

Why can't I exercise during pregnancy? Time to revisit medical 'absolute' and 'relative' contraindications: systematic review of evidence of harm and a call to action

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ABSTRACT

Background Clinical guidelines recommend pregnant women without contraindication engage in regular physical activity. This is based on extensive evidence demonstrating the safety and benefits of prenatal exercise. However, certain medical conditions or contraindications warrant a reduction, modification or cessation of activity due to potential health risks.

Aim To review and evaluate the evidence related to medical disorders which may warrant contraindication to prenatal exercise.

Methods Online databases were searched up to 5 April 2019. Forty-four unique studies that reported data on our Population (pregnant women with contraindication to exercise), Intervention (subjective/objective measures of acute or chronic exercise), Comparator (not essential) and Outcomes (adverse maternal or fetal outcomes) were included in the review.

Key findings We found that the majority of medical conditions listed as contraindications were based on expert opinion; there is minimal empirical evidence to demonstrate harm of exercise and benefit of activity restriction. We identified 11 complications (eg, gestational hypertension, twin pregnancy) previously classified as contraindications where women may in fact benefit from regular prenatal physical activity with or without modifications. However, the evidence suggests that severe cardiorespiratory disease, placental abruption, vasa previa, uncontrolled type 1 diabetes, intrauterine growth restriction, active preterm labour, severe pre-eclampsia and cervical insufficiency are associated with strong potential for maternal/fetal harm and warrant classification as absolute contraindications.

Conclusion Based on empirical evidence, we provide a call to re-evaluate clinical guidelines related to medical disorders that have previously been considered contraindications to prenatal exercise. Removing barriers to physical activity during pregnancy for women with certain medical conditions may in fact be beneficial for maternal–fetal health outcomes.

INTRODUCTION

Prenatal exercise guidelines around the world recommend that women without contraindication engage in regular physical activity throughout pregnancy.^{1–14} These recommendations are based on an extensive body of literature that supports the safety and benefits of prenatal exercise. We have recently demonstrated that regular exercise during pregnancy was associated with a ~40%

reduction in the odds of developing major pregnancy complications such as pre-eclampsia, gestational hypertension and gestational diabetes,¹⁵ a reduction in maternal depressive symptoms¹⁶ and a decreased odds of delivering a macrosomic infant (birth weight >4000g).¹⁷ Critically, these benefits occur without increasing the risk of having a small baby, preterm birth or a miscarriage.¹⁸ Despite these known benefits of physical activity on maternal and fetal health, there remains a subset of women who are advised against exercise due to a variety of pre-existing or pregnancy-specific conditions, known as contraindications.

Physical activity is a spectrum of movement behaviours including moderate to vigorous physical activity (MVPA; for example, exercise), light activities (eg, gentle walking and activities of daily living) and sedentary behaviours (eg, sitting/screen time). Traditionally, women who developed contraindications during pregnancy were prescribed a severe form of sedentary behaviour, known as bed-rest. However, data from comprehensive meta-analyses have shown no benefit of bed-rest on pregnancy outcomes^{19,20} and an increased risk of preterm birth when prescribed to women in developed countries.²¹ Despite the lack of efficacy and severe health risks of this practice, up to 87% of physicians in North America still prescribe bed-rest for high-risk pregnant women for lack of a better therapeutic option.^{22,23} Of particular concern, the majority of physicians prescribing bed-rest to pregnant women do not provide any recommendations of rehabilitative exercise,²² which may alleviate some of the negative side effects of activity restriction.

Most guidelines for prenatal exercise include contraindications with various categorisations (table 1); yet for many contraindications, there is no evidence demonstrating that doctors banning exercise in these women improves pregnancy outcomes. Most contraindications are based on expert opinion and may be outdated in light of new empirical evidence on the wide-ranging benefits of prenatal exercise. The aim of this review is to examine the impact of acute and chronic prenatal exercise in women with contraindications to identify potential benefits or risks to maternal/fetal health. Based on available literature, we propose new classifications for absolute and relative contraindications and provide a call to action for inclusion of these women in future research and guidelines, removing barriers to physical activity in these groups of women where appropriate.



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Table 1 Absolute and relative contraindications to prenatal exercise in guidelines from around the world

Contraindication	SOGC/CSEP ¹⁻³	IOC ⁷	ACOG ⁵	SMA ⁵
Absolute				
Cardiovascular disorders				
Serious cardiovascular disorder	X	Haemodynamically significant	Haemodynamically significant	
Chronic hypertension, uncontrolled	X	X		
Hypertensive disorders of pregnancy				
Gestational hypertension		X	X	
Pre-eclampsia	X	X	X	
Respiratory disorders				
Serious respiratory disorders	X			
Restrictive lung disease		X	X	
Pregnancy-specific disorders				
IUGR	X	X		Growth-restricted fetus
Multiple pregnancies	High order (≥3)	Risk of PTL	Risk of PTL	High order (≥3)
Persistent vaginal bleeding	X	T2 or T3	T2 or T3	
Placenta previa	After 28 weeks	After 26 weeks	After 26 weeks	After 28 weeks
PPROMs	X	X	X	X
Preterm labour (including premature contractions)	X	X	X	Signs of
Cerclage		X	X	
Incompetent cervix	X		X	X
Cervical insufficiency		X		
Other disorders				
Anaemia (severe)		X	X	
Systemic disorder	X			
Thyroid disease, uncontrolled	X			
Type 1 diabetes, poorly controlled	X			
Relative				
Cardiovascular disorders				
Cardiac arrhythmia, unevaluated		X	X	
Cardiovascular disorders, mild/moderate	X			X
Chronic hypertension, uncontrolled			X	Hypertension (all)
Gestational hypertension	X			
Respiratory disorders				
Mild/moderate respiratory disorders	X	X		X
Chronic bronchitis		X	X	
Smoking, heavy (>20 cigarettes/day)			Heavy smoker (all quantities)	
Pregnancy-specific disorders				
IUGR		History of	X	In current pregnancy
History of premature birth	X	X		X
Recurrent pregnancy loss	X	History of		
Previous spontaneous abortion		History of		X
Twin pregnancies >28 weeks	X			X
Cervical enlargement		X		
Other disorders				
Epilepsy, poorly controlled		Seizure disorder	Seizure disorder	
Thyroid disease, uncontrolled			Hyperthyroidism	Hyperthyroidism
Type 1 diabetes, poorly controlled		X	X	X
Orthopaedic limitations		X	X	
Other significant medical conditions	X			X
Anaemia	Symptomatic		X	Hb <100 g/L
Eating disorder	X	Extreme underweight	BMI <12 kg/m ²	X
Malnutrition	X	Extreme underweight	BMI <12 kg/m ²	X
Obesity			BMI >40 kg/m ²	BMI >30 kg/m ²
History of extremely sedentary lifestyle			X	

Adapted from Evenson *et al* (2014).¹³⁵Guidance from the UK Chief Medical Officer states that exercise should be recommended to women with uncomplicated pregnancies.⁴ However, women with obstetric or medical complications may perform moderate intensity physical activity during pregnancy but should receive additional monitoring and/or specialist support.¹³⁶

ACOG, American College of Obstetricians and Gynecologists; BMI, body mass index; CSEP, Canadian Society for Exercise Physiology; Hb, haemoglobin; IUGR, intrauterine growth restriction; PPRoMs, preterm premature rupture of membrane; PTL, preterm labour; SMA, Sports Medicine Australia; SOGC, Society of Obstetricians and Gynaecologists of Canada; T2, second trimester; T3, third trimester.

We systematically searched the literature for studies on physical activity in women with contraindications (see online supplementary material for search strategy) and provide evidence to support or refute the inclusion of these conditions as relative or absolute contraindications in future guidelines. Absolute contraindications are medical conditions in which women are discouraged from engaging in any MVPA, whereas relative contraindications warrant discussion between the pregnant woman and her obstetric healthcare professional about potential risks and benefits of prenatal exercise. Additionally, we considered each contraindication in relation to risks of adverse maternal and neonatal health outcomes (online supplementary table 1). Our recommendations are summarised below, with detailed supplementary information supporting each recommendation in the online supplementary material.

METHODS

Detailed methods are included in the online supplementary material. The PICOS (Population, Intervention, Comparison, Outcome and Study design) framework was used to guide this review.²⁴ The population of interest was pregnant women with absolute or relative contraindications to exercise as defined by previous guidelines (table 1). The intervention/exposure of interest was subjective or objective measures of frequency, intensity, duration, volume or type of prenatal exercise. Acute (ie, a single exercise session) or habitual (ie, usual activity) prenatal exercise was considered. No comparators were required for inclusion in this review and relevant outcomes were any reports related to maternal/neonatal morbidity or mortality. Primary studies of any design were eligible, including case studies. A comprehensive search was created and run (see online supplementary material for complete search strategies) and study screening and selection were managed using Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia).

RESULTS

Overall, 44 unique studies were included in the review (online supplementary figure 1). Additional details about the studies can be found in the online supplementary table 2. A narrative synthesis of results is presented for each contraindication with more details included in the online supplement.

Absolute contraindications

Women with absolute contraindications are discouraged from engaging in MVPA; however, activities of daily living should be continued. We identified the following conditions where engaging in regular MVPA has a strong potential for adverse effects for the mother and/or fetus:

- ▶ Severe respiratory diseases (eg, chronic obstructive pulmonary disease, restrictive lung disease and cystic fibrosis).
- ▶ Severe acquired or congenital heart disease with exercise intolerance.
- ▶ Uncontrolled or severe arrhythmia.
- ▶ Placental abruption.
- ▶ Vasa previa.
- ▶ Uncontrolled type 1 diabetes.
- ▶ Intrauterine growth restriction (IUGR).
- ▶ Active preterm labour.
- ▶ Severe pre-eclampsia.
- ▶ Cervical insufficiency.

Severe respiratory disorders

Individuals with respiratory disorders, including chronic obstructive pulmonary disease, restrictive lung disease, cystic fibrosis and asthma, experience symptoms of dyspnoea, chronic coughing and chest tightness that can be worsened with exertion. The severity of the disease is quantified using a range of diagnostic criteria that considers symptoms, pathophysiology and how advanced the disorder is.

There is a paucity of data regarding the benefits and risks of prenatal physical activity in women with mild–moderate or severe respiratory disorders. In a series of case reports of pregnant women with severe restrictive lung disease, low-intensity walking exercise led to a fall in oxygen saturation of 5%–50%.²⁵ Reduced maternal arterial oxygen content as a result of prenatal exercise may decrease oxygen delivery to the fetoplacental unit and elevate the risk for fetal hypoxia. Given this significant risk to fetal well-being, we believe severe respiratory disorders should remain an absolute contraindication to prenatal exercise. Future experimental research is required to examine whether different modalities of exercise that do not exacerbate symptoms, such as resistance training or yoga, may be safe alternatives for these populations. During such studies, maternal oxygen saturation and fetal well-being should be monitored and appropriate safety measures (eg, supplemental oxygen, walkers, pharmacological interventions like bronchodilators) are strongly recommended.

Women with mild–moderate respiratory disorders prior to pregnancy have more favourable pregnancy outcomes than those with severe disease.²⁶ As such, these women face less risk and greater health benefits of prenatal physical activity. In general, pregnant women with well-controlled (ie, regular use of bronchodilators and inhaled corticosteroids) mild–moderate respiratory disorders tolerate prenatal exercise well. In fact, one study including pregnant women with bronchitis found that regular supervised exercise reduced the incidence of respiratory illness (either new onset or exacerbations) when compared with no exercise.²⁷ In light of these potential benefits and limited risk of harm, women with well-controlled, mild–moderate respiratory diseases who are asymptomatic should be encouraged to maintain MVPA during pregnancy without any restriction. Women with mild–moderate respiratory disease who experience exacerbations or symptoms of exercise intolerance (undue shortness of breath) should reduce the intensity of exercise, but remain physically active (see table 2).

Severe congenital or acquired heart disease

Heart disease (HD) is a term used to encompass a variety of congenital and acquired cardiac disorders including, but not limited to, stenotic or regurgitant valvular lesions, repaired or unrepaired septal defects, operated coarctation of the aorta, healed myocarditis and arrhythmia. Patients with HD are categorised according to their symptoms using the New York Heart Association (NYHA) functional classification system (Class I—no limitation of physical activity to Class IV—symptoms of dyspnoea and/or chest pain at rest).²⁸ Patients with HD are encouraged to engage in regular MVPA to improve health and well-being²⁹; however, these recommendations do not specifically cover pregnant women with HD.

Pregnant women with congenital or acquired HD with exercise tolerance (ie, NYHA functional class I to II) have markedly reduced cardiac responses to exercise compared with pregnant women without HD.^{30–31} However, women with NYHA functional class I or II HD are able to exercise beneath their threshold of exacerbated symptoms and can receive many health

Table 2 Specific classifications of pre-existing contraindications to prenatal physical activity

	Absolute contraindication	Relative contraindication	Potential modifications
	Avoid MVPA, but maintain activities of daily living	Could be recommended MVPA, with or without modifications, and should maintain activities of daily living	
Respiratory disorders			
COPD	Severe: GOLD 3 or 4		Remain physically active below threshold of intolerance
Asthma	Severe: FEV ₁ <60%, daily oral corticosteroid use Symptomatic		Remain physically active below threshold of intolerance
Cystic fibrosis	Severe: FEV ₁ <50% Clinically unstable Worsening disease status Presence of <i>Burkholderia cepacia</i> or MRSA		Remain physically active below threshold of intolerance
Restrictive lung disease	Severe: FEV ₁ <60%		Remain physically active below threshold of intolerance
Type 1 diabetes	Uncontrolled: Unpredictable or frequent hypoglycaemia Presence of comorbidities: Uteroplacental insufficiency Fetal growth restriction Hypertensive disorders Chronic renal disease	Well controlled	Use of continuous glucose monitor and/or insulin pump to improve glycaemic control. Educated about precautionary measures to avoid postexercise and nocturnal hypoglycaemia
Congenital heart disease	Severe: NYHA functional class III or IV	Mild–moderate: NYHA I or II	Exercise below threshold of intolerance
Arrhythmia	Symptomatic or severe: Symptoms including (pre)syncope, onset of ventricular premature beats, exertional fatigue Severe conditions, for example, ventricular tachycardia, implantable defibrillators Contraindicated from exercise prior to pregnancy		Low–moderate intensity activity
Smoking		Moderate–heavy (≥20 cigarettes per day) with comorbidities: IUGR Hypertensive disorders	
Eating disorders		Symptomatic: Inadequate GWG Exhibiting restrictive or compensatory behaviours Reduced fetal growth	Prescribe low-intensity activity within current recommendations (ie, 150 min/week)

COPD, chronic obstructive pulmonary disease; FEV₁, forced expiratory volume; GOLD, Global Initiative for Chronic Obstructive Lung Disease; GWG, gestational weight gain; IUGR, intrauterine growth restriction; MRSA, Methicillin-resistant *Staphylococcus aureus*; MVPA, moderate to vigorous physical activity; NYHA, New York Heart Association.

benefits from doing so. These women should remain physically active within their tolerance levels, but taper exercise intensity (if needed) as pregnancy progresses.^{30,31} In contrast, women with more severe forms of HD (ie, NYHA class III to IV) have diminished exercise capacity and exercise intolerance in their non-pregnant state. In the rare cases of pregnancy in women with NYHA functional class III to IV HD, exercise intolerance is more severe (eg, oxygen desaturation, syncope, reduced uteroplacental blood flow, worsening of symptoms and/or symptomatic arrhythmia) and associated with greater risks.^{30,32} Women with severe HD should therefore avoid prenatal exercise but should continue activities of daily living.

Exercise tolerance of women with HD may be determined through cardiopulmonary exercise testing completed prior to or early during pregnancy. The results from this test could be used to oppose or recommend prenatal physical activity in these women. However, for those women who tolerate physical activity well (NYHA I or II), an exercise test may not be medically indicated, but if conducted the results of could also be used to prescribe exercise. Additionally, the results from exercise testing in women with HD have some predictive value regarding pregnancy outcomes,^{33,34} and as such,³⁵ American College

of Obstetricians and Gynecologists and the Task Force on the Management of Cardiovascular Diseases during Pregnancy recommends this practice.³⁶

Non-pregnant individuals with arrhythmias face greater risks during physical activity as a result of exercise-induced changes in autonomic tone, which could lead to ventricular arrhythmias.²⁹ Individuals with severe or uncontrolled arrhythmias are encouraged to participate in activities with low cardiovascular demand (ie, low intensity).^{37,38} The majority of pregnant women with arrhythmias are treated and well-controlled, and especially if exercising prior to pregnancy should be supported to engage in MVPA. In contrast, women with untreated, symptomatic or severe arrhythmias and who were contraindicated from exercise prior to pregnancy should not participate in prenatal exercise but maintain activities of daily living (see table 2).

Placental abruption

Placental abruption describes the partial or complete separation of the implanted placenta from the uterus that results in maternal bleeding and/or pain. Larger placental abruptions can cause uteroplacental insufficiency, ischaemia, chronic hypoxaemia

and/or fetal death.³⁹ When placental abruption is diagnosed during pregnancy, women should stop MVPA due to the high risks to both maternal and neonatal health.⁴⁰

Strenuous physical exercise has previously been suggested to increase the risk of placental abruption. The immediate risk of placental abruption was 7.8-fold higher in the hour following MVPA compared with periods of lower activity or rest, and this was greater following heavy intensity exercise.⁴¹ However, in this cohort of 663 women, only 54% of the total population engaged in any MVPA in the week preceding placental abruption, and consequently, it is not clear as to whether avoiding exercise would only delay (not prevent) the inevitable outcome of placental abruption.^{41–42} To the contrary, the risk of placental abruption is lower among women who are habitually active compared with those who are sedentary.⁴¹ Women who have risk factors that are associated with placental abruption should be encouraged to maintain MVPA throughout gestation.

Vasa previa

Vasa previa describes a complication in which a fetal blood vessel, unprotected by the umbilical cord or placenta, runs through the amniotic membranes and traverses the cervix.^{43–44} Unrecognised, vasa previa is associated with significant risks of stillbirth as fetal haemorrhage can occur rapidly should membranes rupture prematurely. Women diagnosed with vasa previa during pregnancy are managed through activity restriction and/or hospitalisation to allow close surveillance for signs of labour. The potential risks of vasa previa to fetal health drastically outweigh any benefits of MVPA, and therefore women should be prevented from engaging with prenatal exercise.

Uncontrolled type 1 diabetes mellitus

Women with type 1 diabetes who have poorly controlled blood glucose levels prior to and during pregnancy are at greater risk of adverse maternal and fetal outcomes when compared with women with well-controlled type 1 diabetes.⁴⁵ In non-pregnant individuals diagnosed with type 1 diabetes, physical activity is encouraged to aid glycaemic control and improve overall health and well-being.⁴⁶ As such, prenatal exercise could improve glycaemic control in pregnant women with type 1 diabetes and lead to more favourable pregnancy outcomes.

Previous reports of prenatal physical activity in pregnant women with type 1 diabetes provide somewhat conflicting evidence of health benefits. Critically, the risk of daytime and nocturnal hypoglycaemia appears to be low following exercise in women with well-controlled blood glucose.^{47–48} Pregnant women with well-controlled type 1 diabetes can engage with current MVPA recommendations, but additional measures to mitigate risk should be used. Women should consider the use of a continuous glucose monitor and/or an insulin pump to improve monitoring and control of blood glucose, and women should be well-informed of measures that can reduce the risk of postexercise and nocturnal hypoglycaemia.⁴⁶ In contrast, pregnant women with type 1 diabetes who have unpredictable or frequent hypoglycaemia and/or have comorbidities (such as uteroplacental insufficiency, hypertension or chronic renal disease) should complete activities of daily living, but avoid prenatal exercise (see [table 2](#)).

Intrauterine growth restriction

Impaired fetal growth is a marker of poor placenta function and hypoxaemia. While prenatal exercise does not increase the risk of IUGR, maternal exercise could have negative impacts on

fetal well-being in a pregnancy complicated with uteroplacental insufficiency. In women diagnosed with IUGR, prenatal exercise may lead to reduced blood flow to the fetoplacental unit and fetal hypoxia, further raising the risk of adverse outcomes in this population. However, recommending that women with IUGR restrict all physical activity (ie, bed-rest) is not beneficial to fetal growth or pregnancy outcomes.⁴⁹

At present, there are some data demonstrating the acute effects of prenatal exercise in women with IUGR. Previous studies have shown transient increases in umbilical artery pulsatility index, fetal bradycardia and absent end-diastolic flow in the umbilical artery immediately following exercise in women with IUGR (less than 10th percentile estimated fetal weight); however, these deficits recovered within 20–30 s after stopping exercise.^{50–51} Another study did not identify differences in fetoplacental outcomes following exercise in women with IUGR (estimated fetal weight 1.5 SD below mean weight).⁵² In contrast, exercise in women with IUGR (less than fifth percentile estimated fetal weight) increased umbilical artery resistance and negatively impacted indices of fetal well-being (increased fetal aortic and cerebral artery resistance index).⁵³ These adverse responses to exercise, although transient, may predict those fetuses who consequently develop more severe pathophysiology.⁵⁴

The prevailing literature, although limited, indicates that acute exercise in women with IUGR results in decreased fetal well-being. The risks of MVPA therefore outweigh the benefits in this population, and women with IUGR should be encouraged to avoid exercise, but to maintain activities of daily living.

Active preterm labour

Preterm birth, defined as delivery before 37 weeks of pregnancy, may be the result of spontaneous labour, premature rupture of membranes or induced labour/delivery due to concerns for maternal or fetal health.⁵⁵ Prenatal exercise is not recommended for women who are in active preterm labour.

Many women, especially in the third trimester, experience uterine activity (Braxton-Hicks contractions), which may become more intense or frequent with MVPA.^{56–58} In contrast to preterm labour, Braxton-Hicks contractions subside with rest, are irregular in their timing and are generally uncomfortable but not painful. Pregnant women who experience regular and painful uterine contractions should cease exercise and seek advice from a healthcare provider.^{1–3}

Severe pre-eclampsia

Pre-eclampsia is the development of hypertension with proteinuria, maternal organ dysfunction and/or uteroplacental dysfunction.^{59–60} Pre-eclampsia has more significant consequences to maternal and fetal health when diagnosed at an earlier gestational age and/or with increasing symptoms such as abnormal liver enzymes or thrombocytopenia.^{60–61} Women with severe pre-eclampsia, eclampsia or HELLP (haemolysis, elevated liver enzymes, low platelet count) syndrome require immediate delivery and should not engage in strenuous physical activity, whereas women with milder forms of the disease may be managed until delivery is indicated. The Canadian Hypertensive Disorders of Pregnancy Working Group has stated that strict bed-rest in women who are hospitalised with pre-eclampsia is not recommended.⁶² This shift in management of mild pre-eclampsia necessitates us to consider the effects of physical activity in these women.

Previous research has shown that acute prenatal exercise in women diagnosed with mild pre-eclampsia did not cause

adverse changes in blood pressure, uterine contractions, vaginal bleeding,⁶³ uterine blood flow or fetal heart rate,^{64 65} and in fact reduced diastolic blood pressure postexercise.⁶⁶ However, in women with both pre-eclampsia and IUGR (ie, severe pre-eclampsia), transient adverse responses to prenatal exercise, such as a reduction in placental blood flow were observed.^{64 65}

The accumulating evidence shows that prenatal exercise in women with mild pre-eclampsia offers maternal and fetal health benefits, without increased risk of harm, assuming there has been normal fetal growth. Mild pre-eclampsia should therefore be downgraded to a relative contraindication to exercise, and, in line with the Canadian Hypertensive Disorders of Pregnancy Working Group recommendations, bed-rest or activity restriction should be avoided in these women. Women with mild pre-eclampsia (without concurrent conditions that are absolute contraindications to prenatal exercise) should be encouraged to maintain light physical activity (such as walking, bodyweight exercises or stretching) within current recommendations. In line with previous prenatal physical activity guidelines, women with severe pre-eclampsia should avoid MVPA, but maintain activities of daily living prior to their likely imminent delivery.

Cervical insufficiency

Cervical insufficiency describes a structural and functional deficit of the cervix that is typically characterised by premature, painless cervical dilation occurring alongside one or more mid-second trimester pregnancy losses without evidence of preterm labour, chorioamnionitis or fetal chromosomal abnormalities.⁶⁷ Cervical dilation can lead to pre-viable delivery and as such, presents significant risks to fetal health. Women with cervical insufficiency should be advised to maintain activities of daily living, and potentially, to complete light upper-body resistance exercise, but avoid MVPA. These recommendations also apply to women with a prophylactic or rescue cervical cerclage in place.

Relative contraindications

Relative contraindications are conditions that warrant discussion between a pregnant woman and her obstetric healthcare professional about the potential risks and benefits of exercising during pregnancy. Our systematic review identified a number of conditions where this discussion is encouraged. Based on available evidence, we recommend modification of activities (reduction in intensity, duration or volume; exercise adaptation) be considered over an order that the woman should avoid exercise completely. It is our opinion that the following 10 conditions should be considered as relative contraindications to prenatal exercise:

- ▶ Mild respiratory disorders (discussed previously).
- ▶ Mild congenital or acquired HD (discussed previously).
- ▶ Well-controlled type 1 diabetes (discussed previously).
- ▶ Mild pre-eclampsia (discussed previously).
- ▶ Preterm premature rupture of membranes (PPROMs).
- ▶ Placenta previa after 28 weeks.
- ▶ Untreated thyroid disease.
- ▶ Symptomatic, severe eating disorder.
- ▶ Multiple nutrient deficiencies and/or chronic undernutrition.
- ▶ Moderate–heavy smoking (>20 cigarettes per day) in the presence of comorbidities.

Preterm premature rupture of membranes

PPROMs, defined as spontaneous rupture of the membranes before 37 weeks' gestation, occurs in 3% of all pregnancies.^{55 68} Women who experience PPRMs are typically admitted

to hospital to undergo expectant management,⁶⁹ as the majority of women will deliver within 7 days following rupture. Previously, women were recommended to restrict physical activity on the basis that it might promote amniotic fluid accrual and thereby prolong latency.⁶⁸ However, a randomised controlled trial of physical activity compared with bed-rest in pregnant women with PPRMs found no differences in amniotic fluid index, latency or maternal and neonatal outcomes between groups.⁶⁸ Further, an observational study of women with confirmed PPRMs demonstrated a significantly longer latency in women with low-intensity physical activity (walking; ≥ 500 steps per day) compared with those with lower activity (<500 steps per day). Again, no adverse maternal or fetal outcomes were identified with increasing activity levels.⁷⁰ It is therefore our recommendation that women diagnosed with PPRMs may engage in low-intensity physical activity and maintain activities of daily living until delivery (after full clinical evaluation and without other absolute contraindications).

Placenta previa after 28 weeks' gestation

Placenta previa is diagnosed in the third trimester when the placenta overlies the internal cervical os. Placenta previa is common in the first half of pregnancy (identified in 42.3% of women at 11–14 weeks and 3.9% of women at 20–24 weeks)⁷¹ and commonly resolves by 28 weeks; however, 0.4% of all pregnancies are diagnosed with placenta previa in the third trimester.

Placenta previa presents significant risks to both maternal and fetal health through uncontrolled vaginal bleeding.⁷² However, not all women with placenta previa experience vaginal bleeding, and those women should continue to participate in MVPA until 28 weeks' gestation. At this gestational age, women should be re-evaluated for the presence of placenta previa. If the placenta previa is resolved, women should continue to exercise within current guidelines. However, women diagnosed with placenta previa after 28 weeks' gestation are at risk for spontaneous labour and should avoid MVPA. However, these women should maintain their activities of daily living and low-intensity activity (ie, walking).

Untreated thyroid disease

Untreated thyroid disease is associated with symptoms such as chronic fatigue, exercise intolerance, muscle dysfunction and impairments in heart rate kinetics.^{73 74} Individuals with untreated hyperthyroidism may experience tachycardia and an elevated myocardial workload at rest, whereas individuals with untreated hypothyroidism will have bradycardia and diminished cardiac responsiveness. As such, untreated thyroid disease leads to impaired maternal cardiac and metabolic function that could reduce oxygen and nutrient delivery to the fetoplacental unit. Pregnant women with untreated thyroid disease should refrain from MVPA until symptoms are rectified with appropriate clinical management. These risks are not apparent for women with treated thyroid disease, and as such, these women should maintain MVPA and activities of daily living without special precautions.

Eating disorders

Severe cases of anorexia nervosa and/or bulimia nervosa have the potential to lead to caloric and nutrient deficiencies in utero that impair fetal, infant and child development.^{75 76} The majority of women with current eating disorders are able to reduce their restrictive or compensatory eating behaviours during pregnancy.

Although perinatal complications in this population remain, the relative risk compared with the general population is low.⁷⁷

Prenatal physical activity, in moderation, may offer general health benefits for women with asymptomatic eating disorders, providing that no relapse occurs during gestation. Recent meta-analyses have shown that regular prenatal physical activity in otherwise healthy women reduces the severity of prenatal depressive symptoms and the odds of prenatal depression by 67%.¹⁶ Therefore, maintaining regular prenatal activity may alleviate or manage psychological factors that may trigger symptoms of an eating disorder. Women with asymptomatic eating disorders (appropriate gestational weight gain (GWG), no restrictive or compensatory behaviours and appropriate fetal growth) should therefore be encouraged to engage in prenatal physical activity within current recommendations.

In rare cases of women with severe symptomatic eating disorders, as indicated by fetal growth restriction, inadequate GWG and restrictive/compensatory behaviours, MVPA should be closely monitored across gestation. Extreme symptoms, such as excessive exercise to control weight and/or to counter binge eating, could result in further caloric restriction and thus negatively impact fetal development.^{78,79} Pregnant women with symptomatic eating disorders should avoid MVPA but could engage in low-intensity activity up to duration detailed in current guidelines provided they have regular monitoring from their health-care provider (see table 2).

Undernutrition

In previous guidelines, ‘malnutrition’ was considered a relative contraindication to prenatal exercise; however, this is an umbrella term that encompasses overnutrition, undernutrition and nutrient deficiencies. There is significant evidence demonstrating the safety and efficacy of prenatal exercise in women with overnutrition (those categorised as overweight and obese), as well as in women with isolated nutrient deficiencies (eg, anaemia). Therefore, we recommend that undernutrition should be considered a relative contraindication to prenatal exercise but not ‘malnutrition’.

Women suffering from multiple nutrient deficiencies or chronic undernutrition are at higher risk for complications and therefore require nutritional intervention.⁸⁰ In situations where undernourished women (without other health complications) are able to make dietary adjustments or take supplements to receive adequate nutrients, prenatal physical activity should be encouraged. However, in reality, improving nutritional status for undernourished women may not be possible without external support and improvements in food access and availability.

Smoking

One of the most prominent negative effects of maternal smoking is fetal growth restriction.^{81,82} Maternal cigarette smoking results in increased fetal carboxyhaemoglobin which reduces oxygen transport and delivery to fetoplacental tissues that can cause chronic carbon monoxide poisoning.⁸³ Simultaneously, nicotine-induced vasoconstriction reduces uteroplacental blood flow.⁸⁴ Together, these can lead to fetal hypoxia that will result in delayed short-term and long-term growth and development.^{85–87} Smoking at any point during pregnancy decreases birth weight by approximately 10–12 g per cigarette/day⁸¹ with the greatest impact in the third trimester (27 g reduction in birth weight for every cigarette smoked per day).⁸²

Although prenatal exercise has many benefits to both vascular and placental function in otherwise healthy women,^{88,89} these

benefits may be offset by the negative effects of maternal smoking, especially in women with complications such as IUGR. Previous cohort data demonstrated that women who smoked and exercised during pregnancy had a 30% greater risk of fetal death compared with non-smoking women who did not exercise (87 930 women, adjusted HR: 1.3, 95% CI: 1.03 to 1.65); however, this analyses was not adjusted for other factors that increase the risk of fetal death such as birth weight and other comorbidities.⁹⁰ Additionally, there was no statistical interaction between prenatal exercise and smoking and risk of fetal death on the additive risk scale. Therefore, we interpret that prenatal exercise in currently smoking pregnant women may provide health benefits to some, but may have negative effects in others; particularly those with other comorbidities including those with IUGR. In light of this, we recommend that pregnant women who are heavy smokers (>20 cigarettes per day) who have other comorbidities who wish to participate in MVPA require close observation to ensure appropriate fetal growth (see table 2).

CONSIDERATIONS FOR PHYSICAL ACTIVITY IN RELATIVE CONTRAINDICATIONS

To inform the Society of Obstetricians and Gynaecologists of Canada/Canadian Society for Exercise Physiology 2019 Guideline for Physical Activity throughout Pregnancy, 12 systematic reviews were developed and published in two dedicated issues of the *British Journal of Sports Medicine*.^{15–18,91–98} To provide evidence-based support for the recommendations regarding MVPA, meta-regression analyses were conducted for critical outcomes with at least 10 randomised controlled trials comparing exercise (without cointerventions) to no exercise.^{99,99} To reduce the odds of gestational diabetes, pre-eclampsia, gestational hypertension, prenatal depressive symptoms and excessive GWG by more than 25% (or effect size >0.4), women should aim to achieve 150 min of MVPA spread over ≥3 days of the week. However, substantial benefits were also observed at volumes below these recommendations; data from non-pregnant populations support that engaging in some physical activity is better than none.¹⁰⁰ In light of the potential benefits, even at activity levels below current guidelines, it is essential that the frequency, intensity, duration and/or volume of exercise should be modified for women with relative contraindications, rather than preventing activity altogether.

Not a contraindication

Based on available literature, the following conditions (in isolation) should no longer be considered a barrier to being physically active during pregnancy. These conditions include:

- ▶ Chronic hypertension.
- ▶ Gestational hypertension.
- ▶ Women who are categorised as overweight or obese.
- ▶ Recurrent miscarriage.
- ▶ Short cervix.
- ▶ Twin and high-order pregnancies.
- ▶ Epilepsy.
- ▶ Anaemia.
- ▶ Orthopaedic limitations.*
- ▶ History of extremely sedentary lifestyle.*
- ▶ History of spontaneous preterm labour or fetal growth restriction.*

* More information about each of these factors can be found in the online supplementary material.

Chronic hypertension

Chronic hypertension is associated with significant risks for both maternal and fetal morbidity.^{101–104} The front-line therapies to

treat hypertension are antihypertensive drugs.¹⁰¹ Despite the benefit to maternal blood pressure control, these medications do not reduce the risk of fetal growth restriction, pre-eclampsia or preterm delivery.¹⁰⁵ As such, there is a need for adjunctive therapies to manage pregnancies complicated by chronic hypertension.

Exercise is not a contraindication for women who have controlled chronic hypertension during pregnancy.^{1-3 5 6} Although the impact of exercise in pregnant women with uncontrolled hypertension has not been examined, we can draw information from non-pregnant hypertensive populations for support. In conjunction with antihypertensive drug treatments, acute bouts of physical activity result in a transient increase in blood pressure that is followed by a sustained decrease in blood pressure. The postexercise decrease of approximately 10 and 7 mm Hg in systolic and diastolic blood pressure, respectively, lasts for up to 2 hours following the end of exercise¹⁰⁶ and can be achieved following as little as 10 min of moderate intensity aerobic exercise.¹⁰⁷ This postexercise reduction in blood pressure may therefore reduce the time in which pregnant women with chronic hypertension are exposed to higher-than-average blood pressures during the day. Furthermore, there is a dose-response relationship between exercise volume and postexercise blood pressure reduction, demonstrating that greater levels of exercise will result in greater lowering of blood pressure over a longer period of time.¹⁰⁶

In pregnant women with chronic hypertension, no adverse changes in maternal blood pressure, fetal heart rate, uterine artery or umbilical artery blood flow have been observed following acute moderate-intensity exercise.¹⁰⁸ Additionally, regular prenatal physical activity throughout pregnancy in women with chronic hypertension did not increase the odds of complications such as low birth weight, pre-eclampsia or preterm birth.¹⁰⁹

The prevailing literature provides evidence that women with chronic hypertension benefit from prenatal physical activity (in conjunction with antihypertensive treatment) without increased risks of adverse maternal or neonatal outcomes. However, pregnant women with uncontrolled hypertension (persistent systolic ≥ 140 mm Hg and/or diastolic ≥ 90 mm Hg) should be evaluated by their doctor before starting prenatal physical activity.

Gestational hypertension

As discussed in the Chronic hypertension section, regular physical activity is an important non-pharmaceutical therapy for blood pressure control,¹¹⁰ and as such, may also benefit women diagnosed with gestational hypertension.

Prenatal exercise appears to offer maternal and fetal health benefits, without increased risk of harm, in women with gestational hypertension. No adverse short-term or long-term maternal or fetal outcomes (maternal blood pressure, fetal heart rate, umbilical blood flow, birth weight) were observed following cycling exercise in women with gestational hypertension.^{51 111} Additionally, a randomised controlled trial including hospitalised, high-risk pregnant women and women with gestational hypertension, demonstrated that muscle conditioning exercise did not cause any adverse changes in maternal blood pressure, uterine contractions or vaginal bleeding.⁶³ Furthermore, prenatal exercise could positively impact overall cardiovascular risk profile during pregnancy (eg, insulin resistance and GWG)^{15 97} which could stop the disease progressing to pre-eclampsia, although this requires further investigation.

Due to the potential of health benefits and low risk of adverse outcomes, women with gestational hypertension should engage with prenatal physical activity within recommended guidelines.

Women who are categorised as obese

Globally, the proportion of women categorised as overweight or obese has increased drastically over the past 30 years.¹¹² Recent data from Canada show that 25% of women have obesity during pregnancy and 61% of women are categorised as overweight or obese.¹¹³ Obesity is associated with significantly greater odds of developing gestational diabetes mellitus,¹¹⁴ gestational hypertension, pre-eclampsia and macrosomia compared with women of a normal weight body mass index category¹¹⁵; however, prenatal physical activity may reduce these risks. A recent meta-analysis demonstrated that regular physical activity in women categorised as overweight or obese reduced the risk of preterm birth and gestational diabetes without any risk of adverse fetal outcomes such as low birth weight or stillbirth.¹¹⁶ In addition, no adverse outcomes of prenatal exercise have been reported in pregnant women with obesity.¹¹⁷ As such, women categorised as overweight or obese should complete regular prenatal physical activity.

Due to hormonally mediated increases in joint laxity as well as the biomechanical stress of gestation (eg, change in the centre of gravity, isolated anterior loading), all pregnant women are more likely to suffer from low back or pelvic girdle pain.¹¹⁸ The risk for musculoskeletal pain and injury in the back, hip, knee ankle and foot is higher in pregnant women categorised as overweight or obese due to chronic overloading of connective tissue structures.¹¹⁹ As such, light or non-weight bearing exercise, such as aquatic or cycling exercise, yoga or Pilates, should be recommended for pregnant women categorised as overweight or obese experiencing musculoskeletal pain. In the absence of musculoskeletal pain, weight-bearing exercise can be encouraged as previous exercise studies in this population have used walking interventions without reports of musculoskeletal injury or pain.

Recurrent miscarriage and pregnancy loss

Recurrent miscarriage, defined as the loss of three or more consecutive pregnancies before 24 weeks, affects 1% of women¹²⁰ and may be attributed to genetic, structural, endocrine, immune, thrombophilic or 'unexplained' causes. Fear of miscarriage can be a barrier to prenatal exercise in early pregnancy¹²¹; however, a recent meta-analysis demonstrated no increased odds of miscarriage or perinatal mortality in otherwise healthy pregnant women who exercised compared with those who did not.¹⁸ It should be noted that this included spontaneous miscarriage data, and not specifically, recurrent pregnancy loss. Regardless, it remains unclear as to how exercise would negatively influence factors that lead to recurrent pregnancy loss. Fetal chromosomal defects, accounting for up to 60% of miscarriages, and maternal congenital uterine abnormalities, affecting up to 38% of women with recurrent miscarriage,¹²⁰ are non-modifiable, and as such, would not be affected by prenatal exercise.¹²²

There are no data specifically investigating the association between prenatal exercise and recurrent miscarriage; however, due to the underlying pathophysiology, it is unlikely that regular physical activity within guidelines would increase the risk of a loss in this population. Indeed, prenatal exercise may benefit factors that increase the risk of miscarriage, such as insulin resistance and obesity,¹²³ as well as improve general maternal health. In consideration of the above, women with recurrent pregnancy loss should be encouraged to meet physical activity guidelines;

however, it should be noted that these women may choose to avoid prenatal exercise due to fear of further miscarriage.

Short cervix

Previously, activity restriction was recommended for women with short cervix (<25 mm), but is now discouraged as no beneficial effect on pregnancy outcomes has been proven. In fact, preventing all physical activity increased the rate of preterm birth in women with a short cervix.¹²⁴ Furthermore, exercising >2 days a week for >20 min did not increase the risk of preterm birth in women with short cervix, but was associated with a non-significant reduction in delivery before 37 weeks (adjusted OR: 0.65, 95% CI: 0.33 to 1.03). Additionally, physical activity was significantly lower in women at risk for preterm birth (including those with cervix <20 mm) who delivered before 37 weeks, compared with those who delivered at term.¹²⁵ As such, there is a developing base of evidence demonstrating that physical activity has no adverse effect in women with short cervix and could even delay delivery. Women with short cervix should be advised to avoid high-impact and/or strenuous physical exercise as a precautionary measure, but in the absence of other complications, should be encouraged to meet current physical activity recommendations.

Twin and high-order multiple pregnancies

Multiple pregnancies face a significantly greater risk of maternal and infant morbidity and mortality as a result of preterm birth.¹²⁶ Prenatal physical activity has many health benefits to women with singleton pregnancies,^{15–18 91–93 95 97} and women with multiple pregnancies may experience similar benefits. However, current guidelines restrict twin pregnancies from prenatal exercise after 28 weeks' gestation and prevent all higher-order pregnancies from engaging with any MVPA.

Limited data support that women with twin pregnancies do not have adverse responses to prenatal exercise. Women with twin pregnancies have completed exercise interventions in observational studies with similar outcomes to women with singleton pregnancies (although this comparison was not the primary aim of these studies).¹²⁷ Women with twin pregnancies (n=26) were included in an assessment of physical activity in women at high risk of preterm birth. In this study, higher levels of light walking (measured in steps per day) were shown in women delivering at term compared with those delivering preterm, although this was not significant (p=0.09), likely due to a lack of statistical power.¹²⁵ The reports from these two studies, although limited, support that physical activity in twin pregnancy may reduce the risk of preterm delivery; however, well-controlled investigations into both acute responses and chronic outcomes following exercise in this population are needed to verify these findings.

Of note, in both of the studies presented, women with twin pregnancies were physically active beyond 28 weeks of gestation.^{125 127–129} This is highly important as 92% of obstetricians will recommend that women with twin pregnancies limit their exercise out of concern of preterm labour.¹³⁰ In conflict with this practice, a recent Cochrane review showed that bed-rest had no beneficial effect on pregnancy outcomes (including preterm delivery) in twin pregnancies.¹⁹ Therefore, we believe that in the absence of other medical reasons where ambulation may be detrimental, light physical activity and activities of daily living should be maintained at minimum in twin pregnancies after 28 weeks. Women with uncomplicated twin pregnancies who wish to continue MVPA in the third trimester can do so, with acknowledgement that increased abdominal size, altered

balance, higher fatigue and generalised aches and pains may limit their exercise levels.

At present, the effect of prenatal physical activity on higher-order multiple pregnancies is not known. There is no published data in this group, and this is likely due to the low incidence of women with high-order pregnancies, as well as their extreme risk of preterm birth.¹³¹ Furthermore, the anatomical (large extended abdomen) and physiological (excessive fatigue and musculoskeletal pain) constraints of higher-order pregnancies means that women are less likely to engage in prenatal exercise. However, all women with high-order pregnancies should be encouraged to maintain activities of daily living at minimum.

Epilepsy

Physical activity is increasingly viewed as a complementary therapy for patients with epilepsy. Specifically, regular exercise may improve epileptic seizure control via reduced epileptiform discharges following exercise¹³² and reduce associated comorbidities.¹³³ Pregnant women with well-controlled epilepsy (those who are treated and stable with no recent history of seizures) should participate in MVPA according to current guidelines. In contrast, women with poorly controlled epilepsy (those who experience seizures despite treatment) may face some risk during exercise; however, this can be mitigated. Specifically, falling from tonic-clonic or atonic seizures and/or those that result in a transient loss of consciousness could result in traumatic injury to the fetus. Pregnant women with poorly controlled epilepsy should aim to achieve recommended physical activity guidelines but may need to individualise their intensity (eg, low to moderate), type (eg, weight-supported activities such as recumbent cycling) and location (eg, supervised gym, not exercising alone) of exercise to minimise the risk of harm to themselves and their fetus should they experience a seizure while exercising.

Anaemia

All women develop a degree of physiological anaemia in pregnancy due to haemodilution as a result of blood volume expansion. Haemoglobin levels <100 g/L may result in maternal symptoms, such as fatigue, and may be theorised to result in limitations in maternal oxygen carrying capacity during prenatal activity. However, there have been no negative maternal or fetal outcomes associated with anaemia and MVPA.¹³⁴

At present, there is limited supporting or theoretical evidence to uphold anaemia as a contraindication to exercise in pregnancy. Women with a haemoglobin level <100 g/L should receive oral iron supplements to elevate haemoglobin levels and mitigate the symptoms associated with anaemia. If asymptomatic, women should maintain MVPA. If women are symptomatic, they may consider reducing the intensity of prenatal exercise, but should remain physically active.

CONCLUSIONS

Since 1985, there has been a critical shift in recommendations regarding prenatal exercise, from a potentially harmful behaviour to a critical prescription to improve maternal and fetal health. We have identified 11 conditions (chronic or gestational hypertension, overweight/obesity, recurrent miscarriage, short cervix, multiple pregnancies, epilepsy and anaemia, orthopaedic limitations, history of extremely sedentary lifestyle, history of spontaneous preterm labour or fetal growth restriction) where there is absolutely no evidence to support stopping prenatal exercise, in fact, becoming completely inactive could result in increased risk of adverse pregnancy outcomes. There

What is already known

- ▶ Prenatal exercise guidelines include a list of medical reasons (contraindications) where a reduction or cessation of exercise is recommended.
- ▶ Contraindications are inconsistent among guidelines.
- ▶ Many of the contraindications are based on expert opinion or limited empirical evidence.

What are the new findings

- ▶ We systematically reviewed and synthesised available literature regarding prenatal exercise in women with contraindications.
- ▶ We identified ten conditions where engaging in regular moderate–vigorous physical activity has a strong potential for adverse effects for the mother and/or fetus (absolute contraindications).
- ▶ We identified ten disorders where we recommend modification of activities (reduction in intensity, duration or volume; exercise adaptation) be considered over complete cessation of activity (relative contraindications).

are some conditions (mild respiratory disorders, acquired or congenital HD with exercise tolerance, mild pre-eclampsia, well-controlled type 1 diabetes, PPROMs, placenta previa after 28 weeks, untreated thyroid disease, severe and symptomatic eating disorders, undernutrition, heavy smoking in the presence of comorbidities) where regular physical activity is likely safe, but the exercise prescription may need to be modified and women would benefit from additional monitoring or support from their healthcare professional. Finally, we remain supportive of more serious disorders (severe respiratory disorders, severe acquired or congenital HD with exercise intolerance, placental abruption, vasa previa, uncontrolled type 1 diabetes, IUGR, active preterm labour, severe pre-eclampsia and cervical insufficiency) as reasons to avoid MVPA during pregnancy. However, pregnant women with these conditions should maintain activities of daily living where possible, as per evidence showing the adverse effects of complete bed-rest in pregnancy.

We sought to provide evidence-based classifications of absolute and relative contraindications to prenatal exercise; however, in many cases, previous research was extremely limited. We therefore present a call for future research to include women with medical disorders that have previously been considered contraindications to prenatal exercise. Building on the current lack of data in these women will allow better information for both pregnant women and their obstetric healthcare providers regarding prenatal physical activity.

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