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MASTERCLASS

Impact of exercise during pregnancy on gestational weight gain and birth weight: an overview☆

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Abstract
Objective: This article presents the state of knowledge related to the impact of exercise on gestational weight gain and birth weight.
Transcendence of baby weight: Birth weight is an important indicator of intrauterine environment and maternal and newborn health. There are several factors that can affect birth weight including mother's pre-pregnancy Body Mass Index (BMI), gestational weight gain, Gestational Diabetes Mellitus (GDM), chronic diabetes and gestational age at birth.
Impact of exercise during pregnancy: Physical exercise has the potential to prevent excessive gestational weight gain, GDM and the potential complications associated with obesity during pregnancy. Therefore, women who regularly exercise during pregnancy are more likely to have an appropriate gestational weight gain and in turn, an appropriate birth weight infant, preventing being LGA without increasing risk of SGA, and this reduces risk factors for later life chronic disease development in the child including cardiovascular disease, obesity and diabetes.
Recommendations: It would be advisable to promote compliance with physical activity and exercise recommendations during pregnancy by using the specific resources to prescribe exercise to pregnant women without obstetric contraindications.

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Introduction to gestational weight gain and birth weight

Birth weight is an important indicator of intrauterine environment and maternal and newborn health. Although weight assessment should be considered with other factors such as the child's general health status and parental characteristics, it has been demonstrated that an appropriate birth weight reduces risk factors for later life chronic disease development and may also have lifelong health implications.[1]

There are several factors that can affect birth weight including mother's pre-pregnancy Body Mass Index (BMI)[2] and Gestational Weight Gain.[3] Gestational Weight Gain is categorized as excessive or adequate using the pre-pregnancy BMI. Excessive Gestational Weight Gain (EGWG) is defined as a weight gain of >18.0 kg for underweight, >16.0 kg for normal weight, >11.5 kg for overweight and >9.0 kg for obese women, according to the Institute of Medicine (IOM) recommendations.[4] Gestational Diabetes Mellitus (GDM),[5] chronic diabetes, exercise before and during pregnancy,[6] nutrition, maternal age[7] and gestational age at birth can also affect birth weight. Therefore, there are some modifiable factors that can promote appropriate birth weight including maternal exercise during pregnancy. This article presents the state of knowledge related to the impact of exercise on gestational weight gain and birth weight.

Deviations from the optimal birth weight

Optimal birth weight is defined between 2500 and 4000 g, and Adequate for Gestational Age (AGA) as weight between the 10th and the 90th percentile for the gestational age. Birth weight outside of this range may be an important indicator of health risk factors for future chronic diseases and poor fetal growth in utero.[8–11]

- Small for Gestational Age (SGA): the World Health Organization defines Low Birth Weight as less than 2,500 g regardless of gestational age, and this can be subdivided into very low birth weight (less than 1,500 g) and extremely low birth weight (less than 1,000 g). In general, the latter two statuses are typically indicators of nutritional deficiencies or premature birth. However, the SGA term may be more appropriate since it is based on the correlation between the weight of the newborn and gestational age, and it is defined as a weight below the 10th percentile of a population-specific birth weight for gestational age.
- Large for Gestational Age (LGA): is defined as birth weight greater than 4.0 kg regardless of the gestational age. It is also defined as birth weight above the 90th percentile for the gestational age.
- Macrosomia: this term is usually used when the birth weight is above 4 kg. However, it has also been described that it is when the infant is born with a birth weight $\geq$4.5 kg when complications increase significantly. This term is related to LGA and often these are seen being used interchangeably. However, it is recommended to use the Ponderal Index ($PI = Weight/Length^3 \times 100$) since it allows to differentiate babies at higher risk of perinatal complications according to the percentile (P): harmonic or symmetric macrosomia (PI < P90) or disharmonic or asymmetric macrosomia (PI > P90).[12]
- Intrauterine Growth Restriction (IUGR): is defined as a rate of fetal growth that is less than normal while in utero. Therefore it implies that the fetus does not achieve their optimal development. Intrauterine Growth Restriction is one of the risk factors for a baby being born potentially SGA, however not all newborns that are SGA are fetal growth restricted.[13]

Causes and potential health impact if baby is too small or too big

Genetics may influence birth weight, however besides these cases, being SGA or LGA is an important cause of fetal and neonatal morbidity and mortality.[8–11,14,15]

Small for gestational age (SGA)

The risk of perinatal mortality in SGA newborns is higher than in children with an adequate weight for their gestational age.[16] Commonly identified causes of SGA newborns include pre-pregnancy underweight and inadequate increase of gestational weight,[17] maternal nutritional deficiencies, maternal smoking[18] and alcohol[19] or drug consumption. Other risk factors include increased maternal age, premature birth, multiple gestation, diseases such as arterial hypertension, preeclampsia[7] or diabetes mellitus, and infections such as HIV or toxoplasma.

There also may be potential placental related causes of SGA. When the placenta does not function properly, as a consequence of hypoxia and secondary increase of erythropoietin, the SGA baby presents a greater volume of plasma and circulating red blood cell mass, producing higher blood viscosity, which favors hypoglycemia. Otherwise, SGA children are also more likely to have fasting hypoglycemia, especially in the first days of life.[20]

On the genetic side, some of the fetal causes that increase the risk of SGA are chromosomopathies such as Trisomy 21, congenital anomalies including cardiac abnormalities, and genetic diseases such as achondroplasia.

In SGA babies there is a higher risk of insulin resistance from the first year of life, being more pronounced when there is rapid recovery of weight.[20] Higher blood pressure is also observed in preterm SGA babies.[21] Furthermore, being SGA increases the risk of coronary heart disease, cerebrovascular accidents and Type 2 Diabetes Mellitus in adulthood,[8,10] being also an important risk factor on accelerated postnatal increase in BMI and fat mass.[15,22] Multiple studies have demonstrated that SGA newborns have a decrease in brain volume that could be related to a negative neurocognitive development.[14]

Large for gestational age (LGA) and macrosomia

The main reasons a baby is LGA are EGWG, GDM, mother with a BMI $\geq$25,[23] chronic diabetes, maternal age over 35[24] and poor maternal nutrition. The baby will also have a higher possibility of being >90th percentile if the

gestational age at delivery is greater than 40 weeks. When the mother has diabetes prior to pregnancy or develops GDM, due to the high levels of sugar in the blood there is an increase in the transfer of the glucose to the baby through the placenta. This results in an increase of fetal insulin production and according to the fetal-insulin hypothesis this can cause excessive growth and fat accumulation. Additionally, the LGA babies of diabetic mothers have a greater risk of presenting complications of low blood sugar after birth (hypoglycemia).[25] Pre-pregnancy BMI of overweight or obesity and EGWG increases the risk of developing GDM, so a circle occurs.[26]

The risk of cesarean and instrumental delivery and prolonged labor also increases when the baby is born LGA.[27] Instrumental delivery increases the risk of tears in the cervix, vagina, perineum and anal sphincter, bleeding, mother urinary or fecal incontinence, and bumps or bruises on the baby's head. The risk of shoulder dystocia is also higher, which increases the possibility of maternal hemorrhage and damage to the baby's brachial plexus or clavicle fracture. Similarly, macrosomic babies have a higher risk of phrenic nerve injury, asphyxia or meconium aspiration syndrome. When any of these problems occurs, the risk of maternal or baby death also increases.

Furthermore, several studies link fetal macrosomia with a higher risk of developing Diabetes Mellitus Type 2, obesity and metabolic syndrome in childhood or in adulthood,[11] which would perpetuate this cycle in the next generations.

Therefore, three potentially modifiable factors that contribute to birth weight are EGWG, GDM and obesity. These factors may be modified and controlled with maternal exercise.[28,29]

Impact of exercise during pregnancy

Exercise during pregnancy has positive implications on the health and well-being of both mother and growing fetus including an appropriate gestational weight gain and a healthy birth weight. In fact long term studies have shown that women who regularly exercised during pregnancy are more likely to have an appropriate birth weight infant, and this reduces risk factors for later life chronic disease development in the child including cardiovascular disease,[30] obesity,[31] and diabetes.[32] According to the American College of Obstetrics and Gynecology, pregnant women are recommended to exercise on most days of the week at a moderate intensity for approximately 30 min.[33] Meeting these guidelines has a positive association with a healthy pregnancy, including promotion of appropriate birth weight by preventing EGWG, GDM and the potential complications associated with obesity during pregnancy.

Exercise during pregnancy and prevention of EGWG

Exercising during pregnancy can reduce the risk of EGWG and this may promote appropriate birth weight.[34] A randomized controlled trial that included an exercise group ($n = 382$) compared to a standard care control group ($n = 383$) found a significant reduction in the number of infants born with macrosomia in the exercise group versus the control.[6] The exercise intervention included a supervised training program offered three times per week for 50 min per session. The program began at 9–11 weeks gestation and continued until 38–39 weeks gestation. All sessions included aerobic exercise, muscle conditioning and flexibility exercises. The average adherence to the program was 80% and the incidence of macrosomia was only 1.8% ($n = 7$) in the exercise group compared to 4.7% ($n = 18$) in the control group ($p = 0.03$).

A meta-analysis that included twenty-eight randomized controlled trials reports a similar trend as the odds of having a LGA infant was reduced by 31% with prenatal exercise (odds ratio [OR] 0.69, 95% confidence interval [CI] 0.55–0.86).[34] What is also important to note is that the decrease in LGA infants did not increase the risk of SGA infants (OR 1.02, 95% CI 0.72–1.46). Therefore this meta-analysis demonstrated that prenatal exercise may be an effective way to promote appropriate birth weight. Furthermore, results of this meta-analysis showed that greater exercise volume and duration was associated with less gestational weight gain.[34] This suggests that women who engage in regular exercise throughout pregnancy are more likely to gain an appropriate amount of weight and this will also have a positive influence on birth weight.

A potential mechanism that may explain the beneficiary effects of exercise during pregnancy on maternal weight gain and birth weight is a reduction in leptin and resulting fetal adiposity. A study comparing maternal characteristics between women that gained excessively and those who did not found that leptin concentrations were significantly higher in early pregnancy among the women who gained excessively and similarly fetal leptin concentrations were also higher in this group.[35] Furthermore, fetal adiposity was higher when the mother gained excessively during pregnancy compared to women who met the recommended weight gain guidelines. Similar trends were observed by Davenport et al.,[36] when they investigated the impact of the timing of gestational weigh gain. Women that gained excessively early in pregnancy had babies with greater adiposity when compared to women who met weight gain guidelines. Exercise has been shown to reduce maternal fat storage and fetal adiposity and therefore it may be an effective way to prevent EGWG and promote healthy birth weight.

Exercise during pregnancy and prevention of GDM

Another mechanism that has been associated with increased birth weight is an increase in glucose transported to the fetus and this is a common problem associated with GDM.[37] Prenatal exercise has been identified as an effective intervention to improve maternal insulin sensitivity, reduce circulating levels of glucose and prevent and manage GDM.[38,39]

A recent meta-analysis reported that lifestyle interventions, including prenatal exercise, significantly reduced the incidence of GDM when compared to standard care.[38] Specifically, exercise interventions from Southern-Europe reduced GDM risk by 37% (relative risk [RR] 0.63, 95% [CI] 0.50–0.80). An example of an effective exercise program includes a water and land-based intervention offered to pregnant women three times per week (60 min on land, 50 min in water) beginning at 10–12 weeks gestation until

delivery.[28] Results showed that women randomized to the exercise intervention ($n = 101$) had a significantly lower incidence of GDM (1%, $n = 1$) when compared to women who received standard care ($n = 156$, 8.9% or $n = 13$ diagnosed with GDM; $p = 0.009$).

Exercise may be effective in preventing GDM because regular activity decreases levels of circulating glucose. A randomized controlled trial that included pregnant women who were at high risk of GDM found that a walking program had a positive effect on capillary glucose levels.[40] Women were randomized at 16–20 weeks gestation into a low intensity (30% of heart rate reserve) or vigorous intensity (70% heart rate reserve) exercise group. All participants were also following a modified GDM diet plan. Women walked for 25 min three to four times per week with a gradual increase in time each week until 40 min was achieved and then maintained until the end of the intervention (34–36 weeks gestation). Free-living capillary glucose was monitored once per week pre- and post-exercise using a glucometer. Results showed that women who were at high risk of GDM in the low intensity group had a decrease in glucose concentration, and levels continued to decrease as the length of the walking sessions increased. This study provides support for aerobic exercise during pregnancy in reducing circulating glucose levels and this can reduce the risk of GDM and LGA infants.

Exercise may also have a positive effect on women who are diagnosed with GDM. A meta-analysis including eight randomized controlled trials found that women with GDM who were offered a weekly supervised exercise session had a significant reduction in absolute fasting blood glucose when compared to women who received standard care (weighted mean difference −3.88 mg/dL; 95% confidence interval −7.33, −0.42 mg/dL).[39] Furthermore an exercise intervention that included aerobic exercises, muscle conditioning and flexibility, offered three times per week to pregnant women with GDM, reduced the incidence of macrosomia by 58% (OR 1.76, 95% CI 0.04–78.90) when compared to a standard care control group (4.22, 95% CI 1.35–13.19).[41] As GDM is associated with an increased risk of macrosomia, it is important to consider the positive effect exercise can have on reducing the risk of developing GDM but also its potential preventative effects on macrosomia for women who are already diagnosed with GDM.

Exercise during pregnancy and the preventative effect on obesity related complications

As both EGWG and GDM are risk factors associated with obesity during pregnancy, exercise may be an important intervention that should be made available to this population group. A meta-analysis including seven randomized controlled trials that provided prenatal lifestyle interventions for obese pregnant women concluded that supervised physical activity programs lead to a 0.91 kg reduction in gestational weight gain.[42]

A problem identified in this population group however has been a lack of adherence to program recommendations and due to this there have been inconsistencies in the literature in regards to intervention success.[43] Programs that have had high levels of adherence however have shown that exercise during pregnancy is effective even among women with a pre-pregnancy BMI of obese in preventing EGWG[6,29] and GDM.[44,45] As a result, if fewer obese women exceeded weight gain recommendations and there was a reduction in the number of women diagnosed with GDM then this may also reduce the risk of LGA infants.

Too much or too little exercise?

Research has questioned whether there is an optimal frequency and intensity of exercise during pregnancy that should be maintained and if exceeding this level has any negative implications. Most commonly, research has suggested that perhaps high levels of exercise may increase the risk for SGA infants. Specifically, earlier studies have speculated that a high level of exercise may reduce oxygen and nutrient delivery to the placenta and this may impact fetal growth and specifically fetal size.[46] Limited literature among elite athletes has also shown that acute bouts of vigorous exercise may potentially reduce uterine artery blood flow.[47] More recently however, an evidence statement from the International Olympics Committee expert committee on exercise and pregnancy in recreational and elite athletes, summarized that although birth weight seems to be reduced with higher levels of exercise in elite and recreational pregnant athletes, there is no evidence to suggest that babies are more likely to be born <2,500 g.[48] Furthermore, exercise interventions that have prevented LGA infants have also suggested that exercise does not increase the risk for an SGA infant.[34] Pregnant women however should exercise within the recommended guidelines[33] and further research on higher levels of intensity and frequency is required.

Current exercise recommendations

Currents physical activity and exercise recommendations during pregnancy are described by The American College of Obstetrician and Gynecologist (ACOG).[33] These recommendations include absolute and relative contraindications to exercise during pregnancy, and are addressed to women with uncomplicated pregnancies after a clinical evaluation. Furthermore, any pregnant women with medical or obstetric complications are encouraged to visit their obstetrician or gynecologist to carefully evaluate whether they can exercise during pregnancy. The recommendations also include a list of warning signs to stop exercising such as vaginal bleeding, regular painful contractions or amniotic fluid leakage.

Physical exercise recommendations include safe physical activities as walking, swimming, stationary cycling or low-impact aerobics. Contact sports, activities with high risk of falling such as skiing and surfing, or scuba diving should be avoided during pregnancy. Furthermore, some activities and exercises should be modified in order to avoid rapid movements or positions that result in decreased venous return and hypotension as long periods of lying flat on their backs.

Regular exercise should be developed, with at least 20–30 min of moderate intensity per day, on most or all days of the week. In order to maintain a moderate intensity while exercising, the Borg Rate of Perceived Exertion (RPE) Scale can be used to keep a range of 13–14 (''somewhat hard'').[49]

Proper caloric intake and hydration before, during and after exercising should be encouraged.

Although aerobic exercise at moderate intensity has shown benefits and it is generally recommended, some RCTs that included resistance exercise and strength training in their programs did not find negative impact on general health and body size of the newborn.[50–52] Another RCT that studied the effect of pelvic floor muscle training on birth weight did not find significant differences between groups,[53] and although two more RCTs found a statistical difference on birth weight,[54,55] newborns from both groups were within normal weight range. Therefore, light resistance exercise could be combined with aerobic exercise.

Future research

In order to prevent factors that contribute to inadequate birth weight including EGWG, GDM and obesity, it would be advisable to promote the use of resources that allows health care providers, physical therapists and physical exercise specialists to safely discuss, prescribe and supervise exercise to pregnant women. An example of a resource that can be used is the PARmed-X for pregnancy available online from the Canadian Society for Exercise Physiology.[56]

Secondly, more research about vigorous and high intensity exercise is needed. Although a Randomized Controlled Trial (RCT) evaluated the efficacy of regular supervised, moderate-to-vigorous resistance exercise during pregnancy and did not find any adverse effects on childbirth outcomes including birth weight,[52] given the difficulty of conducting clinical trials with this type of intervention, retrospective studies of high quality and larger sample sizes are needed to assess the safety of this type of exercise.

Finally, more RCTs are needed to understand how different exercise types and intensities impact birth weight. High quality RCTs with larger sample sizes and adherence to the exercise programs are essential.

Conflict of interest

The authors declare no conflicts of interest.

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