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Fetal and maternal cardiac responses to physical activity and exercise during pregnancy

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ABSTRACT

Since the 1970s, researchers have studied the influence of exercise during pregnancy on offspring heart development. With the knowledge and current evidence of fetal programming effects, research has demonstrated that exercise is safe and beneficial for mother, fetus, and neonate. Predominantly, research has focused on maternal and fetal cardiac adaptations related to aerobic exercise during pregnancy; less is known regarding the effects of resistance or combination (aerobic and resistance) training during pregnancy. Ongoing research is focusing on fetal responses to different intensity, duration and modes of maternal exercise throughout pregnancy. This article will summarize our current state of knowledge regarding the influence of exercise intensity, duration, and modes during pregnancy on maternal and fetal cardiac responses.

Contents

1. Introduction

The American Congress of Obstetricians and Gynecologists (ACOG) advises pregnant women, even if sedentary, to participate in at least 30 min of physical activity on most days of the week [1]. However, the naturally occurring increase of sympathetic input during gestation is associated with an increased risk of pregnancy complications, such as pregnancy-induced hypertension, pre-eclampsia, and eclampsia [2]. Since obesity and diabetes are also associated with increased sympathetic activity, women with these conditions during pregnancy have increased

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risk of pregnancy complications. Despite the cardiovascular autonomic changes that occur during pregnancy, there are numerous safe physical activities women should undertake in order to improve or maintain cardiovascular health for themselves and their child [1,3].

Various exercise modes have been shown to be safe for the mother and the fetus throughout pregnancy [1,4,5]. This article will discuss the cardiac adaptation of women to different modes of exercise throughout gestation. Offsetting the potentially negative effects of increased sympathetic activity is parasympathetic activity, which can be easily measured by assessing variability in the timing of each heart cycle. One method to monitor parasympathetic and sympathetic nervous system control during pregnancy (for mother and child) is by measuring heart rate variability (HRV), variation in the time between R–R intervals [6,7]. For example, increased heart rate and decreased HRV have been shown to be associated with hypertension [8–10]. Conversely, long-term aerobic training increases parasympathetic control at rest, which leads to increased heart rate variability and lower heart rate (HR) in adults [11]. Furthermore, exercise during pregnancy may improve cardiac autonomic health of the fetus, thus the fetal cardiovascular adaptations to different modes of exercise will be described, as will evidence concerning the persistence of fetal adaptations into the postnatal period. Overall, this article will explore the cardiospecific adaptations of mother and child in pregnancy and exercise during pregnancy. Based on current empirical evidence, the safe and recommended exercise guidelines will be summarized for pregnancy.

2. Maternal responses to exercise

2.1. Maternal-aerobic

Acute cardiovascular response to aerobic exercise during pregnancy is similar to that observed in the general population: increased heart rate (HR), stroke volume, and cardiac output, with little to no change in blood pressure [12]. Similarly, participating in regular aerobic exercise during pregnancy provides improvements in overall cardiovascular function [13–15]. Despite the pregnancy-associated increase in sympathetic control and regardless of BMI, pregnant women experience lower resting heart rate (HR), as well as increased HRV [16] and cardiac output, in response to consistent aerobic exercise [17–19]. These changes in response to aerobic training during pregnancy are most likely due to increases in autonomic control, indicated by overall HRV [16]. By decreasing heart rate and increasing heart rate variability, exercise has shown to be an effective intervention in reducing resting blood pressure for hypertensive and pre-hypertensive women [20], and possibly for reducing incidence of pre-eclampsia and HELLP (Hemolysis, Elevated liver enzymes, Low platelet count) Syndrome [21]. As a result, regular moderate to high intensity exercise during pregnancy may be an effective preventative measure in the development of gestational hypertension, pre-eclampsia and its variants, i.e. HELLP syndrome. The lack of change of blood pressure before and after acute resistance exercise during pregnancy is similar to the aerobic exercise response [18,22], and is due to the peripheral vasodilation that occurs during gestation [23]. Blood lipid regulation is improved in women who participate in aerobic exercise during pregnancy [17,18,24]. All of these cardiovascular changes as a result of aerobic exercise during pregnancy lead to improved aerobic submaximal capacity [25] and contribute to overall improved health post-partum, decreased risk of adverse conditions, decreasing complications during labor and delivery, and decreased time for maternal recovery [26–28]. Therefore, there are numerous maternal and pregnancy benefits to aerobic exercise while pregnant.

2.2. Maternal resistance training

Resistance training has grown in popularity among many women. Studies have demonstrated that participation in resistance training during pregnancy is safe [12,29–31], and beneficial. Although the intensity of exercise necessarily decreases [32] as pregnancy progresses, women feel better, gain less weight, and experience fewer pregnancy symptoms (i.e. nausea, fatigue, headache) [32] with strength training throughout pregnancy. Although many studies focused on increased maternal strength and flexibility from participating in resistance exercise while pregnant [33], some report cardiovascular effects. The cardiovascular responses (i.e. blood pressure before, during, and after exercise) to strength training in pregnant women are similar to those observed in non-pregnant women [29,31]. Blood pressure is greatest when performing strength exercises using larger muscle groups and HR is elevated in all strength exercises for pregnant women [29]. Similar to aerobic exercise, resistance training has no effect on maternal blood pressure. Regular resistance training leads to no adverse pregnancy outcomes or injuries, [33] and no difference in type of delivery [34].

2.3. Maternal circuit training

Only a few studies have measured maternal adaptations and health outcomes in response to combination (aerobic and resistance) training during pregnancy. One study examining the chronic response to various types of exercise during pregnancy [35] found increasing resting heart rate as pregnancy progressed. However, the increase in heart rate with progressing gestation is smaller in exercisers relative to controls [35]. Therefore, women who participate in any type of exercise throughout gestation have improved cardiovascular fitness compared to controls [28,35]. This may be due to decreased afterload (with decreased vascular resistance) or increased stroke volume. Most likely this is due to increased stroke volumes since this has been reported previously as a result of exercise throughout pregnancy [36]. Another study found resistance training combined with aerobic exercise associated with decreased prevalence of hypertension and diabetes during pregnancy relative to aerobic only or controls [37]. Significantly fewer women engaging in combination exercise deliver via Cesarean section and those engaging in combination exercise have significantly shorter recovery time after delivery compared to controls [26,28]. 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 [37]. Thus, all types of exercise are safe during pregnancy and may be beneficial as well.

3. Fetal responses to exercise

There is growing evidence to support the association of prenatal programming by *in utero* events, which suggests that the focus of disease prevention or research interventions should begin in gestation. It is critical to utilize sensitive and specific prenatal and postnatal measures in order to detect these differences early and accurately in order to design interventions that will steer development appropriately. In order to do this, medical professionals need sensitive tools, such as HR and metrics of heart rate variability (HRV), which can serve as useful measures of developmental programming effects when used in longitudinal studies of fetal and neonatal development. Besides a measure of cardiac function, HRV in the fetus and newborn serves as a proxy for the degree of integration between central and peripheral nervous systems, as well as an index of target-organ maturation in the developing fetus [38]. Normally changes in fetal heart development are seen in a gradual slowing of fetal heart rate along with increases in heart rate variability [39] attributed to the maturation and integration of the autonomic nervous system.

3.1. Fetal response to maternal aerobic exercise

Current research is focused on determining if maternal physical activity has the potential to program fetal cardiovascular system towards health and decreased risk of heart disease. Previous research