OBSTETRICS

Exercise in pregnancies complicated by obesity: achieving benefits and overcoming barriers

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An increasing number of women are entering pregnancy in an overweight or obese state. Obese women and their offspring are at increased risk of adverse perinatal outcomes, which may be improved by regular moderate-intensity antenatal exercise. Current guidelines recommend that all pregnant women without contraindications engage in ≥30 minutes of moderate-intensity exercise on a daily basis. However, obese women are usually less physically active and tend to further reduce activity levels during pregnancy. This commentary summarizes the potential short- and long-term benefits of antenatal exercise in obese pregnant women, highlights the challenges they face, and discusses means of improving their exercise levels. In addition, we make recommendations on exercise prescription for pregnancies complicated by obesity.

Key words: barrier, exercise, obesity, offspring, pregnancy

Over the last 30 years, obesity rates among women of reproductive age have increased steadily in developed nations,[1-3] and a similar trend is now observed in many developing countries.[4] Therefore, an increasing number of women enter pregnancy in an overweight or obese state.[5] For example, the rate of obesity during pregnancy exceeds 20% in the United States[6] and Britain,[7] and more than one-third of the obstetric population is overweight or obese in Australia.[8]

Physical activity is defined as any voluntary movement produced by skeletal muscles that results in energy expenditure, which includes sports and a range of recreational, occupational, and household activities.[9] On the other hand, *exercise* is defined as physical activity that is planned, structured, and repetitive whose final or intermediate objective is the improvement or maintenance of physical fitness.[9] It is recommended that all pregnant women without medical or obstetric contraindications participate in regular moderate-intensity exercise during pregnancy.[10-12]

Adverse effects of maternal obesity on perinatal outcomes

Obesity is associated with adverse pregnancy outcomes, such as gestational diabetes mellitus (odds ratio [OR], 3.6),[13] gestational hypertension (OR, 2.5),[14,15] preeclampsia (OR, 2.14),[16] and thromboembolic complications.[17] Obese women have a higher risk of maternal death[18] and are more likely to experience difficulties with labor, to have higher rates of induction (OR, 1.7),[16] cesarean delivery (OR, 2.0),[19] and postterm birth (relative risk, 1.35),[14] and to have a longer hospital stay (OR, 2.7).[19] More than 60% of overweight or obese pregnant women tend to gain weight in excess of recommended guidelines,[20] which leads to interpregnancy weight gain and an increased risk of obesity-related complications in subsequent pregnancies.[21] In addition, obese women tend to experience central adiposity in the postpartum period,[22] which is more detrimental to long-term health.[23,24]

Maternal obesity is also associated with an increased risk of adverse outcomes for the offspring. These include a greater risk of fetal death (OR, 1.4),[16,25] congenital malformations such as neural tube defects (OR, 1.9),[26,27] macrosomia (OR, 1.7),[14,17,28] and being large-for-gestational-age (LGA) at birth (OR, 2.4).[16,29] The offspring of obese mothers have increased perinatal complications such as shoulder dystocia (OR, 2.9), birth injuries (OR, 1.5), and perinatal asphyxia.[26] They are also more likely to be admitted to a neonatal intensive care unit (OR, 1.4)[19] because of complications such as hypoglycemia or respiratory distress.[26]

Of note, *obesity in pregnancy* is defined most commonly as a body mass index of ≥30 kg/m^2,[30] based on maternal prepregnancy weight or the first weight measured at prenatal care. However, there is some variation in the threshold used to define obesity,[16] and some studies cited here also define obesity by weight thresholds in kilograms or pounds.[28] In addition, it is difficult to differentiate the adverse effects of obesity per se from the effects of associated comorbidities such as gestational diabetes mellitus and hypertension.

Importantly, maternal obesity is associated with a higher risk of offspring

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Received Feb. 24, 2014; revised May 8, 2014; accepted June 3, 2014.

Supported by Gravida: National Centre for Growth and Development, University of Auckland, Auckland, New Zealand (grant number 12MP09).

The authors report no conflict of interest.

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0002-9378/$36.00 • © 2015 Elsevier Inc. All rights reserved. • http://dx.doi.org/10.1016/j.ajog.2014.06.009

obesity,[31] which tracks from infancy[32] through to early childhood[33] and beyond.[34] Despite a postulated direct causal link between maternal and offspring obesity,[31,35] the exact mechanisms by which in utero programming of offspring obesity occurs is uncertain.[36] Nonetheless, the in utero milieu of obese mothers differs from that of normal weight mothers[37,38] and is implicated in the postulated "intergenerational obesity cycle,"[35] which suggests that obese mothers provide excess nutrition to their fetus that causes fetal overgrowth/adiposity and increases the propensity to fat mass accrual in childhood and adulthood.[35] Thus, obese mothers tend to have larger babies who are more likely to become obese infants. These obese infants tend to become obese children with obesity tracking into adulthood; in female offspring, this again results in maternal obesity, which perpetuates a cycle of "obesity begetting obesity."[35] In fact, the increase in average birthweight and the higher rate of LGA births that have been seen over the past few decades is attributed to increased rates of maternal obesity and gestational diabetes mellitus.[29,39]

In normal pregnancy, insulin sensitivity in the mother decreases with advancing pregnancy[40] and leads to an increase in maternal catabolism and nutrient transfer to the fetus. The fetus responds to increased nutrient availability by increasing insulin secretion, which in turn stimulates insulin-like growth factors and promotes fetal growth and fat mass accrual.[41,42] Obesity is associated with insulin resistance, and obese pregnant women are more insulin resistant than nonobese pregnant women.[43] Many studies have shown that maternal insulin sensitivity is related inversely to birthweight and neonatal fat mass.[44-47] Maternal obesity and the consequent reduction in insulin sensitivity results in increased nutrient supply to the fetus, which leads to fetal overgrowth and adiposity.[35,45,48] Thus, the offspring of obese mothers have increased neonatal adiposity and are heavier at birth.[49,50] It is of note that increased birthweight is associated with a greater risk of obesity[51-54] and metabolic complications[55] in adult life.

Impact of antenatal exercise on perinatal outcomes

There is expert consensus that antenatal exercise leads to positive effects on maternal health, both during pregnancy and the postpartum period.[56] Large observational studies have shown that exercise is associated with reduced risks of gestational diabetes mellitus,[57] pregnancy-induced hypertension and preeclampsia,[58] and excessive gestational weight gain.[59] Exercise has also been associated with reduced rates of cesarean and instrumental delivery and reduced length of hospital stay for childbirth[60,61]; physical inactivity has been associated with an increased risk of perineal lacerations and vaginal operative delivery.[62] Other potential advantages of antenatal exercise include maintenance and improvement of aerobic capacity,[63,64] which can potentiate quicker return to prepregnancy activity levels after delivery and can help with the loss of weight that was gained during pregnancy.[65]

However, intervention studies have not conclusively demonstrated a positive impact of exercise on maternal outcomes. Several intervention studies have reported that antenatal exercise can improve glucose tolerance,[66] gestational weight gain,[67,68] postpartum weight retention,[69] and maternal perception of health.[70] However, Cochrane systematic reviews have not shown any benefits of antenatal aerobic exercise on gestational diabetes mellitus, preeclampsia, or other risks for the mother or infant.[63,71,72] These reviews state that the data available are insufficient to guide practice and reiterate that larger and better trials are needed to identify the benefits and risks of aerobic exercise in pregnancy.

Of the variables that influence trial outcome, the definition of exercise intensity and type of exercise performed are two of the most relevant. Exercise intensity can be measured in several ways, including percentage of maximal aerobic capacity, percentage of aerobic capacity reserve (the difference between resting and maximal aerobic capacity), percentage of maximum heart rate, percentage of heart rate reserve, and rate of perceived exertion according to the Borg scales.[73] As a result, studies have used various methods to define intensity and volume of exercise, which makes it difficult to interpret results across studies. Similarly, the type of exercise (eg, weight bearing vs nonweight bearing and aerobic vs resistance training) also may impact on outcomes. Therefore, it can be difficult to perform metaanalyses on exercise trials in pregnancy, even when the methods used are robust.

It is noteworthy that most studies have been conducted in normal weight pregnant populations, and the findings cannot be extrapolated directly to obese pregnant women. Recently however, there have been a number of intervention studies,[74-78] systematic reviews,[79-81] and a metaanalysis[82] that have investigated the effects of exercise and other lifestyle modifications on pregnancy outcomes in overweight and obese pregnant women. There is some evidence that suggests that exercise can be helpful in improving fitness[64,75] and glucose tolerance[75,82,83] and limiting weight gain[76-78,81,82] in obese pregnant women. However, not all of these studies have found a positive effect from antenatal exercise.[74] In fact, a systematic review found that, apart from limiting gestational weight gain, the benefits of antenatal exercise in overweight and obese women on maternal and perinatal outcomes remain unproved.[81] Nonetheless, it is important to stress that no negative effects have so far been reported,[81] and more robust, randomized trials that evaluate the effect of antenatal exercise on clinical outcomes in obese women are required.

There has been some concern regarding theoretic risks to the fetus as a result of strenuous antenatal exercise, based on evidence from animal research. These risks include fetal malformations from exercise-induced hyperthermia in early gestation, fetal hypoxia, intrauterine growth retardation from redistribution of maternal blood flow and nutrients from uteroplacental circulation to exercising muscle, and preterm delivery from increased uterine contractility.[84] However, there is no evidence that nonstrenuous antenatal

exercise in healthy well-nourished women adversely affects fetal well-being.[84-86] Numerous studies on maternal exercise during pregnancy over the past 20 years have demonstrated its safety, in particular that moderate-intensity exercise does not cause observable harm to the fetus.[56,63,87-89]

Studies on the effects of antenatal exercise on fetal growth and birthweight have provided conflicting results. Kramer and McDonald,[63] in their Cochrane review, reported that increasing aerobic exercise in pregnancy in sedentary women had no significant effect on mean birthweight (mean difference, 50 g). Nonetheless, the effects of antenatal exercise on fetal growth are confounded by the timing, intensity, and frequency of exercise.[90-93] There are a few studies on nonobese women that have reported that regular moderate/vigorous maternal exercise up to 5 times a week in the latter half of pregnancy can cause a reduction in birthweight that ranges from 150-400 g, which is still within the normal birthweight range.[90,92,94] One of these studies, however, also showed that vigorous exercise >5 times a week caused an increase in low birthweight,[92] which suggests that exercise in pregnancy should be done in moderation. A meta-analysis by Leet and Flick,[93] who considered the timing of maternal exercise during pregnancy, evaluated women who continued to exercise vigorously at least 3 times a week into the third trimester. Their offspring were 200 g lighter at birth than babies of active control subjects who reported low or moderate levels of exercise <3 days per week and 400 g lighter than those of sedentary control subjects.[93] This implies that antenatal exercise in later pregnancy has the potential to alter birthweight. However, a similar reduction in birthweight could have different implications for the offspring of obese mothers who are prone to over-nutrition in utero, compared with offspring of lean mothers.

Because both extremes of birthweight are associated with long-term consequences such as a higher risk of obesity in later life,[41] normalization of birthweight may be beneficial to offspring health. An observational study on nearly 80,000 Danish newborn infants suggested that any form of exercise during pregnancy decreases the risk of both LGA and small-for-gestational-age births.[95] Further, an intervention study on regular supervised light-intensity resistance training in the second and third trimesters of pregnancy showed an attenuation of the effect of maternal weight on offspring birthweight.[96] These studies provide some evidence that antenatal exercise may help prevent extremes of birthweight. Among obese women, exercise combined with nutritional interventions in pregnancy reduced the risk of delivering LGA babies.[76,97] Overall, the potential of moderate-intensity antenatal exercise in pregnancy to improve birthweight and perinatal outcomes in the offspring of obese women needs further investigation by well-designed clinical trials, because current evidence is inadequate.[81]

Antenatal exercise and long-term offspring health

There is growing interest in the potential mitigating effects of lifestyle interventions before or during pregnancy on offspring obesity.[56] Offspring of obese women who are born after maternal weight reduction by bariatric surgery have better outcomes compared with their siblings who are born before maternal weight loss. These include lower risk of LGA birth,[98,99] a 50% reduction in childhood obesity rates, improved insulin sensitivity, more favorable lipid profiles, and lower C-reactive protein (an inflammatory marker) concentrations in childhood.[100,101] Therefore, these studies suggest that amelioration of the maternal obesity status (and consequently the metabolic milieu the fetus is exposed to in utero) can improve offspring outcomes. Regular exercise with or without weight loss also leads to a metabolic improvement, such as an increase in insulin sensitivity[102,103]; evidence of beneficial effects of exercise during pregnancy in obese women is now forthcoming.[75,83] Therefore, one can postulate that the in utero environment can be improved by maternal exercise in pregnancy, which leads in turn to improved offspring outcomes.

As previously discussed, the offspring of obese women are heavier and more likely to become obese later in life. Thus, a modest reduction in birthweight and a reduction in LGA births (without a concomitant increase in small-for-gestational-age births) likely indicates improved long-term outcomes for the offspring.[91] Importantly, there is a dearth of data on the long-term outcomes in offspring in association with exercise during pregnancy. Thus, it is still unclear whether a reduction in excess birthweight because of exercise actually would translate to improved long-term health outcomes for the offspring, particularly regarding obesity rates and insulin resistance in childhood and later life.[56,91] In 1996, Clapp[104] demonstrated that exercise during pregnancy led to a reduction in offspring birthweight and subcutaneous fat mass at birth; more importantly, these changes persisted up to 5 years of age. This appears to be the only published data available on long-term offspring outcomes of exercise in pregnancy to date. There is an urgent need of randomized controlled trials that will examine the effects of exercise during pregnancy, with long-term follow-up evaluation to establish whether maternal exercise can indeed alter obesity risk in the offspring of obese women.

Barriers to exercise during pregnancy

It should be noted that there are obstacles that may hinder implementation of exercise regimes among pregnant women. Women in both developed and developing countries tend to engage in less physical activity during pregnancy.[105,106] Current exercise recommendations for healthy pregnant women, which are similar to those for nonpregnant individuals, advocate ≥30 minutes of moderate-intensity exercise on most (if not all) days of the week.[11] However, fewer women meet daily exercise recommendations during pregnancy compared with the nonpregnant state.[107]

It is important to understand factors and perceptions that lead to the decline

in physical activity levels during pregnancy. There are a number of physiologic changes of pregnancy that can make exercise more difficult and less acceptable to the pregnant women, such as an increased sense of breathlessness, change in center of gravity with alteration of posture and balance, and ligamentous laxity.[108,109] Further, weight gain in pregnancy leads to an increase in the cardiorespiratory effort required to perform a given amount of physical activity.[110] In addition, there are practical reasons to avoid certain contact sports and other forms of exercise that involve an increased likelihood of falling or abdominal trauma, which may harm the fetus.[10,11] Apart from these factors, pregnant women also perceive a number of additional barriers to exercise such as tiredness, low motivation, and lack of enjoyment and report concerns regarding pregnancy complications and fetal harm. There are also a number of external factors that are important, such as lack of childcare, lack of time, overly protective family members, lack of outdoor spaces to be active, and the cost of exercise facilities.[79]

The decline in physical activity in pregnancy appears particularly to be marked among obese women.[111,112] For overweight and obese pregnant women, poor self-image may be an extra hurdle to exercising in public or in groups. One study showed that 45% of pregnant women were dissatisfied with their body size and shape and that these individuals were more likely to gain weight excessively in pregnancy.[113] Another study revealed that, although some obese women view limiting pregnancy weight gain as a motivator for exercising during pregnancy, many women prefer to postpone attempting weight control until after childbirth.[114]

Although most women maintain frequent contact with their healthcare providers during pregnancy, adequate support for antenatal exercise does not appear to be forthcoming from obstetric care. Obese women report that they received limited advice on safe and appropriate forms of antenatal exercise or were advised to be cautious and limit exercise during pregnancy.[115,116] The latter advice, in particular, may stem from outdated medical teaching when women used to be advised to reduce their exercise levels during pregnancy.[10] In addition, they also perceived that the healthcare provider's knowledge on appropriate exercise in pregnancy was limited.[115] Lack of knowledge about

TABLE
Proposed steps for exercise prescription in pregnancies that are complicated by obesity

Step	Notes
1. Contraindication	Exclude contraindications for antenatal exercise.[10,11]
2. Information provision	Discuss potential benefits and risks of antenatal exercise and address any concerns.
	"Recreational exercise and pregnancy"[129] and "PARmed-X for pregnancy"[10] can be useful aids.
3. Personalized goals	It is important to personalize goals to maximize engagement.[121]
	Decide on an exercise regime compatible with the patient's lifestyle and liking.
4. Timing of exercise initiation	If previously sedentary, the second trimester seems to be the best time to commence an exercise program, once morning sickness has abated.[10]
5. Type of exercise	Recommend low-impact aerobic exercises (brisk walking, stationary cycling, swimming, and water aerobics).
	Avoid activities that involve a risk of loss of balance, falls, or abdominal trauma.
	Avoid the supine position after 16 weeks of pregnancy.[10,11]
6. Intensity of exercise	Avoid vigorous exercise.
	If already active, maintain moderate-intensity activities; if sedentary, start at low intensity and gradually increase to moderate intensity.
	Use validated heart rate ranges for overweight and obese pregnant women[124]:
	Low intensity: 102-124 beats/min (20-29 years of age); 101-120 beats/min (30-39 years of age)
	Moderate intensity: 125-147 beats/min (20-29 years of age); 121-142 beats/min (30-39 years of age)
	If heart rate cannot be monitored, the "talk test" can be utilized to ensure that exercise does not exceed moderate intensity; as the "talk test" implies, the woman is exercising at a comfortable intensity if she is able to maintain a conversation during exercise.[10]
7. Duration of exercise	If previously sedentary, start with 15 minutes of moderate-intensity exercise and increase in 5-minute increments up to 30 minutes.[10]
	Include low-intensity warm-up and cool-down periods.[10,11]
8. Frequency of exercise	If previously sedentary, start at 3 sessions per week on nonconsecutive days and increase up to ≥4 sessions per week.[10,11]

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TABLE
Proposed steps for exercise prescription in pregnancies that are complicated by obesity *(continued)*

Step	Notes
9. Behavioral change	Use behavioral changing techniques[121,122]:
	Goal setting and planning: identify appropriate activities and set weekly/monthly exercise targets.
	Self-monitoring: use an exercise diary or a heart rate monitor.
	Feedback: inquire about exercise at each antenatal visit, address any new concerns, and continuously encourage patient.

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appropriate exercise, conflicting advice, and lack of access to correct information, support, and advice on exercise during pregnancy[79,114,115] are all important modifiable factors that must be addressed.

Improving exercise in pregnancy that is complicated by obesity

Pregnancy can be a powerful incentive to establish healthy lifestyle changes in obese women.[117] In the general population, a more proactive approach by clinicians in promoting exercise is advocated; merely inquiring how much a patient is exercising can be a good starting point.[118,119] Maternity healthcare providers similarly can encourage obese pregnant women to exercise during pregnancy with appropriate advice during initial antenatal care visits and using subsequent clinical visits for ongoing reinforcement. As a result, we propose a series of steps for the prescription of exercise in pregnancies that are complicated by obesity (Table).

Before women are advised to exercise during pregnancy, it is important that contraindications to antenatal exercise are excluded. There are many absolute contraindications to antenatal exercise that include ruptured membranes, risk of preterm labor, hypertensive disorders of pregnancy, incompetent cervix, growth-restricted fetus, high-order multiple gestation (≥triplets), placenta previa after the second trimester, persistent second or third trimester bleeding, uncontrolled type I diabetes mellitus, thyroid disease, and other serious cardiovascular, respiratory, or systemic disorders.[10,11] It is also important that women receive adequate guidance on suitable types of antenatal exercise and exercise intensity, frequency, and duration.[120] Brisk walking, stationary cycling, swimming, and aqua aerobics cause less strain on ligaments and joints and are preferable to high-impact exercises such as jogging and running during pregnancy.[10] In overweight and obese women especially, non−weight-bearing exercises such as aqua aerobics and stationary cycling are likely to be more appropriate as pregnancy advances.

It is important to encourage regular monitoring of exercise with self-reported measures combined with low-cost objective measures of physical activity whenever possible.[121,122] Heart rate monitors are useful tools to monitor compliance with prescribed exercise and to ensure that women exercise at appropriate intensity.[123] Validated target heart-rate zones for exercise in overweight and obese pregnant women have been developed recently[124] (Table), and detailed guidelines specific to this group of women are now available.[120,125] It is also important to consider the prepregnancy activity level and modify the exercise prescription accordingly (Table).

However, more research is needed to establish the best methods of encouraging and sustaining exercise in pregnancy, especially in obese women. Two recent systematic reviews on behavioral interventions for improving physical activity in pregnant women provide some insight.[121,122] The review by Currie et al[121] concluded that, although no specific technique can be recommended, healthcare professionals can help pregnant women to stay active by providing information on the importance of physical activity, discussing appropriate forms of exercise, emphasizing personal goals, and planning during face-to-face encounters. Pearce et al[122] concluded that little is known about the efficacy of interventions for physical activity during pregnancy and emphasize the need for more research in this area. Further, understanding the attitudes and cultural acceptability of exercise among pregnant women from diverse backgrounds is also important.[126] Moreover, the community applicability and cost-effectiveness of providing opportunities for exercise must be ascertained.[127,128] Considering the increasing number of obese women entering pregnancy and the health consequences for mother and baby, adequate education and support for exercise in pregnancy appears to be a timely need.

Conclusion

Despite limited evidence, regular exercise in pregnancy that is complicated by obesity seems to benefit both mother and offspring. Unfortunately, low prepregnancy physical activity levels and numerous social and physical limitations appear to prevent obese women from achieving recommended levels of exercise during pregnancy. Lack of information, motivation, and support are modifiable barriers to exercise in pregnancy that can be addressed by the incorporation of regular advice and guidance by clinicians on safety, benefits, and appropriate exercise prescriptions for obese pregnant women into maternity care. The cost-effectiveness of such measures should take into consideration the short- and potential long-term health benefits of exercise during pregnancy not only for obese women but also for their offspring and future generations.[31] An ongoing clinical trial will hopefully provide valuable evidence

to clarify the short-term risks and benefits of exercise in such pregnancies, and future studies are needed to evaluate long-term outcomes.[123]

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