating pregnant women may begin or maintain an exercise program at moderate (inactive) or vigorous (active) intensities.

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**LEVEL OF EVIDENCE: II**

Specific evidence-based recommendations on exercise during pregnancy are lacking. The majority of pregnant women seek exercise information from commercial books, magazines, and friends rather than their health care provider.<sup>1</sup> Obstetricians are hesitant to advise sedentary women to initiate exercise during pregnancy, and nearly half counsel exercisers to reduce activity.<sup>2</sup> Many obstetricians continue to recommend limiting maternal heart rate to less than 140 bpm,<sup>3</sup> a restriction removed from the American College of Obstetricians and Gynecologists guidelines in 1994.<sup>4</sup>

Existing recommendations for physical activity during pregnancy have been extrapolated from the physical activity and public health literature. The first public health guidelines<sup>5</sup> were subsequently adopted by American College of Obstetricians and Gynecologists.<sup>6</sup> Updated public health recommendations provide specific definitions of moderate and vigorous intensity.<sup>7</sup> In 2008, the U.S. Department of Health and Human Services issued comprehensive guidelines on physical activity<sup>8,9</sup> and pregnant women are addressed. First, healthy women (nonexercisers and moderate exercisers) should begin or continue moderate-intensity aerobic activity during pregnancy, accumulating at least 150 minutes per week. Because vigorous-intensity exercise has not

*From the Department of Gynecology and Obstetrics, Division of Maternal-Fetal Medicine, Johns Hopkins University School of Medicine, Johns Hopkins Bayview Medical Center, Baltimore, Maryland.*

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*Corresponding author: Linda M. Szymanski, MD, PhD, Department of Gynecology and Obstetrics, Division of Maternal-Fetal Medicine, Johns Hopkins Bayview Medical Center, 4940 Eastern Avenue, Room 121, Baltimore, MD 21224; e-mail: lszymanski@jhmi.edu.*

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been carefully studied, these women are not advised to start vigorous exercise. Second, women who currently exercise vigorously may continue their exercise provided they remain healthy.<sup>8</sup>

Despite recommendations for pregnant women to be active,<sup>6,8</sup> the majority are not meeting guidelines<sup>10–12</sup> and physical activity consistently decreases during pregnancy.<sup>10,12–14</sup> We speculate that obstetricians have not encouraged exercise in pregnancy in part as a result of a paucity of data on fetal safety. This lack of counseling may deprive women of the overall health benefits of exercise and pregnancy-specific benefits such as a decreased risk of gestational diabetes.<sup>6,8,15–17</sup>

This research aims to address gaps in existing data by evaluating fetal well-being in response to exercise using standard tests obstetricians find relevant in determining the health of a fetus. The primary objective was to evaluate acute fetal responses to the amount of exercise currently recommended by Health and Human Services. Specifically, individually prescribed exercise sessions included: 1) moderate-intensity exercise in currently inactive and active women; and 2) vigorous-intensity exercise in currently active women.

## MATERIALS AND METHODS

Healthy, pregnant women, with accurate dating (last menstrual period confirmed by first- or second-trimester ultrasonography), currently receiving routine prenatal care were eligible for inclusion in the study. All women had low-risk pregnancies and no contraindications to exercise.<sup>6</sup> Exclusion criteria included multiple gestation, body mass index (BMI, calculated as weight (kg)/[height (m)]<sup>2</sup>) higher than 35, smoking, history of preterm delivery before 34 weeks, cervical insufficiency or cerclage in place, vaginal bleeding, placenta previa, any chronic medical condition (including pregestational diabetes or chronic hypertension), gestational diabetes or hypertension, or a fetus with known structural or chromosomal abnormalities or growth restriction. Participants were volunteers and constituted a convenience sample. They were recruited primarily from Johns Hopkins–affiliated obstetric clinics. Recruitment flyers were posted in all clinics and the ultrasound unit and eligibility was confirmed by the investigators. Testing was performed between 28 0/7 and 32 6/7 weeks of gestation. This gestational age was chosen because the use of fetal well-being tests, particularly umbilical artery Doppler measurements, is unclear before 28 weeks.<sup>18</sup>

Women were classified according to self-reported physical activity into three groups. The nonexercise group did not perform regular physical activity (more

than 20 minutes per session for more than three times per week) the 6 months before pregnancy or during pregnancy. Two exercise groups included women who were physically active at moderate to vigorous intensities before pregnancy and continued exercising during pregnancy. The regularly active group described their exercise as mild to moderate (typically walking) and exercised more than 20 minutes per session 3 or more days per week. The highly active group described their activity as vigorous and exercised more than 4 days per week. Most were runners before pregnancy and many continued running during pregnancy. The Johns Hopkins University School of Medicine institutional review board approved the protocol, and all participants provided written informed consent.

All testing was performed in the Fetal Assessment Center in proximity to Labor and Delivery at Johns Hopkins Bayview Medical Center. Women in the exercise groups reported for three visits; nonexercisers reported for two visits. All tests were performed within a 2-week period.

For the “peak” exercise test, on the first visit, all women underwent a progressive treadmill test to volitional fatigue according to a modified Balke protocol.<sup>19</sup> After a 2-minute warm-up at 3.0 mph and 0% grade, the speed was maintained at 3.0 mph and the incline increased 2% every 2 minutes. After the incline reached 12%, it remained at this level and speed was increased 0.2 mph every 2 minutes. Volitional fatigue was defined as the voluntary limit beyond which a participant no longer desired to continue the prescribed protocol. Treadmill time was recorded in minutes excluding the warm-up. Peak oxygen consumption was estimated using a validated predication equation for pregnant women.<sup>19</sup> The peak test provided the data necessary to prescribe target heart rate ranges for the subsequent moderate- and vigorous-intensity exercise sessions.

The moderate-intensity session consisted of all women returning to perform a 30-minute exercise session at moderate intensity on the treadmill (40–59% of aerobic capacity reserve).<sup>9</sup> Target heart rates were calculated by the heart rate reserve method using the resting and peak maternal heart rates obtained during the peak test. Each participant controlled the treadmill speed and grade to achieve their individualized target heart rate. Once they reached their target rate, they exercised for 30 minutes and adjusted speed and grade to maintain their heart rate in the target range.

In the vigorous-intensity exercise session, only those women in the exercise groups returned for the



vigorous-intensity session, which was conducted in the same manner as the moderate-intensity session. The target heart rate was calculated using the vigorous-intensity range of 60–84% of heart rate reserve.<sup>9</sup>

During all exercise tests, maternal electrocardiography was continuously recorded. Rating of perceived exertion using the 0 to 10 point scale<sup>20</sup> was obtained at the end of the peak test and during the middle of the submaximal exercise tests.

Fetal well-being measures included umbilical artery Doppler indices, fetal heart tracing, fetal heart rate, and biophysical profile. The primary outcome measure for fetal well-being was the umbilical artery Doppler systolic to diastolic ratio. This variable was chosen as our primary outcome variable because it can be precisely measured and reproduced. Additionally, a number of existing studies have used this as a primary outcome variable, thus providing us with the appropriate data to perform a power analysis.

All testing was performed in the afternoon, starting between 3:30 and 7:30 PM. Women were instructed not to eat or drink anything except water for 1 hour before arrival. On arriving to the Fetal Assessment Center, women laid in a semirecumbent position with a leftward tilt. Electrodes were placed to obtain a maternal three-lead electrocardiogram and a fetal heart tracing was obtained. A minimum of 20 minutes was recorded. Blood pressure, using an automated sphygmomanometer on the left arm, and maternal resting heart rate were obtained after a minimum of 15 minutes of rest. Ultrasonography was then performed. The same researcher (L.M.S.), an obstetrician trained in maternal–fetal medicine, performed all ultrasonograms. After obtaining resting ultrasonographic data (umbilical artery Doppler indices), the participant performed the exercise session. Immediately after the exercise test, they returned to the semirecumbent position with a leftward tilt. Ultrasonography was performed to obtain Doppler measures followed by the biophysical profile. After the biophysical profile was completed and time to completion recorded, another fetal heart tracing was obtained.

Ultrasonography was performed using a Phillips IU22 ultrasonography system. Umbilical artery flow velocity waveforms were obtained using color Doppler imaging in a free loop of umbilical cord. Several time points, each containing a minimum of three sequential uniform waveforms, were obtained and stored.

Built-in software calculated the systolic to diastolic ratio, resistance index, and pulsatility index. Mean values were calculated for each frame and averaged over the several time points obtained. The fetal heart rate was calculated from umbilical Doppler data. The immediate postexercise fetal heart rate was determined from the

first Doppler measure obtained. Gestational age at delivery, mode of delivery, birth weight, and Apgar scores were obtained from delivery records.

Sample size was calculated to achieve 80% power at the .05 level of significance. Two analyses were performed using umbilical artery Doppler data. First, data from an existing study evaluating systolic to diastolic ratios at 32 weeks of gestation after exercise at 71% of estimated maximal heart rate<sup>21</sup> indicated 12 participants per group would be sufficient. Systolic to diastolic ratios pre-exercise were 2.6 with a standard deviation of 0.33 and postexercise were 2.22 with a standard deviation of 0.33. Second, reference data from umbilical artery Doppler systolic to diastolic ratios<sup>22</sup> attempting to detect a change from the 50th percentile to the 75th percentile from 28–32 weeks indicated 11–13 per group, depending on gestational age, would be sufficient. For example, at 32 weeks, the systolic to diastolic ratio at the 50th percentile is 2.67 and the 75th percentile is 3.11. To be conservative, a standard deviation of 0.4 was assumed.

Shapiro-Wilk tests were performed to evaluate for normality. As a result of small sample sizes, the Kruskal-Wallis test was used to compare demographic and descriptive variables among the groups. The fetal heart rate was also analyzed using the Kruskal-Wallis test. Wilcoxon rank-sum tests were then performed when a significant difference was found using Bonferroni corrections for multiple comparisons. Differences in Doppler indices before and after the moderate and vigorous exercise sessions in the groups were analyzed using a mixed effects regression analysis examining main effects of activity group and time (pre–post) accounting for within-participant correlation and the group-by-time interaction. For Doppler variables that were not normally distributed, log transformations were used to normalize the distributions. Delivery data were analyzed by either the Kruskal-Wallis test or Fisher's exact test (categorical variables). Statistical significance was reached at  $P < .05$ . Statistical analyses were performed using STATA 12.0 and SAS 9.2.

## RESULTS

Forty-five healthy pregnant women participated in the study from May 2010 to May 2011. Descriptive characteristics and responses to the peak exercise test are summarized in Table 1. There were no significant differences in age, race, parity, BMI, or gestational age among groups ( $P > .05$ ). As expected, there were significant group differences in maternal resting heart rate ( $P < .001$ ) with the lowest heart rate in the highly active women. Treadmill time and predicted  $\text{VO}_2$  peak, indices of physical fitness, increased with in-



creasing activity level and all groups were different from each other ( $P<.001$ ). There were no group differences in rating of perceived exertion ( $P>.05$ ), which was 8 or higher in all groups (7="very hard"), indicating excellent effort.

The umbilical artery systolic to diastolic ratio was the only variable not normally distributed. Therefore, log transformations were performed for statistical analysis. The nontransformed means and standard deviations are reported.

Descriptive data for the moderate-intensity exercise session (40–59% heart rate reserve) are shown in Table 2. There were no differences among groups ( $P>.05$ ). Actual average intensity of the exercise was similar among groups, ranging from 51.1% to 51.9%, confirming the women worked at a moderate intensity. One participant in the nonexercise group stopped the session 3.5 minutes early secondary to increased contractions. The contractions subsided and fetal measures were all reassuring.

The fetal heart rate and umbilical artery Doppler data, before and immediately after the moderate-intensity exercise session, in all groups, are shown in Table 3. The fetal heart rate was similar among groups ( $P=.26$ ) and increased with exercise. This increase reached statistical significance in the regularly active group only ( $P=.01$ ). The mean umbilical

artery systolic to diastolic ratios are between the 25th and 50th percentiles according to reference data.<sup>22</sup> No differences were seen in any umbilical artery Doppler indices among groups or with exercise ( $P>.05$ ).

All participants in both exercise groups achieved biophysical profile scores of 8 of 8 within 30 minutes after the exercise session. Fourteen of 15 participants in the nonexercise group achieved biophysical profile scores of 8 of 8 within 30 minutes; one participant achieved a score of 8 of 8 after 30 minutes and 23 seconds. The fetal heart tracings after the exercise sessions met criteria for reactivity within 20 minutes and were reassuring in all participants.<sup>23</sup>

Descriptive data for the vigorous-intensity exercise session (60–84% heart rate reserve) in the two exercise groups were similar and are shown in Table 4. Six participants were unable to perform the vigorous session secondary to scheduling constraints ( $n=4$ ) or illness ( $n=2$ ); thus, 24 participants (13 highly active and 11 regularly active) completed the session. The actual average intensity of the exercise session was 71.8% and 73.8% in the regularly and highly active women, respectively, confirming vigorous-intensity exercise.

The fetal heart rate and umbilical artery Doppler indices during the vigorous exercise session are shown in Table 5. The fetal heart rate remained in the

**Table 1. Baseline Maternal Demographic and Descriptive Variables**

Variable	Nonexercisers (n=15)	Regularly Active (n=15)	Highly Active (n=15)	P
Age (y)	32.9±5.8	34.3±2.5	32.9±4.0	.47
Race				.54
White	10	13	13	
African American	1	1	1	
Asian	4	0	1	
Hispanic	0	1	0	
Nulliparous	9	7	13	.07
Body mass index (kg/m <sup>2</sup> )				
Prepregnancy	24.2±4.2	22.9±2.8	22.3±2.4	.35
At testing	27.6±3.6	27.2±2.8	25.9±2.2	.40
Gestational age (wk)	30.7±1.1	30.2±0.9	30.3±1.0	.40
Resting blood pressure (mm Hg)				
Systolic	103±9.7	107±9.5	108.3±7.0	.25
Diastolic	60.2±7.1	63.5±8.9	67.4±6.9	.04
Maternal heart rate (bpm)				
Resting	79.0±11.6	71.9±7.4	61.6±7.2	<.001*
Peak	163.0±18.8	163.3±8.9	172.4±11.7	.12
Treadmill time (min)	12.1±3.6	16.6±3.4	22.3±2.9	<.001†
Predicted VO <sub>2</sub> peak (mL/kg/min)	21.3±2.5	23.8±2.2	27.7±1.4	<.001†
Rating of perceived exertion (peak)	8.0±1.6	8.3±1.3	9.1±0.6	.21

bpm, beats per minute.

Data are mean±standard deviation or n unless otherwise specified.

\* Highly active different from other groups; no difference between nonexercisers and regularly active.

† All groups different from each other.



**Table 2. Maternal Parameters During Moderate-Intensity Exercise Sessions**

Variable	Nonexercisers (n=15)	Regularly Active (n=15)	Highly Active (n=15)	P
Gestational age (wk)	31.7±0.8 32.1 (30.1–32.9)	31.1±1.2 31.1 (29.4–32.9)	31.1±0.9 31.0 (29.4–32.4)	.16
Average maternal heart rate (bpm)	121.7±11.9 126 (104–139)	119.2±7.0 123 (104–128)	118.7±9.2 117 (107–138)	.64
Percentage of heart-rate reserve	51.2±2.9 51 (47–56)	51.9±2.9 52 (48–57)	51.1±3.4 52 (43–55)	.83
Rating of perceived exertion	2.7±1.4 3.0 (1.0–6.0)	2.5±0.6 2.3 (1.5–4.0)	2.6±0.5 2.8 (2.0–3.3)	.72

bpm, beats per minute.

Data are mean±standard deviation and median (range) unless otherwise specified.

normal range and was not different between the two groups ( $P=.50$ ). There was a significant increase postexercise in both groups ( $P=.001$ ). There were no significant group differences in umbilical artery indices; however, the main effect for time was significant for all indices ( $P<.05$ ). The group-by-time interaction was not significant for any Doppler variable ( $P>.05$ ).

All participants in the regularly active group and 12 of 13 participants in the highly active group achieved biophysical profile scores of 8 of 8 within 30 minutes; one participant in the highly active group achieved a score of 8 of 8 at 33 minutes and 49 seconds. The fetal heart tracings after the exercise sessions met criteria for reactivity within 20 minutes and were reassuring in all participants.<sup>23</sup> Umbilical artery Doppler measures were obtained by 1:07 minutes postexercise on average.

None of the delivery variables differed among the groups. All participants delivered at term, except one highly active woman delivered at 36 6/7 weeks of gestation and one nonexerciser delivered at 36 1/7 weeks of gestation (preterm labor). Both of these

newborns were discharged home with their mother on postpartum day 2. Mean gestational age at delivery was 39.7±1.3, 39.6±1.1, and 39.2±1.3 weeks for nonexercisers, regularly, and highly active groups, respectively. Birth weight was similar among the three groups ( $P=.10$ ). For the nonexercisers, birth weight ranged from 2,875 to 4,451 g with a mean of 3,460±427 g and a median of 3,390 g. Birth weight for the regularly active ranged from 2,890 to 4,700 g with a mean of 3,408±426 g and a median of 3,302 g; birth weight for the highly active ranged from 2,665 to 3,590 g with a mean of 3,167±299 and a median of 3,215 g. One participant in the highly active group delivered a small-for-gestational-age newborn (2,690 g at 39 3/7 weeks of gestation, less than 10th percentile).<sup>24</sup> Two participants delivered large-for-gestational-age neonates (more than 90th percentile), one regularly active (4,700 g at 39 5/7 weeks of gestation), and one nonexerciser (4,451 g at 41 0/7 weeks of gestation). Apgar scores were not different among the groups ( $P>.05$ ) and all 5-minute Apgar scores were higher than 7.

**Table 3. Fetal Parameters During Moderate-Intensity Exercise Sessions**

Variable	Timing	Nonexercisers (n=15)	Regularly Active (n=15)	Highly Active (n=15)
Fetal heart rate (bpm)	Pre	142.3±6.9	135.4±7.7	138.9±9.6
	Post	149.5±9.5	146.5±10.8*	146.9±7.3
Umbilical artery Systolic to diastolic ratio	Pre	2.54±0.33	2.63±0.30	2.62±0.23
	Post	2.57±0.31	2.67±0.44	2.58±0.34
Resistance index	Pre	0.60±0.05	0.61±0.04	0.61±0.05
	Post	0.60±0.05	0.61±0.06	0.61±0.05
Pulsatility index	Pre	0.85±0.10	0.88±0.09	0.88±0.07
	Post	0.87±0.09	0.89±0.12	0.87±0.10

bpm, beats per minute; pre, pre-exercise; post, postexercise.

Data are mean±standard deviation.

P values for umbilical artery Doppler indices (group, time, interaction): systolic to diastolic ratio: 0.70, 0.86, 0.61; resistance index: 0.75, 0.52, 0.84; pulsatility index: 0.70, 0.89, 0.58.

\* Pre-exercise and postexercise difference ( $P=.01$ ).



**Table 4. Maternal Parameters During Vigorous-Intensity Exercise Sessions**

Variable	Regularly Active (n=11)	Highly Active (n=13)	P
Gestational age (wk)	31.6±0.9 31.7 (30.1–32.9)	31.4±0.9 31.4 (30.0–32.9)	.43
Average maternal heart rate (bpm)	138.4±7.0 142 (123–145)	142.2±9.1 140 (128–156)	.43
Percentage of heart-rate reserve	72.1±3.4 73.0 (66–77)	73.5±5.7 73.0 (65–83)	.62
Rating of perceived exertion	4.2±1.3 3.6 (3.0–7.0)	3.8±0.7 4 (2.8–4.7)	.54

bpm, beats per minute.

Data are mean±standard deviation and median (range) unless otherwise specified.

## DISCUSSION

The *Physical Activity Guidelines for Americans*<sup>8</sup> recommend that pregnant women who are not already highly active get at least 150 minutes of moderate-intensity aerobic activity per week during pregnancy. Participating in vigorous-intensity exercise is not recommended for previously inactive women or women who engage in only moderate-intensity exercise. Women who are currently vigorously active may continue this level of activity during pregnancy according to the guidelines.

This investigation assessed the effects of the current physical activity guidelines for pregnant women<sup>6,8</sup> on fetal well-being. The recommended intensities were implemented using an exercise mode and duration that

are typical and practical. We chose 30-minute sessions as a feasible approach to achieve the recommended 150 minutes weekly, ie, five sessions lasting 30 minutes. In addition, this is the prescription recommended in the updated public health guidelines.<sup>7</sup> In accordance with the Health and Human Services guidelines,<sup>8,9</sup> moderate intensity was defined as 40–59% of heart rate reserve and vigorous intensity was defined as 60–84%.

Our major finding is that exercise according to the current Health and Human Services guidelines was well tolerated by both the mother and the fetus, as indicated by a variety of commonly used tests of fetal well-being. During moderate-intensity exercise, umbilical artery systolic to diastolic ratios were within the normal range and did not significantly change with exercise. During vigorous-intensity exercise, all umbilical artery indices showed decreases postexercise. Although statistically significant, this decrease is likely not clinically significant. A decrease in umbilical artery systolic to diastolic ratio after exercise has been reported in other studies on healthy pregnant women.<sup>21</sup> We speculate that postexercise decreased vascular resistance results in increased blood flow to the fetus. If the fetus was hypoxic, one would expect vasoconstriction in placental circulation, resulting in an increased vascular resistance, and elevations in Doppler indices. Thus, this change with exercise is likely a reassuring finding.

In the Health and Human Services Advisory Committee report,<sup>9</sup> it is noted that approximately 600 studies were published between 1985 and 1994 indicating exercise during pregnancy causes “no harm,” and many studies have reported no negative effects on several pregnancy outcomes, including rate of preterm delivery, birth weight, and mode of delivery.<sup>16,25</sup> However, fewer data are available on fetal responses to exercise and this study provides evidence that acute fetal well-being is not negatively affected when exercising according to recommendations.

In the recent Health and Human Services recommendations for the general population, various methods of gauging exercise intensity are provided in addition to target heart rates. Perceived exertion scales are one suggested method. Rating of perceived exertion scales have been validated as a clear, concise, and effective means to regulate exercise intensity in a number of populations.<sup>26</sup> Two scales are generally used, the original 6–20 scale and the category rating of perceived exertion scale, ranging from 0 to 10, with numbers anchored by verbal expressions that are simple and understandable.<sup>20</sup> According to the Health and Human Services guidelines, a 5–6 on the category rating of perceived exertion scale reflects

**Table 5. Fetal Parameters During Vigorous-Intensity Exercise Session**

Variable	Timing	Regularly Active (n=11)	Highly Active (n=13)
Fetal heart rate (bpm)	Pre	133.5±7.4	137.2±9.9
	Post	153.1±8.8*	156.8±10.7*
Umbilical artery Systolic to diastolic ratio	Pre	2.71±0.45	2.51±0.20
	Post†	2.46±0.39	2.5±0.27
Resistance index	Pre	0.62±0.05	0.60±0.03
	Post†	0.58±0.06	0.59±0.05
Pulsatility index	Pre	0.90±0.11	0.85±0.07
	Post†	0.83±0.13	0.82±0.09

bpm, beats per minute; pre, pre-exercise; post, postexercise.

Data are mean±standard deviation.

P values for umbilical artery Doppler indices (group, time, interaction): systolic to diastolic ratio: 0.47, 0.02, 0.16; resistance index: 0.56, 0.02, 0.21; pulsatility index: 0.48, 0.02, 0.22.

\* Pre-exercise and postexercise difference ( $P=.001$ ).

† Significant main effect for “time” ( $P<.05$ ).



moderate intensity and a 7–8 reflects vigorous intensity. However, this may not be appropriate for pregnant women. In the present study, rating of perceived exertion scores during both moderate and vigorous exercise sessions were lower than these recommendations. During moderate exercise, all women, regardless of activity status, provided similar numbers (mean 2.5–2.7). Similarly, during vigorous exercise, mean rating of perceived exertion ranged from 3.8 to 4.2. This finding is in agreement with existing data<sup>27,28</sup> and is concerning because pregnant women may not perceive when the exercise intensity is high. Thus, if using rating of perceived exertion to gauge intensity, they may exercise significantly more intensely than the guidelines intend. More data are needed to evaluate the use of rating of perceived exertion for exercise intensity monitoring in pregnant women.

There are several strengths of the current study. First, the existing guidelines for exercise during pregnancy were evaluated in a practical manner. Walking is one of the easiest and most accessible forms of exercise; therefore, these findings are applicable to most healthy pregnant women. Second, women were classified according to activity level and tested accordingly. This is important because health care providers appear to provide different recommendations to women depending on their prepregnancy activity levels. Third, women underwent a peak exercise test to more accurately prescribe the recommended intensity ranges. Fourth, a variety of fetal well-being tests were performed to provide an overall assessment of fetal status.

This study was limited in that it was not powered to address neonatal outcomes. However, we did collect delivery data, and all women delivered healthy neonates. Although two women delivered between 36 and 37 weeks of gestation, the deliveries were uncomplicated, and both newborns were discharged from the hospital 2 days after delivery.

Additionally, this study only evaluated fetal responses to a single exercise session between 28 and 32 6/7 weeks of gestation. It is possible that responses are different at different gestational ages. Our results also only apply to exercise performed in the currently prescribed intensity ranges and may not apply to very strenuous exercise. Furthermore, these findings only address healthy women without pregnancy complications. Other populations and various gestational ages need to be studied. For example, all of the women in our study had normal prepregnancy BMIs. Prepregnancy BMI and excess gestational weight gain have both increased over the years in women of childbearing age, placing these women at higher risk for

pregnancy complications.<sup>29</sup> Among other interventions, increasing physical activity is likely an important intervention and more data on safety of exercise in this subgroup of pregnant women are needed.

We also acknowledge that a limitation in this investigation, and other studies on exercise during pregnancy, is that fetal well-being measures were assessed immediately postexercise rather than during exercise because it is technologically difficult to evaluate the fetus during exercise. Many studies have limited their exercise to stationary cycle ergometry as an exercise mode in an effort to improve fetal monitoring; however, this has also proven technologically difficult. We chose walking and jogging because it is a very practical and popular mode of exercise for pregnant women. If the fetus was hypoxic during the exercise session, we would expect the fetal well-being measures to be nonreassuring after exercise. We found no untoward fetal responses to the individually prescribed exercise in our study population.

In conclusion, health care providers should feel more reassured that pregnant women can exercise during pregnancy when following existing exercise recommendations.<sup>6,8</sup> We are highly encouraged that, in our study population, existing exercise recommendations were well-tolerated by women and their fetuses. Importantly, we did not identify any adverse acute fetal responses to current exercise recommendations. It is our hope that this investigation will justify the initiation of larger trials to address the safety of exercise in pregnancy. The potential public health benefits of exercise are too great for obstetricians to miss the opportunity to effectively counsel pregnant women about this important health-enhancing behavior.

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