Influence of Exercise Mode on Maternal, Fetal, and Neonatal Health Outcomes

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Abstract

Research has demonstrated aerobic exercise is safe and beneficial for mother, fetus, and neonate. Unlike aerobic exercise, little research has focused on the effects of resistance training during pregnancy. Preliminary studies have shown that acute resistance training is safe for pregnant women. It has been found to be effective in increasing lean body mass in pregnant women. Research studying chronic resistance training during pregnancy has focused on delivery outcome rather than examining the chronic health effects or adaptations of resistance training exposure for the expectant mother. Additionally, scarce research has been done to examine the effects of acute maternal resistance training on the fetus, except to conclude that the fetus is not at an increased risk of distress during maternal resistance exercises.

Some researchers have studied circuit (aerobic and resistance) training on acute maternal responses or chronic adaptations during pregnancy. In response to prolonged circuit training during pregnancy, women who exercised more were less likely to have a Cesarean delivery and spent less time recovering in the hospital. Furthermore, research has not been completed on the fetal responses or adaptations as a result of acute or chronic maternal circuit training throughout pregnancy, except to report that birth weights are similar between exercising and control groups. Logically, if aerobic and resistance exercise programs individually are safe for the pregnant woman and her fetus, then a combination program would also be safe. Clearly, more research is needed and this article will summarize our current state of knowledge regarding exercise during pregnancy.

ABBREVIATIONS

ACSM: American College of Sports Medicine; ACOG: American Congress of Obstetrics and Gynecology; SOGC: Society of Obstetricians and Gynaecologists of Canada; CSEP: Canadian Society for Exercise Physiology; HR: heart rate; HRV: heart rate variability; HF: high frequency power in frequency domain of HRV; VO2: oxygen consumption.

INTRODUCTION

The purpose of this article is to compare the effects of aerobic, resistance, and circuit training throughout pregnancy on maternal and fetal physiological adaptations. The contents of this text will expound on the available literature and its applicability to pregnant patients. Topics discussed include: guidelines for aerobic exercise during pregnancy, maternal and fetal responses to aerobic exercise, offspring measures related to aerobic exercise, maternal and fetal responses to resistance training, and maternal and fetal responses to circuit training during pregnancy.

Guidelines for aerobic exercise

The recommendations for aerobic exercise prescription during pregnancy published by the ACSM, ACOG, SOGC, and CSEP fully agree and cross-reference one another. These recommendations begin with clearance by a physician to participate in exercise. If a pregnant woman is healthy and has a low-risk pregnancy (i.e. no contraindications for exercise as listed in Table 1), then she should participate in moderate intensity aerobic exercise for at least 30 minutes most days of the week, with a goal of 150 minutes per week [1-5]. Previously sedentary, overweight and obese pregnant women are encouraged to begin with 15 minutes per exercise bout and gradually increase to the recommended 30 minutes [1-5]. Moderate intensity has been defined as approximately 60-80% of maximum heart rate or target heart rate zone (Table 2), 12-14 on the Borg scale rating of perceived exertion (Table 3), or by using the "talk test," which means being able to converse while exercising without feeling short of breath [2,4-8]. Since pregnancy involves numerous physiological and anatomical changes, target heart rate (Table 2) zones for non-gravid women are not sufficient to meet the physiological demands of the pregnancy. Due to this
Maternal responses to aerobic exercise

Aerobic exercise during pregnancy provides as many health benefits as in non-pregnant populations [13-15]. Benefits range from improvements in cardiovascular functioning, metabolic functioning, weight management, and mental health functions acutely and after prolonged periods of exercise training. Though gravid women experience similar benefits to exercise as the adult population, their acute responses to exercise are slightly different when compared to pre-pregnancy values because of the physiological and anatomical changes associated with pregnancy (Table 3) [3]. As in non-pregnant populations, pregnant women of all BMI classifications experience adaptations, such as improvements in resting heart rate (HR) and cardiac output (Q), in response to chronic aerobic exercise [12, 16, 17]. Blood pressure (BP) does not significantly change throughout the course of pregnancy between women who exercise throughout pregnancy and those who do not, regardless of the level of intensity [16, 18]. Santos et al. found that aerobic submaximal capacity is improved in overweight pregnant women after an aerobic exercise training program. The regulation of insulin, glucose, and blood lipids is also improved in pregnant women who participate in aerobic exercise [4, 12, 16], as in non-gravid populations [14]. Body composition measures also change, such as decreased fat deposition, in response to aerobic exercise during pregnancy similar to the non-pregnant population [12-16]. Gestational weight gain is much more variable for overweight and obese pregnant women participating in an exercise program [15, 17, 19]. In addition, previously sedentary women who begin an exercise program during pregnancy experienced improved cardiovascular function, improved body composition, and less weight gain during pregnancy, thus decreasing their risk of developing gestational diabetes mellitus and hypertension [7].

Ruchat et al. [20] utilized a light intensity and moderate intensity aerobic exercise program coupled with a nutrition intervention in normal weight pregnant women. Although participants gained excess pregnancy weight prior to the start of this intervention, women in the exercise groups gained significantly less weight throughout the entire course of their pregnancy than women in the control group. Despite this finding in the exercising groups, neonate weight, length, and BMI did not significantly differ between groups [20]. Mottola et al. [21] employed a similar exercise and nutrition intervention in overweight and obese pregnant women. No significant differences were found for total weight gained between the groups [21]. The amount of weight


<table>
<thead>
<tr>
<th>Absolute Contraindications to Aerobic Exercise During Pregnancy</th>
<th>Relative Contraindications to Aerobic Exercise During Pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemodynamically significant heart disease</td>
<td>Severe anemia</td>
</tr>
<tr>
<td>Restrictive lung disease</td>
<td>Unevaluated maternal cardiac arrhythmia</td>
</tr>
<tr>
<td>Incompetent cervix/cerclage</td>
<td>Chronic bronchitis</td>
</tr>
<tr>
<td>Multiple gestation at risk for premature labor</td>
<td>Poorly controlled type I diabetes</td>
</tr>
<tr>
<td>Persistent second or third trimester bleeding</td>
<td>Extreme morbid obesity</td>
</tr>
<tr>
<td>Placenta previa after 26 weeks gestation</td>
<td>History of extremely sedentary lifestyle</td>
</tr>
<tr>
<td>Premature labor during the current pregnancy</td>
<td>Intrauterine growth restriction in current pregnancy</td>
</tr>
<tr>
<td>Ruptured membranes</td>
<td>Poorly controlled hypertension/preclampsia</td>
</tr>
<tr>
<td>Pregnancy induced hypertension</td>
<td>Orthopedic limitations</td>
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<tr>
<td></td>
<td>Poorly controlled seizure disorder</td>
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<tr>
<td></td>
<td>Poorly controlled thyroid disease</td>
</tr>
<tr>
<td></td>
<td>Heavy smoker</td>
</tr>
</tbody>
</table>

Table 2: Modified target heart rate zones developed for normal, overweight, and obese pregnant women.

<table>
<thead>
<tr>
<th>Modified Target Heart Rate Zones for Pregnant Population</th>
<th>Age</th>
<th>Normal Weight</th>
<th>Overweight &amp; Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 20 years old</td>
<td>140-155</td>
<td>110-131</td>
</tr>
<tr>
<td></td>
<td>20-29 years old</td>
<td>135-150</td>
<td>108-127</td>
</tr>
<tr>
<td></td>
<td>30-39 years old</td>
<td>130-145</td>
<td>108-127</td>
</tr>
<tr>
<td></td>
<td>&gt; 40 years old</td>
<td>125-140</td>
<td></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Borg Scale for Rating of Perceived Exertion (RPE)</th>
<th>Borg Scale for Rating of Perceived Exertion (RPE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Very, very light</td>
</tr>
<tr>
<td>7</td>
<td>Very, very light</td>
</tr>
<tr>
<td>8</td>
<td>Very light</td>
</tr>
<tr>
<td>9</td>
<td>Fairly light</td>
</tr>
<tr>
<td>10</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>11</td>
<td>Hard</td>
</tr>
<tr>
<td>12</td>
<td>Very hard</td>
</tr>
<tr>
<td>13</td>
<td>Very, very hard</td>
</tr>
<tr>
<td>14</td>
<td>Very, very hard</td>
</tr>
</tbody>
</table>

physiological phenomenon, target heart rate zones for normal weight, overweight and obese pregnant women have been developed and are listed in (Table 2) [5, 7, 8]. Also, HR is the most accurate measure of intensity, especially for women who have trained prior to pregnancy [9]. The goal of exercise during pregnancy is to maintain or increase fitness and avoid maximal exertion [5, 10, 11]. To achieve this goal, it is currently recommended to utilize aerobic types of exercise such as walking, cycling, and swimming [1-3, 5, 12]. Pregnant women should avoid activities that increase their risk of losing balance or could result in fetal trauma, such as ball-sports and recreational activities like skiing, biking outside, horseback riding, etc. [1-3, 5, 12]. Overall, these recommendations are similar to those for non-gravid populations as published by the ACSM [3]. Previously sedentary, overweight and obese non-gravid individuals should exercise at a light to moderate intensity (57-75% HR<sub>max</sub>), 20-30 minutes a day, most days of the week [3].
gained over the course of the pregnancy was within the acceptable range and not in excess, according to guidelines published by a Canadian health initiative. Weight gain of the intervention groups was not compared to matched normal-weight controls.

Management of gestational weight gain is important in preventing the development of gestational diabetes mellitus and hypertension in pregnancy, preventing delivery complications and adverse fetal outcomes, and decreasing the amount of weight retained post-partum. Rossner [24] found that weight gain during pregnancy was the most significant predictor of weight retention 1 year postpartum. Weight retention can have adverse effects for the woman, increasing her susceptibility to various disease states, as well as adverse fetal health outcomes in future pregnancies. Edwards et al. [25] reported that excess gestational weight gain may have greater consequences for neonatal health than maternal health in normal weight, overweight and obese pregnant women. Oken et al. [23] further supported this claim, finding that excess gestational weight gain related directly to infant and childhood weight statuses. They found that excess gestational weight gain resulted in increased child adiposity at age 3 in normal weight, overweight and obese pregnant women [23]. Thus, the management of weight gained during pregnancy is important to improving maternal, neonatal, and childhood health and well-being.

These improvements in maternal health during pregnancy contribute to overall improved health post-partum, decreased risk of adverse conditions, and improved outcomes in future pregnancies. Aerobic exercise positively influences pregnancy outcome by decreasing complications for both mother and baby during labor and delivery, including a decreased need for Cesarean section delivery and decreased hospitalization time for maternal recovery [26-28]. Since pregnant women respond and adapt to exercise in a similar manner, the ensuing health benefits are likely to be similar regardless of weight classification and parity.

**Fetal responses to aerobic exercise**

Previous research has shown fetal adaptations in response to maternal aerobic exercise [29-33]. Szymanski and Satin [33] monitored fetal HR before, during, and after single moderate and vigorous intensity exercise sessions. Fetal HR increased post-exercise in both groups, but did not exceed normal limits [33]. Ultrasound was also used to monitor the fetus before and after exercise sessions with no adverse outcomes noted. These results indicate that acute maternal aerobic exercise of moderate or vigorous intensity is tolerated by the fetus. Other studies have also reported no signs of fetal distress in response to acute maternal aerobic exercise. Kennelly et al. [34] measured fetal HR and variability before and after a single maternal aerobic exercise test in overweight pregnant women. No significant change in fetal HR occurred during the exercise test [34]. However, a significant difference in HRV was noted between pre and post exercise measures. These results suggest that a single bout of high intensity maternal aerobic exercise does not increase the risk of fetal distress. Clapp et al. [35, 36] measured amniotic erythropoietin levels to determine if regular maternal aerobic exercise throughout pregnancy induces a fetal hypoxic effect. Results indicated that erythropoietin levels were not significantly different between exercising women and non-exercising controls, further suggesting that the fetus is not in danger of chronic hypoxia or bradycardia as a result of chronic maternal aerobic exercise [35,36].

Multiple studies [29-31,37-40] have found that measures of fetal HRV increase with gestational age. Multiple studies have found that offspring of exercising pregnant women do not significantly differ in birth size (i.e. length, abdominal circumference) compared to offspring of women who do not exercise throughout pregnancy. Two studies completed by Clapp [41] and Clapp et al. [42] reported that, at birth, neonates of exercising mothers weighed less due to less body fat percentage and total body fat mass than neonates of controls [41, 42]. However, there was no significant difference found in lean body mass between the offspring of each group [41, 42]. Szymanski and Satin [33] found that birth weight was not significantly different between neonates of exercising pregnant women and controls. Ruchat et al. [20] found that offspring of normal weight pregnant women who participated in an exercise and nutrition intervention did not significantly differ in regards to birth weight and BMI among maternal intervention groups (light intensity, moderate intensity, and control). A similar study employing overweight and obese pregnant women also found that birth weight of offspring did not differ significantly between overweight and obese pregnant women or between exercising women and matched controls from a local medical database [21]. Each of these studies provides evidence that fetuses of exercising pregnant women, of any weight classification, are likely to have a normalized birth weight.

**Maternal responses to resistance training**

Studies have demonstrated that participation in resistance training during pregnancy is safe [56], and women felt better about themselves, gained less weight, and felt relief from somatic problems (i.e. nausea, fatigue, headache) [43]. As pregnancy progressed, the intensity of exercise decreased [43]. Further studies found resistance with aerobic exercise is associated with decreased prevalence of hypertension and diabetes during pregnancy relative to aerobic only or controls [44]. Resistance exercise during pregnancy also decreases patients with GDM that need insulin and improves glycemic control [45, 46]. Studies show no adverse pregnancy outcomes associated with resistance training during pregnancy [47]. Women may experience increased strength and flexibility from participating in resistance exercise while pregnant [47]. O’Connor et al. [11] employed a 12 week, low-to-moderate intensity resistance training program in 32 pregnant women. The purpose of the study was to determine the safety and efficacy of a strength program to decrease low back pain and to determine the rate of musculoskeletal injury due to resistance training during pregnancy. The program consisted of six different exercises focusing on legs, arms, back, and abdomen. Intensity was maintained by using the 6-20 Borg scale of perceived exertion, which was also applied to help progress the external load of each exercise completed. The average external load increased progressively over the 12 week period, which suggests an increase in maternal strength over time, although no assessments were completed to substantiate this claim. No injuries were reported over the 12 week program, but the primary symptom reported was dizziness [11]. There was also no significant change in maternal resting BP noted from the beginning to the end of the 12 week program [11]. O’Connor et al. [11] emphasized and recommended education of proper breathing and lifting techniques and general muscular conditioning throughout the 12 week program.

Resistance training is a mode of exercise employed by many individuals to maintain or increase muscle strength and has grown
in popularity among many different populations. However, in the pregnant population, only a few studies have analyzed the acute and chronic effects of resistance training on the mother and fetus [7, 10-12, 48]. Preliminary studies have shown that acute resistance training can be safe and efficacious for the mother and her unborn child [7, 10, 11, 48]. Avery et al. [48] measured maternal HR and BP in response to strength exercises during the third trimester. During each session (at 31, 32, and 33 weeks gestation), participants completed hand grip, single leg extension, and double leg extension exercises in seated and supine positions with varying intensity levels. Maternal HR and BP were measured with each increase in intensity for both positions of the aforementioned exercises. The measured responses to strength training in pregnant women were similar to those of non-pregnant controls, with no differences in BP at rest and during each exercise [48]. BP in both groups was greatest when larger muscle groups were utilized, while HR was only elevated in pregnant women [48]. O’Connor et al. [11] also reported no significant difference in maternal BP before and after acute maternal resistance training of 6 different strength exercises. This unaltered measurement of BP before and after acute resistance exercise during pregnancy is the same as noted in response to acute aerobic exercise [16, 49].

A case study completed in a single obese pregnant woman investigated the use of progressive resistance training throughout the 2nd and 3rd trimesters [50]. The participant completed a combination of upper and lower body exercises three times a week. The pregnant mother maintained a moderate intensity, regulated by her heart rate. Over the course of the program, the participant gained lean body mass, decreased BMI, and increased training volume by 58% [50]. It appears from these results that moderate intensity progressive resistance training throughout pregnancy is safe and beneficial to maternal health. Similarly, Barakat et al. [51] reported no significant difference in maternal gestational weight gain or type of delivery in normal weight pregnant women in response to chronic light intensity resistance training. No adverse health outcomes or injuries were reported during the training period.

These responses in the pregnant population are similar to those reported in non-gravid populations [52, 53]. Dionne et al. [52] reported increased fat free mass and resting energy expenditure in normal weight non-pregnant women after a 6 month resistance training program. Donges and Duffield [53] reported increased fat free mass and decreased fat mass in overweight non-pregnant women after 10 weeks of either resistance training or aerobic training programs. Regardless of whether a woman participates in aerobic only, aerobic + resistance training, or control group, there are no differences in preterm labor, mode of delivery, and gestational age [44].

**Fetal responses to resistance training**

In the aforementioned study by Avery et al. [48], fetal HR was measured before, during, and after each maternal resistance exercise, with no significant changes in fetal HR observed. This study concluded that the fetus tolerates acute maternal strength exercise well and that acute maternal strength exercises do not cause fetal distress before, during, or after. This agrees with a retrospective study that found frequency, intensity, and time measures related to resistance training were inversely related to fetal complications, such that increased resistance training was associated with decreased likelihood of fetal complication during pregnancy [55]. However, the primary recommendation of this study is for pregnant women to avoid supine exercises in the third trimester as it may increase the risk of fetal hypoxia and bradycardia due to increased maternal BP and decreased blood flow to the fetus [48]. Barakat et al. [51] reported increased fetal HR in response to light intensity maternal resistance exercises. This response indicates that the acute fetal HR response to maternal resistance exercises is normal and similar to the response reported when exposed to acute maternal aerobic exercise. These results further substantiate the claim that the fetus is not at an increased risk of distress or adverse health outcomes in response to acute maternal exercise, regardless of the type and intensity.

Although many studies have reported no negative or adverse pregnancy outcomes as a result of maternal resistance training [11, 56, 57], none of these studies have completed measures of fetal health in response to chronic maternal resistance training. Therefore, very little is known about the long term effects of chronic maternal resistance training on fetal and neonatal health, even though it appears to be safe. Post-hoc analyses (unpublished data) show that intermittent maternal exercises (i.e. strength training) correlates with increased overall HRV, whereas continuous maternal exercise (i.e. aerobic) correlates with increased HF (a parasympathetic measure). These analyses suggest that different modes of maternal exercise have different effects on the developing cardiovascular system. Additionally, there is no research regarding the influence of acute or chronic maternal resistance training in overweight and obese pregnant women. Although the subjects participating in Dr. May’s previous study represent all weight classifications, the study was not specifically designed to look at the effects of overweight and obese pregnant mothers’ exercise on fetal heart outcomes. There are also no generally accepted guidelines or recommendations for resistance training during pregnancy to accompany those for aerobic exercise. Unfortunately, the present literature is lacking in this area while there is a growing interest in providing research-based resistance training recommendations to pregnant populations.
Maternal responses to circuit training

The combination of aerobic and resistance training has become more popular among healthy, non-gravid populations. Aerobic training is known to increase cardiovascular and pulmonary health while resistance training results in increased muscular strength and endurance. Research on the acute responses and chronic adaptations in maternal and fetal health of combining these modes of exercise has not been sufficiently addressed in the pregnant population. Acute responses of maternal health due to participation in circuit training during gestation have not been reported. However, non-gravid participants in a single session of circuit training experienced decreased systolic and diastolic BP, stroke volume, and cardiac output and increased systemic vascular resistance and HR compared to control values, acute aerobic training only, and acute resistance training only [58].

Few studies have measured maternal chronic adaptations and maternal health outcomes in response to circuit training during pregnancy. A study by Hall and Kaufmann [26] explored pregnancy outcomes after a combination training exercise regimen throughout pregnancy. This regimen consisted of a 3-5 minute warm-up, followed by individually prescribed strength and flexibility exercises, and ended with a 1-2 mile cycling workout. Exercise groups were divided into low, medium, and high according to the number of exercise sessions completed throughout the course of pregnancy. Women who completed more exercise sessions were less likely to have a Cesarean section than women who exercised less or not at all (Med/Hi > Low/Control). Additionally, women who exercised spent less time in the hospital after delivery compared to non-exercise controls. Price et al. [28] measured cardiorespiratory fitness, strength, and flexibility in overweight pregnant women participating in a circuit training program throughout the 2nd and 3rd trimesters. At each testing session (every 6 weeks from 12 wks GA to 8 wks postpartum), the exercising groups produced during a 2 mile walk, than controls, with a significant difference at 30-32 weeks gestational age [28]. Exercising pregnant women had significantly higher strength, measured by a 7kg lift test, than controls from 18 weeks gestational age to 8 weeks postpartum [28]. Flexibility measures were not significantly different between groups. Significantly fewer women in the exercise group delivered via Cesarean section than controls and time to recovery postpartum was significantly shorter as well [28]. Circuit training combining aerobic and resistance exercise leads to adaptive benefits of the placenta [39]. This adaptation of the vascular system reduces the risk of pre-eclampsia, diabetes, and hypertension while pregnant [59]. It is suggested that HR is more accurate for gauging exercise intensity during weight-bearing exercise while pregnant [9].

Fetal responses to circuit training

Very few studies have researched the effects of maternal circuit training on fetal health. A retrospective analysis found that overall women decrease their level of aerobic and resistance exercise during pregnancy, and most importantly maternal and fetal complications occur at a rate similar to the general population [55]. Hall and Kauffman [26] found no significant differences in birth weight of offspring among groups. However, a significant difference was found in 1 and 5-minute APGAR scores of offspring among groups, with those of women who completed the most exercise sessions having a higher score. Price et al. [28], also reported no significant differences in birth weight between exercise and control groups. Although little has been reported as far as acute or chronic fetal health measures in response to maternal circuit training, based on the available data this type of exercise is also safe during pregnancy.

Since other studies have shown that pregnant populations have similar acute and chronic aerobic and resistance exercise training responses as non-gravid populations, one can postulate that pregnant populations will also benefit from the use of combination training regimens similar to their non-gravid counterparts. Although preliminary studies have shown that resistance training and aerobic training do not adversely affect fetal development individually, the effects on fetal health outcomes from combining these two modes of exercise warrants further investigation, especially in overweight and obese mothers.

DISCUSSION AND CONCLUSION

Various types of exercise throughout pregnancy have been proven safe and efficacious for the mother and her unborn child. Although a popular belief remains that women who are not previously active should refrain from beginning regular exercise during pregnancy, a plethora of research has refuted this claim. Moderate intensity aerobic exercise is safe and recommended for improved maternal and fetal health outcomes such as cardiovascular health, management of gestational weight gain, prevention of chronic diseases, neonatal morphometric, and childhood health measures. Resistance and circuit training has grown in popularity among non-gravid populations, but currently remains inadequately researched regarding pregnancy. More research is needed to determine if these modes of exercise provide any long-term benefit to maternal, fetal, and/or neonatal health. Additionally, little research has focused on overweight and obese pregnant women who, like their non-gravid counterparts, appear to significantly benefit from participation in a regular moderate intensity exercise program throughout gestation. Studies are currently being done to address many of these unanswered questions related to maternal and fetal health and exercise during pregnancy.

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REFERENCES


