

Meah *et al.* 2020*Br J Sports Med*
doi:10.1136/bjsports-2020-102042**ONLINE SUPPLEMENT****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.**Victoria L. Meah¹, Gregory A. Davies², Margie H. Davenport¹¹ Program for Pregnancy and Postpartum Health, Physical Activity and Diabetes Laboratory, Faculty of Kinesiology, Sport and Recreation, Women and Children's Health Research Institute, Alberta Diabetes Institute, University of Alberta, Edmonton, Alberta, Canada.² Department of Obstetrics and Gynecology, Queen's University, Kingston, Ontario, Canada.**Corresponding Author**Margie H. Davenport, PhD
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doi:10.1136/bjsports-2020-102042**Online Supplementary Table 1. Prevalence and outcomes associated with complications that are contraindications to prenatal exercise.**

Contraindication	Prevalence	Adverse maternal and neonatal outcomes
Respiratory disorders		
Chronic obstructive lung diseases (COPD) <i>Including asthma and bronchitis</i>	Asthma: 9.4% of pregnant women[1] Chronic bronchitis: 2% of women of childbearing age[2]	<i>Maternal:</i> <ul style="list-style-type: none"> Hypertensive complications (aOR: 1.35, 95%CI: 1.2-1.6)[3] <i>Neonatal:</i> <ul style="list-style-type: none"> Preterm labour (aOR: 1.21, 95%CI: 1.1-1.4)[3] Fetal hypoxia during asthma exacerbation[3] Fetal growth restriction[3] Asthma exacerbations reducing placental function, leading to preeclampsia.[3]
Cystic Fibrosis <i>Genetic disorder that leads to the production of thick mucus in respiratory, digestive, and reproductive tracts</i>	0.007% of total births[4]	<i>Maternal:</i> <ul style="list-style-type: none"> Respiratory failure, due to chronic infection or progressive lung destruction[5] Undernutrition/malabsorption due to pancreatic insufficiency[5] Gestational diabetes[5] <i>Neonatal:</i> <ul style="list-style-type: none"> Preterm birth[6]
Restrictive lung disease <i>Including pulmonary fibrosis, sarcoidosis, and pulmonary embolism</i>	Uncommon during pregnancy as the typical age of diagnosis is after childbearing years in women[7]	Limited reports suggest that these women have similar pregnancy outcomes to those of otherwise healthy women.[8]
Congenital or acquired heart disease (HD) <i>Including, but not limited to, stenotic or regurgitant valvular lesions, repaired or un-repaired septal defects, operated coarctation of the aorta, healed myocarditis and arrhythmia</i>	0.001% of the all pregnancies in the United States.[9]	<i>Maternal:</i> <ul style="list-style-type: none"> Chronic heart failure: <ul style="list-style-type: none"> Non-complex HD (OR, 9.7; 95%CI, 4.7-20.0) Complex HD (OR, 56.6; 95% CI, 17.6-182.5)[10] Serious ventricular arrhythmias due to complex HD (OR, 31.8; 95% CI, 4.3-236.3)[10] Maternal in-hospital mortality (OR, 79.1; 95% CI, 23.9-261.8)[10] Stroke[10] Pulmonary edema[11]

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		<p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Fetal growth restriction <ul style="list-style-type: none"> ○ Non-complex (OR, 1.6; 95% CI, 1.3-2.0) ○ Complex (OR, 3.5; 95% CI, 2.1-6.1) [10] • Perinatal death[12] • Respiratory distress syndrome[12] • Intraventricular hemorrhage[12] • Preterm birth[12]
Placental abruption	1% of pregnancies[13]	<p><i>Maternal:</i></p> <ul style="list-style-type: none"> • Antepartum and intrapartum hemorrhage[14] • Hypovolemic shock[14] • Serious maternal complications (including pulmonary edema, acute respiratory failure, acute heart failure, acute myocardial infarction, cardiomyopathy, puerperal cerebrovascular disorder, coma, and amniotic fluid embolism) <ul style="list-style-type: none"> ○ Mild abruption (RR: 1.52, 95%CI: 1.35-1.72) ○ Severe abruption (RR: 4.29, 95%CI: 4.11-4.47)[15] <p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Preterm labour[14] • Low birthweight (OR: 13.7, 95%CI: 7.4-25.2)[16] • Fetal distress[14]
Vasa previa	1 in 2,500 births [17]	<p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Fetal hemorrhage when membranes rupture[17]
Type 1 Diabetes Mellitus	4 in 1000 pregnancies[18]	<p><i>Maternal:</i></p> <ul style="list-style-type: none"> • Preeclampsia (18.1% vs. 2.6% in an otherwise healthy control population, P: <0.001)[19] <p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Preterm birth (RR: 7.0, 95%CI: 6.3–7.6)[19] • Birthweight \geq 4,500 g (RR: 2.3, 95%CI: 1.9–2.9)[19] • Stillbirth (RR: 4.7, 95%CI: 3.2–7.0)[19] • Congenital malformations (RR: 1.7, 95%CI: 1.3–2.2)[19] • A 1% increase in first trimester HbA_{1c} increases the risk of perinatal death (aOR: 4.5, 95%CI: 1.1–18.4)[20]
Intrauterine growth restriction (IUGR)	10% of pregnancies [22]	<p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Intrauterine demise[23]

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<i>Estimated fetal weight <10th percentile for gestational age</i> [21]		<ul style="list-style-type: none"> • Preterm labour[23] • Neonatal mortality and morbidity[23] • Neurodevelopmental delays during childhood[24]
Preterm labour <i>Delivery < 37 weeks of gestation</i>	11.1% of livebirths worldwide[26]	<p>Development of cardiovascular disease in adulthood[25]</p> <p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Neonatal death[27] • Neonatal infection[27] • Chronic lung disease[27] • Cardiovascular disease in later life[27] • Sensory impairments and impaired neurodevelopment[27]
Preeclampsia <i>Development of hypertension with proteinuria, maternal organ dysfunction or uteroplacental dysfunction.</i>	Up to 8% of pregnancies[28]	<p><i>Maternal:</i></p> <ul style="list-style-type: none"> • Cardiovascular morbidity in the 5-15 years following delivery including [29,30] <ul style="list-style-type: none"> ○ Heart failure [RR: 4.19, 95%CI: 2.09–8.38] ○ Stroke [RR: 1.81, 95%CI: 1.29–2.55]) <p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Preterm birth (aOR: 7.05, 95%CI: 5.14-9.68)[31] • SGA (aOR: 2.81, 95%CI: 1.89-4.18)[31] • Admission to a neonatal intensive care unit[32] • Lower cognitive function in childhood[33]
Cervical insufficiency <i>Structural and functional deficit of the cervix, typically characterized 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</i>	1% of all pregnancies [34]	<p><i>Maternal:</i></p> <p>Preterm labour (cervical length <26 mm; RR: 9.49, 95%CI: 5.95-15.15)[35]</p>
Preterm premature rupture of membranes (PPROMs) <i>Spontaneous rupture of the membranes < 37 weeks gestation at least 1 h before the onset of contractions</i> [36,37]	Occurring in up to 3% of all pregnancies [36,37]	<p><i>Maternal:</i></p> <ul style="list-style-type: none"> • Intraamniotic infection, a cause of PPRoms, can increase the risk of long term complications in infants, such as cerebral palsy (OR: 2.42; 95%CI: 1.52–3.84).[38] <p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Preterm birth[39]

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		<ul style="list-style-type: none"> • neonatal morbidity, including pulmonary hypoplasia, and mortality associated with prematurity.[40]
Placenta previa after 28 weeks <i>Placental implantation that overlies or is within 2 cm of the internal cervical orifice</i>	0.4% of pregnancies[41]	<p><i>Maternal:</i></p> <ul style="list-style-type: none"> • Antepartum and intrapartum hemorrhage (95%CI: 42.7-60.6)[42] • Placental abruption (OR: 13.1, 95%CI: 8.2-20.7),[42] <p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Preterm labour due to placental abruption[14]
Thyroid disease Hypothyroidism	0.5% of pregnancies[43]	<p><i>Maternal hypothyroidism:</i></p> <ul style="list-style-type: none"> • Preeclampsia (OR: 1.7, 95%CI: 1.1 to 2.6)[44] • Preterm labour (OR: 1.9, 95%CI: 1.1 to 3.5)[44] • Excessive weight gain[43] <p><i>Neonatal hypothyroidism:</i></p> <ul style="list-style-type: none"> • Fetal mortality (OR: 2.7, 95%CI: 1.6-4.7)[44]
Hyperthyroidism	0.2% of pregnancies[43]	<p><i>Maternal clinical hyperthyroidism:</i></p> <ul style="list-style-type: none"> • Gestational hypertension[45] • Preeclampsia (OR: 3.94)[46] • Gestational diabetes mellitus (OR: 1.8)[46] • Congestive heart failure[45] <p><i>Neonatal clinical hyperthyroidism:</i></p> <ul style="list-style-type: none"> • Stillbirth (OR: 8.42, 95%CI: 2.01-35.2)[46] • Preterm birth (OR: 1.24, 95%CI: 1.17-1.31)[47] • Fetal growth restriction (OR: 2.16)[46]
Eating disorders <i>Including anorexia nervosa, bulimia nervosa, binge-eating disorder and eating disorders not otherwise specified</i>	Up to 9% of pregnant women[48]	<p><i>Maternal:</i></p> <ul style="list-style-type: none"> • Postnatal depression (OR: 2.8, 95%CI: 1.2-6.2)[49] <p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Fetal growth restriction (OR: 1.6, 95%CI: 1.3–1.8) [50] • Small for gestational age (OR: 1.5, 95%CI: 1.2–1.9)[50] • Preterm labour (OR: 3.3, 95%CI: 1.3– 8.8).[49]
Smoking	1.7% of the global population smoke during pregnancy and 72.5% (95%CI: 70.4–75.0) were daily smokers [51]	<p><i>Neonatal:</i></p> <ul style="list-style-type: none"> • Stillbirth (OR: 1.47, 95%CI: 1.37-1.57)[52] • Preterm birth (adjusted OR: 1.8, 95%CI: 1.6-2.0)[53] • Longer-term adverse health outcomes for offspring such as childhood obesity (OR: 1.55, 95%CI: 1.40-1.73)[53]

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		<ul style="list-style-type: none"> • Chronic carbon monoxide poisoning[54] • Fetal growth restriction[54] • Reduced birthweight[55]
Chronic Hypertension <i>Systolic or diastolic blood pressure $\geq 140/90$ mmHg diagnosed prior to pregnancy or up to 19 weeks gestation</i>	3% to 5% of pregnancies[56]	<i>Maternal:</i> <ul style="list-style-type: none"> • Up to 25% of women with chronic hypertension will progress to preeclampsia[56] <i>Neonatal:</i> <ul style="list-style-type: none"> • Preterm birth (OR: 5.5, 95%CI: 3.2-9.4)[57] • Placental abruption (RR: 2.4, 95%CI: 2.3–2.5)[58] • Congenital malformations (OR: 1.3; 95%CI 1.2-1.5)[59] • Fetal growth restriction at term (RR: 1.5, 95%CI: 1.0-2.2) and preterm (RR: 5.5, 95%CI: 3.2-9.4)[57]
Gestational hypertension <i>Systolic or diastolic blood pressure ≥ 140 or 90 mmHg respectively measured ≥ 20 weeks gestation</i>	Affects 30 women in every 1000 deliveries.[60] 17% of women diagnosed with gestational hypertension will progress to preeclampsia[61]	<i>Maternal:</i> <ul style="list-style-type: none"> • Progression to preeclampsia[61] <i>Neonatal:</i> <ul style="list-style-type: none"> • Preterm birth (aOR: 1.82, 95%CI: 1.23-2.68) [31]
Obesity <i>Defined as a BMI > 30 kg/m²</i>	21% of women are categorized as obese [62]	<i>Maternal:</i> <ul style="list-style-type: none"> • Gestational diabetes mellitus (OR: 3.56, 95%CI: 3.05–4.21)[63] • Gestational hypertension (aOR: 2.5, 95%CI: 2.1-3.0)[64] • Preeclampsia (aOR: 1.6, 95%CI: 1.1-2.25)[64] <i>Neonatal:</i> <ul style="list-style-type: none"> • Macrosomia (aOR: 1.7, 95%CI: 1.4-2.0)[64] <i>Note: all odds are increased when a woman is classified as morbidly obese (BMI > 40 kg/m²)</i>
Recurrent miscarriage and pregnancy loss <i>Loss of ≥ 3 consecutive pregnancies < 24 weeks</i>	1% of couples trying to conceive[65]	<ul style="list-style-type: none"> • Significant psychological burden for women and their partners.[66]
Short cervix <i>Cervical length < 25 mm</i>		<i>Maternal:</i> <ul style="list-style-type: none"> • Preterm labour (cervical length < 26 mm; RR: 9.49, 95%CI: 5.95-15.15)[35]
Multiple pregnancies	All multiple pregnancies: 3.5% of live births[67]	<i>Maternal twin pregnancies:</i> <ul style="list-style-type: none"> • Hypertensive complications[68]

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	Twins: 96.57% of all multiple pregnancies[67] Triplets: 3.18% of all multiple pregnancies[67] Quadruplets and higher: 0.25% of all multiple pregnancies[67]	<ul style="list-style-type: none"> • 60% greater odds of postpartum depression[69] <i>Neonatal twin pregnancies:</i> <ul style="list-style-type: none"> • Preterm labour is 12-times more likely[67] <i>Higher order pregnancies (maternal and neonatal):</i> <ul style="list-style-type: none"> • Similar risks to twin pregnancies, with significantly increased risks of adverse outcomes[70]
Epilepsy	0.3 to 0.5% of all pregnancies[71]	<i>Maternal:</i> <ul style="list-style-type: none"> • Hypertensive disorders (OR: 1.37, 95%CI: 1.21-1.55)[72] <i>Neonatal:</i> <ul style="list-style-type: none"> • Preterm labour (OR: 1.16, 95%CI: 1.01-1.34)[72] • Fetal growth restriction (OR: 1.26, 95%CI: 1.20-1.33) [72] <i>Note: the development of these complications may be related to the use of anti-epileptic drugs.[72]</i>
Anemia <i>Mild physiologic anemia and/or iron deficiency</i>	Up to 38% of pregnant women[73]	<i>Maternal:</i> <ul style="list-style-type: none"> • Placental abruption[74] <i>Neonatal:</i> <ul style="list-style-type: none"> • Preterm labour (RR: 1.56, 95%CI: 1.25–1.95)[75] • Low birthweight (OR: 1.42, 95%CI: 1.31–1.55) [76] Perinatal mortality (OR: 1.73, 95%CI: 1.32–2.26)[76]

N.B. OR, odds ratio; 95%CI, 95% confidence interval; RR, risk ratio; aOR, adjusted odds ratio; BMI, body mass index.

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Methods

This systematic review was conducted in accordance with the PRISMA guidelines and the PICOS (Population, Intervention, Comparison, Outcome and Study design) framework[77] was used to guide this review.

Population

The population of interest was pregnant women with absolute or relative contraindication to exercise as defined by previous guidelines and listed in Table 1 (within manuscript).

Intervention (exposure)

The intervention/exposure of interest was subjective or objective measures of frequency, intensity, duration, volume or type of prenatal exercise. Exercise was defined as any bodily movement generated by skeletal muscles that resulted in energy expenditure above resting levels.[78] Although exercise is a subtype of physical activity, for the purpose of this review we used the terms interchangeably. Acute (i.e., a single exercise session) or habitual (i.e., usual activity) prenatal exercise was considered.

Comparison

No comparators were required for inclusion in this systematic review.

Outcome

Relevant outcomes were any maternal or neonatal health outcomes. This included, but was not limited to: preterm birth (less than 37 weeks gestation), birthweight, gestational age at birth, admittance to hospital, development of complications such as preeclampsia, or any other outcomes relevant to maternal or fetal morbidity or mortality.

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Study Design

Primary studies of any design were eligible, including case studies. Narrative or systematic reviews and meta-analyses were excluded.

Information sources

A comprehensive search was created and run by a research librarian using the Ovid interface (MEDLINE, EMBASE, All EBM [Evidence-Based Medicine], Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, PsycINFO), the EBSCO interface (CINAHL Plus with Full-text, Sport Discus), Scopus, Web of Science Core Collection and ClinicalTrials.gov up to April 5, 2019. See Online Supplement for complete search strategies.

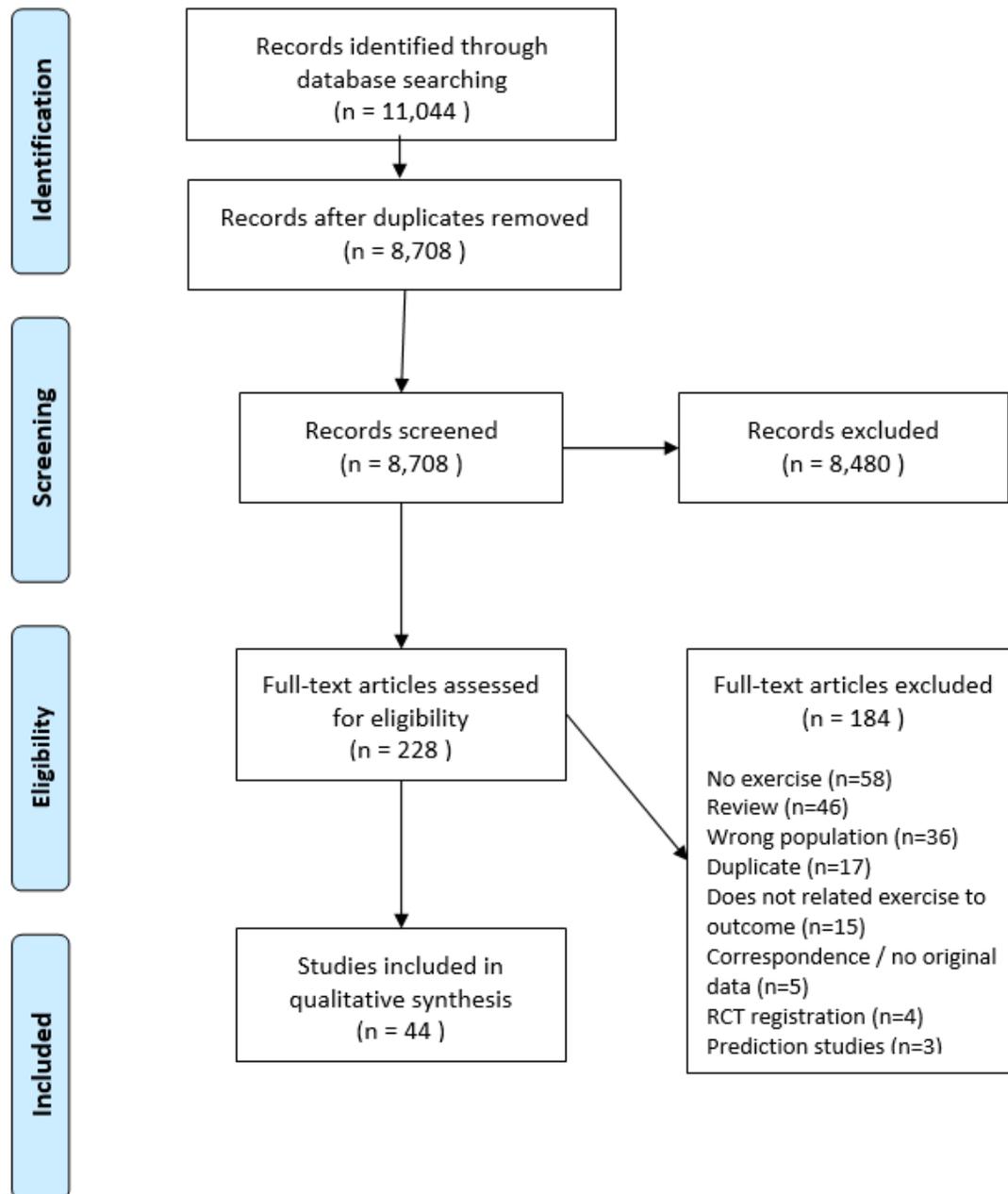
Study selection and analysis

Study screening and selection was managed using Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia). Titles and abstracts of all retrieved articles were independently screened by two reviewers. Abstracts that met the initial screening criteria were retrieved as full-text articles. Two reviewers reviewed full-text articles for relevant PICO information and discrepancies were resolved by a third individual. A narrative synthesis of results was presented for each contraindication.

Results

Overall, 44 unique studies were included in the systematic review (Online Supplement Figure 1).

Additional details about the studies can be found in the Online Supplement Table 2.

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Online Supplement Figure 1. Flow chart of study screening and inclusion/exclusion

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Online Supplement Table 2. Study characteristics and outcomes.

Author, year, country, study type	Sample size (n)	Age (years)	Gestational age (weeks)	Contraindication Group(s)	Details	PA Self-reported/objective, acute/chronic	Definition of PA	Compliance	Tolerance	Results	Linked papers
Artal <i>et al.</i> , (1985), USA, non-randomized intervention	Study: 13; Control: 42	Study: 28±6.1; Control: 29±7.5	Study: 32.6±6.7; Control: 30.4±10.6	Women with type 2 diabetes (insulin-requiring)		Objective, acute	All women in the study exercised ~90 minutes after a standardized lunch (standardized). Women were placed in a semi-supine position for a control period for 30 mins before exercising for 15 minutes at a constant speed of 2 mph (2.33 METs). The exercise was followed by a 30 minutes recovery period in the semi-supine position.			No differences in maternal HR and BP following acute exercise between groups. Plasma glucose fell with exercise in both groups. No abnormal changes in fetal heart rate in either group.	
Barakat <i>et al.</i> , (2009), Spain, RCT	Study: 72; Control: 70	Study: 30.4 (0.3); Control: 29.5 (0.4)	T2/T3	Women who developed anemia	Women were enrolled into the study with no medical contraindications for exercise, but developed anemia during the RCT.	Objective, chronic	Study: Women were enrolled in 3 x/week of individually supervised resistance exercise training sessions. Each session consisted of 35–40 minutes of light intensity resistance exercises, which were performed with barbells or low-to-medium resistance bands. They included one set of <10-12 repetitions of abdominal curls, biceps curls, arm extensions, arm side lifts, shoulder elevations, seated bench press, seated lateral row, lateral leg elevations, leg curls, knee extensions, knee (hamstring) curls and ankle flexion and extensions. Maternal HR was controlled <80% HRmax. Control: Women maintained their level of activity.	Adherence to training in the experimental group was 90%.	No major adverse effect and no major health problem were noted in the 72 subjects from the training group.	Regular exercise during the second half of pregnancy does not increase the risk of maternal anaemia, gestational outcomes or APGAR scores.	Some data extracted from: Barakat <i>et al.</i> (2008). Does exercise training during pregnancy affect gestational age? A RCT. <i>Br J Sports Med.</i> 42(8):674-8.

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Boggess <i>et al.</i> , (1995), USA, observational	7 (with walking data)	28.3±4.9	-	Women with interstitial or restrictive lung disease	Included severe diagnoses of: idiopathic pulmonary fibrosis, hypersensitivity pneumonitis, sarcoidosis; moderate diagnoses of: dermatomyositis, kyphoscoliosis, multiple pulmonary emboli; and mild cases of: idiopathic pulmonary fibrosis, eosinophilic pneumonitis, and mixed connective tissue disease.	Women were managed by pulmonologists and obstetricians in their prenatal care. In addition to these visits, oxygen saturation was measured at rest and during walking. Oxygen therapy was provided to maintain oxygen saturation about 94%.	Case 1: idiopathic pulmonary fibrosis - oxygen saturation fell to 50% with walking at 20 weeks. Patient delivered at 31 weeks via C-section. Case 2: hypersensitivity pneumonitis - oxygen saturation fell to 88% with walking at 20 weeks. Patient had an uncomplicated pregnancy. Case 3 - sarcoidosis (repeated measurements in first and second pregnancy) - during first pregnancy, oxygen saturation fell to 86% with walking at 12 weeks, but had an otherwise uneventful pregnancy. She continued to have desaturation with exercise in the postpartum, and suffered further desaturation during walking in her subsequent pregnancy, even when breathing supplemental oxygen. The second pregnancy was also uneventful. Case 4: dermatomyositis - oxygen saturation fell to 95% with walking at 8 weeks, no pulmonary complaints but did develop GH at 35 weeks and was treated with bed rest. Case 6 - multiple
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pulmonary emboli - oxygen desaturation fell from 97% to 91% with walking at 30 weeks. Pulmonary hypertension remained stable and she had no recurrence of pulmonary emboli. Her pregnancy was uncomplicated and labor was induced at 39 weeks, with documented fetal lung maturity. Case 7 - idiopathic pulmonary fibrosis - at week 12, oxygen saturation fell from 98% to 77% with walking, although this was not observed again upon repeat testing. At 16 weeks, oxygen saturation fell only to 95%, no treatment was given and pregnancy was uncomplicated.

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Bruce & Johnson (1961), USA, observational	16 women (32 tests)	Not reported	Not reported for all, but included tests in first, second and third trimesters.	Women with heart disease	Women with heart disease attending usual care at their hospital.	Objective, acute	Women completed a standardized exercise test involving walking at 1.7 mph on a treadmill at a gradient of 10%.	Dyspnea and fatigue were more present in the second trimester compared to the first or third trimesters, but all tests were well tolerated.	Out of 32 tests on 16 cardiac patients during pregnancy, no symptoms were observed in 12 women. Dyspnea alone occurred once while in twelve instances dyspnea and fatigue occurred concomitantly. None had chest pain. The maximal heart rates for this exertion varied from 116 to 172bpm. One woman was unable to raise systolic blood pressure during exercise. No women exhibited a fall or exertional hypotension. One woman with congenital aortic stenosis and left ventricular failure could not be tested in her first pregnancy, but following corrective open heart surgery during the second trimester, had a satisfactory course thereafter. In her second pregnancy, she presented with premature ventricular beats during the exercise test, but no other abnormal responses. Two other patients showed ST depression during exertion, but were both digitalized.
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Brun <i>et al.</i> , (2011), Canada, RCT	Study : 6; Contr ol: 5	30±3.8	31±3.5	Women with gestational hypertension, PE (mild to moderate), IUGR, twins or triplets and threatened PTB	Women were hospitalized and bed rested (complete bed rest with only bathroom privileges) for at least 3 days prior to participating in the study.	Objective, acute	All groups: All women in the exercise and control groups listened to music (tempo 70-90 bpm) for the 30 minute protocol. Study: While listening to music, women in the exercise group completed muscle conditioning exercises with a elastic band under the supervision of a certified kinesiologist. Women completed the exercise whilst reclined, in a semi-lying or semi-recumbent position. Women completed gentle stretching for 5 minutes, 20 minutes of muscle conditioning exercises and 5 minutes of stretching and relaxation. Muscle conditioning exercises included exercises for upper back, quadriceps, hip extensors, soleus, gastrocnemius deltoids, pectorals, biceps and triceps muscles. Each exercise was completed using an exercise band that provided enough resistance to complete 2 sets of 15 repetitions. The exercise protocol lasted for 30 minutes, preceded and followed by a 20 minute observation period during which maternal HR, BP and uterine contractions were measured. Control: While listening to the same music, women in the control group remained in a side-lying or semi-recumbent position for 30 minutes.	The exercise protocol was well tolerated by hospitalized antenatal women.	No change in BP or uterine contractions following acute exercise. There were no reports of delayed-onset muscle soreness, vaginal bleeding, delayed uterine contractions up to 2 days after the intervention. Birth weight was not significantly different between groups.
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Bubnjević & Ugarković, (2017), Serbia, case study	1	33	-	Diagnosed with Hashimoto's thyroiditis prior to the pregnancy	At week 5, hormonal therapy with levothyroxine sodium was increased from 25 to 50 mg.	Objective, chronic	Patient was active prior to pregnancy (running marathons within 5 years before pregnancy). The patient continued to run regularly until the final week of her gestation. Her training depended on her functional ability and subjective well being and was recorded in a log. In the third trimester the number of training sessions per week and the length of the runs were reduced (month 7: 6 sessions per week, 7 km each; month 8: 5 sessions per week, 5 km each; month 9: 4 sessions per week, 5km each). The intensity of all runs remained moderate to light (4:30–6:15 min/km). Markers of maternal and fetal well being were monitored throughout her pregnancy. Maternal HR and BP were monitored before, during and after occasional running sessions.	There was no negative course or outcome of pregnancy in a subject with Hashimoto's thyroiditis due to continuous light to moderate aerobic exercise. A healthy infant of average weight and height, and with a high Apgar score, was born by normal vaginal delivery at 39+4 weeks.
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Chaddha <i>et al.</i> , (2005), Canada, Observational	Study: 12, Control: 23	Study: 29.6±3.2, Control: 34.4±6.38	Study: 25±1.6, Control: 25±1.9	Women with uteroplacental vascular insufficiency	Defined as abnormal uterine artery Doppler (mean pulsatility index >1.45 between 22-26 weeks)	Objective, acute	Women in the study and control groups performed exercise on a recumbent cycle ergometer at 2 exercise levels: Level 1: 10% PPO, Level 2: 15% PPO for 5 minutes each. The values for PPO were determined by pre-pregnancy PA, height and weight. Exercise was done sequentially in the same session as: baseline, Level 1, 5 min rest, Level 2, 5 min rest. Maternal cardio-respiratory responses were measured during exercise and umbilical artery blood flow and fetal cardiac output were measured during the rest periods.	Mean umbilical artery PI increased in response to exercise in the uteroplacental vascular insufficiency group and decreased in the comparison group with normal uterine artery Doppler. Three of the women with uteroplacental vascular insufficiency developed transient AEDF in the umbilical arteries after each level of exercise, and 2 of these pregnancies were later complicated by early-onset IUGR with AEDF before delivery. Women with uteroplacental vascular insufficiency had higher rates of IUGR (n=5), hypertension (n=2), PE with toxemia (n=6), HELLP (n=1), non-reassuring stress test (n=2) and absent end-diastolic umbilical flow (n=2) compared to the control group (n=0 in all complications). Women with uteroplacental vascular insufficiency delivered smaller babies (1.7±1 vs. 3.2±0.4 kg) significantly earlier in gestation (33±3.7 vs. 40±1.4 weeks).
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Maternal
cardiovascular and
FHR responses to
exercise showed no
significant changes in
either group.

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Chahal <i>et al.</i> , (2018), Peru, case-crossover	663	Cases: 70.2% were between 20-34, Controls: 86.2% were between 20-34	Cases: 35.1±4.1, Controls: 34.1±4.4	Women with placental abruption	Met one or more of the following 4 eligibility criteria: 1) antepartum hemorrhage after 20 weeks of gestation; 2) uterine pain or tenderness (localized or diffuse); 3) fetal distress or death; and 4) retroplacental blood clot.	Self-reported, chronic	Women were invited to participate in a 30-minute in-person interview, taking place 2 days (IQR 1-3 days) after placental abruption. Information was collected on exposure (e.g., participation in moderate or heavy physical exertion) immediately preceding placental abruption and comparing this with the expected frequency of exposure based on women's exposure patterns during similar control time periods. To help standardize reporting of the intensity of physical exertion, women were shown a 15-point visual analogue Borg Scale and examples of physical exertion at each level of intensity were provided. Women were asked about their usual frequency of exertion during the year before pregnancy, the first 3–6 months of pregnancy, months 6–9 of pregnancy and during the week before placental abruption onset.	352 (54%) reported that they engaged in moderate or heavy physical exertion in the week before placental abruption. Among the 352 who engaged in MVPA, 263 (75%) reported engaging in such exertion once that week and 42 (12%) reported more than 3 times that week. The immediate risk of placental abruption was 7.8-fold higher (95% confidence interval (CI): 5.5, 11.0) within an hour of moderate or heavy physical exertion compared with periods of lower exertion or rest. The rate ratio of placental abruption within an hour of physical exertion was higher following heavy-intensity physical exertion (rate ratio (RR)=13.7, 95% CI: 7.0, 26.5) than after moderate physical exertion (RR=6.0, 95% CI: 4.0, 9.0; P for homogeneity=0.04). The rate ratio of placental abruption was lower for women who habitually engaged in physical activity more than 3 times per week in the year before pregnancy (RR=3.0, 95% CI: 1.6,
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5.9) compared with women who engaged in such activity or fewer times per week (RR=17.3, 95% CI: 11.3, 26.7; P for homogeneity<0.001)

Cheredniche nko, (1987), Russia, observational	Study : 50, Control: 30	18-32	After 20 weeks	Women with hypertension	Split into stage 1 and stage 2 hypertension	Objective, chronic	Women with hypertension completed an exercise protocol after 20 weeks gestation. Women started walking for 15-20 minutes for 2km. After 15 days, they increased walking for 40-45 minutes for 4km, and then after a further 15 days for 60 minutes for 6km.	Women who exercised had improved gas exchange, physical capacity and experienced a positive effect on pregnancy and birth.
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Da Silva <i>et al.</i> , (2010), Brazil, observational	Study: 37, Control: 37	Study: 21 (19, 26), Control: 22 (18, 24)	Study: 37 (34, 38), Control: 37 (33, 38)	Women diagnosed with preeclampsia	16 presented with mild preeclampsia, 21 with severe preeclampsia	Objective, acute	Women in the study and control groups completed a physical activity questionnaire (PPAQ), a 6MWT, manovacuometry and spirometry procedures. The 6MWT was performed according to protocol. BP, HR, oxygen saturation and RPE was measured before and after the test.	All the patients completed the 6MWT without need to pause	Maternal BP was significantly higher before and after 6MWT and Maternal HR was significantly higher after 6MWT in the preeclampsia group. Oxygen saturation was not significantly different between the two groups before and after exercise. 6MWT was significantly lower in the preeclampsia group, and RPE was significantly higher in the preeclampsia group compared to the controls. BP was significantly greater both during and following 6MWT in the severe preeclampsia group versus the mild preeclampsia group. There were no differences in 6MWT distance between severe and mild preeclampsia. The presence of preeclampsia was correlated with a reduction in the 6MWT distance of 99.6 m (R ² 98.5%, CI -53, -146 m, p <0.001). There were no significant differences in PPAQ responses between the preeclampsia and control groups.
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Davies <i>et al.</i> , (1999), UK, case study	1	33	29	Woman with twin pregnancy	Objective, chronic	A 33-year-old woman athlete with a personal best time of 2 hours 36 min for the marathon before conception was studied. Following an after-conception examination by an obstetrician, she decreased her weekly running distance from 155 km/week at a heart rate of 140–180 beats/min prior to conception to an average of 107±19 km/week at 130–140 beats/min during pregnancy. A submaximal treadmill test was done at 29 weeks antepartum that included 4 continuous incremental stages each of 4 min duration at 3.33–4.17 m/s for the determination of metabolic and cardiorespiratory parameters.	The woman exercised until 35 weeks of gestation, and stopped exercising after the diagnosis of cholestasis 3 days before an elective C-section at 36 weeks. Fetal anthropometric and haemodynamic data were normal (birthweights 2.21 and 2.3kg). Maternal blood pressure was stable throughout pregnancy. During and after pregnancy metabolic and cardiorespiratory responses to submaximal exercise were augmented likely due to a reduction in biomechanical running efficiency mediated by a lumbar lordosis and a 7 kg increase in body mass, but otherwise intensive endurance training had no negative impact on maternal or fetal health.	Bailey <i>et al.</i> , (1998). Endurance training during a twin pregnancy in a marathon runner. <i>Lancet</i> , 351(9110), 1182.
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Devoe <i>et al.</i> , (1987), USA, Observational	Group 1: 50, Group 2: 50	Group 1: 20.7±5.0, Group 2: 23.1±4.2	Group 1: 38.2±3.1, Group 2: 38.8±2.2	Women with high-risk conditions including IUGR, postdates, diabetes mellitus, hypertension, decreased fetal movement and decreased amniotic fluid volume	All women were high risk, but randomized into 2 groups to complete the alternating protocol of ambulation and bed rest or <i>vice versa</i> .	Objective, acute	Case 1: Regular exerciser before pregnancy, primary modes of weight control were vomiting and exercise. During pregnancy, she continued to jog 4-5 per week in the first 4 months of gestation, decreasing to 3-4 times per week in the 5th and 6th months, but	No differences between groups in incidence of C-section, APGAR scores, fetal distress, perinatal death, IUGR, post-maturity syndrome, or birth weight between groups. The incidence of fetuses with significant variable or late decelerations ranged from 12% to 18% during any 30-minute session and was most frequently associated with post-maturity syndrome (seven cases). Thirteen fetuses in each group exhibited occasional late or variable decelerations during one or more of their 30-minute test segments. These fetuses experienced post-maturity (group 1: 5 vs. group 2: 2), fetal distress (4 vs. 6), IUGR (1 vs. 1), and 5 min APGAR score <7 (1 vs. 1).
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Ertan <i>et al.</i> , (2004), Germany, Observational	Study : 10, Contr ol: 33	Not report ed	T3	Women with IUGR	Diagnosed as fetal abdominal circumference <5th percentile for gestational age	Objective, acute	All women completed an exercise protocol during T3. The exercise period began with a 3 min acclimatization period (30 W), followed by 10 min of moderate exertion (1.25 W/kg body weight for each woman) on a bicycle ergometer. Immediately after exercise, Doppler flow measurements were taken and FHR was performed for 15 minutes before and after exercise.	In the IUGR group, all fetal aorta RI values after exercise were within the 'threshold' or the pathologic range and did not return to normal values after exercise. Fetal MCA RI was significantly lower than baseline values following exercise and returned to normal levels slower than AGA fetuses. The umbilical artery RI was at 'threshold' in 1 patient, and 'pathological' in 4 patients following exercise in the IUGR group. After exclusion of the 3 cases with 'pathological' umbilical artery RI before exercise, the RI became normal following exercise in the rest of the IUGR group (n=7). FHR and uterine artery RI were unchanged after exercise in the IUGR group. Maternal HR, BP, glucose and lactate responded similarly to exercise in both groups.
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Frankel, (2010), USA, case study	1	25	7 to 23	Women with end-stage cystic fibrosis	Awaiting lung transplant, became pregnant before beginning pulmonary rehabilitation	Objective, chronic	The patient participated in pulmonary rehabilitation from week 7-23 of pregnancy. This included airway clearance, breathing retraining, stretching, strengthening, aerobic training and education.	Declining exercise tolerance	Patient was able to ambulate 20-30 minutes without resting on supplemental oxygen in the first trimester, but by week 22, patient required multiple breaks and a rolling walker to complete 20 minutes of ambulation. Patient increased weight lifted on leg resistance machine by 5-10 lbs until week 16. Her 6MWT distance did not change from weeks 7 to 13. Patient was hospitalized for 2 weeks at week 17 for cystic fibrosis exacerbation and again at week 23 for worsening dyspnea. This admission was followed by a tracheostomy and subsequent mechanical ventilation at week 24. Patient had emergency C-section during surgery. Infant was discharged at 4 months. Patient remained on mechanical ventilation until bilateral lung transplant 3 months postpartum, after which she was discharged, and her 6 minute walk test had returned to pre-pregnancy value.
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Grobman <i>et al.</i> , (2013), USA, RCT	Activity restriction: No activity restriction: 252, 394	Activity restriction: 21 (20-25.5), No activity restriction: 19,720 (19-23)	At measurement: Activity restriction: 20.3 (19.4-21.1), No activity restriction: 19.7 (18.7-20.9)	Women with short cervix (less than 30 mm, 10th percentile)	Asymptomatic women, cervix measured by mid-trimester transvaginal ultrasound	Self-reported, acute	Secondary analysis of an RCT which involved weekly intramuscular 17-alpha-hydroxyprogesterone caproate or placebo. For this analysis, women were asked on a weekly basis whether they had been placed on any form of activity restriction. This included restriction of pelvic (prohibition of sexual activity), work, or non-work activity. "Any activity restriction" was defined as being placed on any type of rest. Partial activity restriction included allowance of some work or non-work activity, whereas complete restriction required all work and non-work activity to cease. The association between activity restriction and preterm birth in women with short cervixes was then investigated.	98% of total cohort (n=657) responded to questions regarding activity restriction	Nearly 40% of women with short cervix were recommended some form of activity restriction. Activity restriction did not reduce the rate of preterm birth in asymptomatic nulliparous women with a short cervix. In fact, PTB was more common among women placed on any activity restriction (37% compared to 17%, P<0.001, OR 2.91, 95% CI 2-4.21). After controlling for treatment group and for the noted demographic and ultrasonographic differences among those with and without activity restriction, PTB remained significantly more common among those placed on any activity restriction (adjusted OR 2.37, 95% CI 1.60-3.53)
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Hackett <i>et al.</i> , (1992), UK, observational	Complicated: Normal uteroplacental flow: 25.1±14, Abnormal uteroplacental flow: 8; Control: 12	Complicated: Normal uteroplacental flow: 25.1±4.7, Abnormal uteroplacental flow: 4.6; Control: 27.7±7.2	Complicated: Normal uteroplacental flow: 34.8±3.5, Abnormal uteroplacental flow: 33.3±4.7; Control: 34.6±2.4	Women with chronic hypertension or SGA, or both.	Additionally women with complications were grouped by abnormal or normal uteroplacental flow.	Objective, acute	Following a 15 minute rest period, all women completed a 50W isometric pedaling exercise on a bed-type ergometer. Before and immediately after the exercise test, blood flow velocities were recorded from the same femoral and uteroplacental arteries.	All participants successfully completed the exercise protocol.	There were no differences between groups in HR in response to exercise. Women with complicated pregnancies and abnormal uteroplacental flows had significantly greater mean change in uteroplacental flow following exercise when compared to women with complicated pregnancies and normal uteroplacental flows. The mean change of all complicated pregnancies was greater than in uncomplicated pregnancies.
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Hernández-Díaz <i>et al.</i> , (2014), USA, Case-control, crossover	Study: 100, Contr ol: 158	Study: 31.5± 5.6, Contr ol: 32.3± 4.8	Study: 33.0±3.3, Control: 32.7±3.3	Women with spontaneous PTB or PPROM	Admitted to obstetric services and diagnosed with PTB or PPROM.	Self-reported , acute	Data were collected through in-person interviews that included questions on close-ended questions on self-declared racial, educational, and economic background; personal and family history of reproductive diseases; and reproductive events during the current pregnancy. Detailed information was collected regarding the transient factors of interest (i.e. heavy physical exertion, sexual activity, skipping meals, eating spicy food, caffeine and alcohol intake, acute infections, use of licit and illicit drugs, traumas, and stressful events) during the 72 h before the onset of painful contractions and/or rupture of membranes. Exercise was coded using the METs. Women were also asked open-ended questions about what they believed initiated PTB or rupture of membranes.
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Associations between exercise and the risk of spontaneous PTB were not significant: *Any exercise*: discordant pair ratio: case 21/17 control, OR: 1.2, CI 0.7, 2.3, and *exercise > 5 METs*: discordant pair ratio: case 9/12 control, OR: 0.8, CI 0.3, 1.8. Distribution of 'any exercise' in the 0-24 and 48-72 hours before spontaneous PTB was 32 and 28% in cases, and 28.5 and 32.9% in controls. Distribution of 'exercise > 5 METs' in the 0-24 and 48-72 hours before spontaneous PTB was 12 and 15% in cases, and 20.9 and 20.3% in controls. Over-exertion (dancing, lifting weight) was a commonly reported theory as the trigger of PTB by patients.

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Hollifield <i>et al.</i> , (1990), USA, case study	1	23	Throughout pregnancy	Pregnant woman with bulimia	Recruited from group therapy for bulimia. Began bingeing and purging at age 15, no history of anorexia.	Self-reported, chronic	Case 1: Regular exerciser before pregnancy, primary modes of weight control were vomiting and exercise. During pregnancy, she continued to jog 4-5 per week in the first 4 months of gestation, decreasing to 3-4 times per week in the 5th and 6th months, but increasing frequency in the 7th month. Patient attempted to counter pregnancy weight gain in 5th month but restricting food and running in 100-degree temperatures. Prior to each prenatal visit, patient would jog to point of exhaustion and restrict food and fluid.		Patient delivered 3713g baby through emergency C-section after prolonged vaginal delivery. Infant showed no health problems at 3 months postpartum.
Hollingsworth & Moore, (1987), USA, observational	Exercise: T1D M: 13, Control: 12; No exercise: T1D M: 21, Control: 8	Exercise: T1DM : 25±4, Control: 26±5; No exercise: T1DM : 25±4, Control: 24±4	Between 21 to 27 and 35 to 38 weeks	Women with insulin-dependent, T1DM	Fasting plasma C-peptide levels <1.0 ng/dl	Objective, chronic	Women enrolled into the study between 21 to 27 weeks and were studied serially until 35 to 38 weeks gestation. All women were given pedometers and asked to keep daily records of exercise and dietary intake. Women in the 'exercise' group were instructed to walk 20 minutes after each meal and to record the pedometer reading for each period and at bedtime. Women in the 'no exercise' group were given no activity instructions but were requested to record the pedometer reading each night at bedtime.	T1DM women in the exercise group walked significantly more than T1DM women in the no exercise group. The T1DM exercise group exercised less than the control exercise group.	Postprandial walking did not improve glycemic control in women with T1DM, but did significantly reduce fasting plasma cholesterol and triglycerides. There were no significant differences in maternal complications between groups. There was an increase in the number of PTB in the exercise control and T1DM women compared to the no exercise control and T1DM women. Hypoglycemia events, usually mild, were similar between T1DM exercise and no exercise groups. C-sections were higher in T1DM but not different between exercise and no exercise groups. Women with T1DM

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who exercised had fewer infants with hypoglycemia, hypocalcemia, hyperbilirubinemia or macrosomia compared to the no exercise group. Exercising women with T1DM had smaller placentas and lower birth weights and lengths (within healthy ranges) compared to no exercise T1DM, but no differences in infant body mass index or placental index.

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<p>Houser <i>et al.</i>, (2015), USA, case study</p>	<p>3 case studies</p>	<p>Case 1: 25, Case 2: 19, Case 3: 29</p>	<p>-</p>	<p>Women with Ebstein's anomaly</p>	<p>Case 1 and Case 2 also had atrial septal defect and Case 3 had patent foramen ovale</p>	<p>Objective, acute</p>	<p>Women with Ebstein's anomaly were assessed for oxygen desaturation with mild activity pre device closure. Case 1 completed leg lifts, Case 2 completed a 6MWT and Case 3 walked 30 yards. Women then underwent catheterization at 18, 28 and 24 weeks respectively.</p>	<p>Preclosure - desaturation with mild activity</p>	<p>Post-closure: Case 1: Desaturated from 87% to 83% after 1 min of leg lifts. Case 2: Desaturated from 92% to 81% on 6MWT. Case 3: Desaturated from 99% to 85% after walking for 30 yards. Post-closure: All three subjects experienced immediate improvement in oxygen saturation and there were no maternal or fetal complications during the procedure. Improvement in systemic arterial saturations persisted through the remainder of the pregnancy, and all subjects experienced an improvement of at least one NYHA functional class post-procedure and following delivery. Case 1 and 3 delivered SGA babies. Case 3 developed PIH and had a PTB. The infant of Case 1 was born with an atrial septal defect, ventricular septal defect and microcephaly.</p>
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Iakovleva <i>et al.</i> , (1990), Russia, observational	Study : 30, Control: 20	16-19	16 - 36	Women with bronchitis, tonsillitis and gastritis	Objective, chronic	Study: Women completed a general exercise programme 20-30 minutes per day every other day. This included breathing and gymnastics exercises as well as cycling at 60-75% of maximal oxygen consumption, for 10-15 minutes. The exercise was supervised 3 times per week. Every 3-4 weeks, physical capacity tests were repeated and the exercise programme was adjusted. Control: Women with respiratory and gastrointestinal disorders continued with standard prenatal care.	Through out the program , the women that were in the test group had no adverse events.	Exercise capacity in the exercise group dropped by 15% over the course of pregnancy. Women in the exercise group had better sleep and improved physical capacity compared to women in the control group. Women in the exercise group delivered at term with no neonatal or maternal complications. In the control group, there were 12 cases of new respiratory illness and 2 had exacerbated illnesses. One woman with exacerbated illness in the control group delivered preterm.
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Kasawara <i>et al.</i> , (2013), Brazil, RCT	Study: 58, Control: 58	Study: <19 = 1(1.7), 20-29 = 21(36.2), 30-39 = 26(44.8), ≥40 = 15(25.9), Control: <19 = 1(1.7), 20-29 = 20(34.5), 30-39 = 31(53.5), ≥40 = 6(10.3)	Study: 17.3±3.4, Control: 18.5±3.4	Women diagnosed with chronic hypertension, a history of PE or both	Between 12 and 20 weeks of gestation. Chronic hypertension defined as BP ≥140/90 mmHg diagnosed before pregnancy or before 20 weeks gestation.	Objective, chronic	All women were not physically active at the time of recruitment. Study: Women engaged in physical exercise on a stationary bicycle once a week for 30 minutes under the supervision of a physical therapist. Women began the intervention between 12 and 20 weeks and continued the exercise until the end of pregnancy. Women were asked to maintain a HR 20% greater than resting values, not surpassing 140 bpm. In the final 2 minutes of exercise, women decreased the speed of cycling to cool down. Women then completed 5 minutes of stretching exercise whilst remaining seated on the bicycle. Control: Women were not engaged in any physical exercise and did not receive information about exercise.	The mean number of exercise sessions performed by the study group was 9.24±7.03. Of the women who performed below the mean value of the group, 14 chose to interrupt exercise due to a change of address or prenatal location.	No complications were observed during exercise sessions, for example hypertensive crisis, hypotension, hypothermia, musculo skeletal lesions or other complications.	There were no differences between the groups regarding mode of delivery, reasons for C-section, and maternal complications. Adjusted multiple regression analysis showed that physical exercise did not represent a risk of neonatal outcomes such as low birthweight, macrosomia, SGA, LGA, or prematurity.	Parent paper of: Kasawara <i>et al.</i> , (2012), Adherence to exercise with bicycle during pregnancy in women with risk of preeclampsia. <i>Pregnancy Hypertension</i> , 2(3), 266-267. Kasawara <i>et al.</i> , (2011), Assessment of physical exercise for pregnant women with risk for preeclampsia development: Preliminary data. <i>Journal of Perinatal Medicine</i> , 39.
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et al.,
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Effects of
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Kim & Park, (2018), Republic of Korea, RCT	Study : 23, Control: 22	Study: 32.22 ±2.58, Control: 31.50 ±4.48	Study: 32.33±2.88, Control: 32.54±3.67	High risk pregnancies admitted to hospital	>24 weeks of pregnancy and hospitalized for more than 2 days, prescribed bed rest	Objective, acute	Study: Exercise was completed in the supine or lateral position on the bed. The aim of the exercise was to increase muscle strength and included isometric and isotonic exercises. The session included 5 min WU, 20 min of strength exercises and WD exercise for 5 min (total 30 min). WU and WD exercise included stretching exercises such as ankle circles, lying high/hip stretch, outer thigh stretch, upper back/neck stretch, calf stretch, shoulder shrugs, and arm circumduction. Main strengthening exercises consisted of leg extension, knee to chest, biceps curls, triceps extensions, upper back exercise, and chest press. Resistance bands were used - 1.8 kg was used on 100% extension of resistance. The exercise protocol was started on Day 3 of admission, and repeated once per day for 4 days. Measurements were taken before, during and after the exercise session. Control: Women received standard prenatal care and completed similar measurements.	69.6% (16 patients) of the participants provided positive subjective evaluations such as "refreshing," "fresh," "sweating on the body," "thought I would be out of breath, but was not," "was sleepy after the exercise," "the exercise intensity and time are appropriate," "my stomach did not feel lumpy after exercise," and "the	Pilot testing was conducted in 5 high risk women, and based on feedback, the number of repetitions in some exercises was reduced from 12 to 6. There were no symptoms of abdominal discomfort or bleeding.	There were no significant differences in uterine contraction frequency between groups and/or exercise. Maternal BP and HR were similar between groups at all phases of the study. The average baseline FHR was higher during exercise than before exercise, and decreased to normal levels after cessation. FHR variability did not differ between the exercise and control group. Physical discomfort was significantly lower in women after exercise compared to the control group. State anxiety was significantly reduced from pre- to post-intervention in the exercise group, but there were no differences between groups. Strengthening exercise has minimal risk and may alleviate psychophysiological side effects of activity restriction.
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Kumareswaran <i>et al.</i> , (2013), UK, observational crossover	10 to 12	33.2±3.7	20±6	Women with well-controlled type 1 diabetes	Women completed a study investigating blood glucose control with continuous subcutaneous insulin infusion and continuous glucose monitoring. Comparisons were then made between women in a controlled study day (including exercise) and free-living day while wearing the continuous glucose monitor. Data extracted is from the latter study i.e. comparison between exercise and no exercise.	Objective, acute	Women were given a continuous glucose monitor for both the controlled study and free living conditions. Women completed a ramped step test (8 minutes of stepping on an elevated platform getting progressively quicker) to enable calibration of accelerometry device. In the controlled study period, all women completed three 20-min self-paced postprandial walks (after breakfast, lunch, and dinner) and two sessions of brisk treadmill walking (in the afternoon and morning). The afternoon treadmill exercise incorporated 25 minute of walking at 4.8 km/h followed by a 5-min rest interval and 25 min at 2.6 km/h at 10% incline. The morning exercise involved two 25 minute sessions of walking at 3.9 km/h with no gradient, separated by a 5-min rest. Data was compared to a 'free living' condition in which women continued to wear a glucose monitor and accelerometer at home for up to 3 days.	Compliance was 100%.	The period of controlled diet and enhanced exercise lowered plasma glucose, with the effect persisting overnight, while avoiding significant hypoglycemia. There were eleven (65%) symptomatic hypoglycemia episodes occurring within 2 hours of moderate intensity treadmill sessions despite setting of basal infusion rates or reduction of preprandial insulin boluses. Additionally there was one episode of hypoglycemia overnight in one subject who also experienced 4 earlier episodes after the afternoon exercise. No event required intravenous dextrose treatment.	Parent paper of: Kumareswaran <i>et al.</i> (2013). Accuracy of Continuous Glucose Monitoring during Exercise in Type 1 Diabetes Pregnancy. Diabetes Technology and Therapeutics: 15(3), 223-229. Murphy <i>et al.</i> (2011). Closed loop insulin delivery protects against nocturnal hypoglycaemia after moderate physical activity in pregnant women with Type 1 diabetes.
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Lau <i>et al.</i> , (1990), Hong Kong, case study	1	33	29	Woman with complete atrioventricular (AV) block	Diagnosed during previous C-section as a result of a contracted pelvis 8 years prior. Patient received permanent pacing at 29 weeks current pregnancy due to recurrent dizziness and exertional dyspnea.	Objective, acute	Patient received permanent pacing using a minute ventilation sensing pacemaker at 29 weeks of gestation. The pacemaker was programmed with a slope of 20, and upper and lower rate of 70 and 125 bpm, respectively. To assess the rate of response of the pacemaker, HR during daily activities is assessed. Testing took place at 31 weeks and included a submaximal exercise test using the Bruce protocol, as well as activities such as climbing stairs or walking in the garden.	After pacing, the patient no longer experienced dizziness and exertional dyspnea was much improved.
Lui <i>et al.</i> , (2011), USA, Retrospective observational	89	28.3±6.3	Not reported	Women with moderate or complex congenital heart disease pre-pregnancy and during T1	Included women with diagnoses of septal defect (surgically repaired, ASD, VSD, AV canal defect), right-sided obstructive lesions (pulmonary stenosis), left-sided obstructive lesion (repaired aortic	Objective, acute	This was a retrospective study of women with congenital heart disease and who had completed cardiopulmonary exercise testing (CPET) within 2 years prior to pregnancy or within the first trimester (72±31 weeks from delivery date). Protocols from participating centres varied, however VO ₂ max was assessed during ramp cycle ergometer or graded treadmill exercise. Patients exercised to symptom-limited maximum. Cardiac, obstetric and neonatal outcomes were identified from records.	HRpeak, %HRmax, and chronotropic index were all associated with a maternal cardiac event during pregnancy. Measures of HR response and VO ₂ peak were not associated with an obstetric event (e.g. preeclampsia). Measures of HR response correlated significantly with a neonatal event; specifically, HRpeak, %HRmax, HRR, and chronotropic index. VO ₂ peak was not significantly related to an adverse neonatal event.

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Medeiros, (2009), Brazil, observational	12	Not reported	24 to 32	Women with chronic hypertension	coarctation, LVOT obstruction, aortic stenosis, mitral stenosis), repaired Tetralogy of Fallot, transposition of the great arteries, Ebstein anomaly, repaired double outlet right ventricle, single ventricle with Fontan physiology.	Objective, acute	Women completed PA on a treadmill for 30 minutes reaching 70% of HRmax. Maternal HR, BP and umbilical artery velocities were taken before and after aerobic activity.	12 out of 17 women recruited completed the exercise protocol.	There were no significant differences between pre- and post-exercise umbilical RI or PI, fetal middle cerebral artery blood flow velocity. Maternal SBP and HR were increased in the sitting position following exercise, but no differences in DBP or MAP or any parameter in the left lateral position were observed.
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Morris <i>et al.</i> , (1956), UK, observational	Study : 19; Control: 21	Not reported	32 - term	Women with mild to severe PE	All women were hospitalized. PE was defined as DBP 85-95 mmHg.	Objective, acute	All groups: Women were asked to pedal against resistance (9 foot-lbs/sec) for 4-5 minutes while maintaining a speed of 10 mph. Women were then stopped for injection for the study procedure before continuing to cycle for 6-9 minutes more. In total, the exercise was on average 450 revolutions in 10-16 minutes, with a working rate of 9 foot pounds per second.	Compliance was excellent in this study.	In both groups, diastolic BP increased significantly during exercise but decreased back to resting level after 5 minutes of exercise cessation. In the pre-eclamptic women, post-exercise blood pressure was lower than their resting value, and was accompanied by an improvement in the uterine clearance rate. FHR did not change significantly in any group immediately following maternal exercise. In both study and control groups, there was either an increase (+5bpm) or no change in FHR following exercise in the majority of patients, however 3 women in the control and 1 woman in the IUGR experienced mild FHR decelerations (-5 bpm from baseline) following exercise. The umbilical artery SD ratio was not different to baseline values following exercise in either group.
Nabeshima <i>et al.</i> , (1997), Japan, Observational	Study : 7; Control: 17	Not reported	36 - 42	Women with IUGR	Fetal weight was estimated as 1.5 SD less than the average gestational weight by ultrasonography and later confirmed as IUGR at delivery	Objective, acute	All women completed a submaximal exercise test. Graded walking on a treadmill was performed, with an upper maternal HR limit of 150 bpm. The test was designed as walking at a speed of 3km/h throughout with modification of incline every 3 minutes. The first stage was walking with 0%, Stage 2: incline was 15%, with an increment of 5% every 3 minutes thereafter. Before and after exercise, women were placed in the semi-recumbent position for monitoring of maternal HR, fetal HR and umbilical artery waveforms. Average test duration was 8.8+2.8 minutes (range 5 to 15).	Mild FHR decelerations (5bpm decrease from baseline) were observed following maternal exercise in both control and IUGR.	

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Narendran <i>et al.</i> , (2005), India, non-randomized intervention	Study : 68; Control: 53	Study: 26.6±3.9; Control: 26.8±4.6	18-20 until term	Women with abnormal Doppler velocimetry score of umbilical and uterine vessels at 20 weeks	Self-reported, chronic	Exercise: Women in the exercise group practised yoga for one hour a day from study entry to delivery. In the first week after enrollment, yoga was taught by a well-trained yoga therapist in groups of 2-8. Yoga practice included physical postures, breathing techniques and meditation. Yoga practice was adjusted over each trimester. Women were asked to practise these techniques at home and were reviewed every 3-4 weeks during their routine antenatal visits. Control: Women walked half an hour twice a day (standard obstetric advice).	Compliance in both the groups was ensured by frequent telephone calls and activity diaries but data not reported	No adverse events related to the practice of yoga in the study group.	When compared to the control group, the study group had significant increases in babies with birthweight ≥ 2.5 kg. Occurrence of complications such as PIH, IUGR, PTB, emergency C-section, and fetal death had lower trends in the exercise group compared to the control, but this was significant at 0.1.
Petrikovsky <i>et al.</i> , (2018), USA, observational	640	22 - 42	36 - 42	Women with indications of decreased fetal movements, advanced maternal age, restricted fetal growth, pre-gestational diabetes and GDM, post term pregnancy, and history of fetal distress during previous pregnancies	Objective, acute	Women completed exercise on a motorized treadmill. This included moderate intensity exercise of a 15 min walk at a speed of 3 mph with an incline of 15% to 25%. Fetal responses to maternal exercise were interpreted as negative (absence of deceleration, possible presence of acceleration), positive (presence of late decelerations and sustained bradycardia) or inconclusive.	.	Positive fetal responses to maternal exercise (i.e. presence of late decelerations and sustained bradycardia) have a high correlation with adverse perinatal outcomes such as category III FHR tracing, 5 min APGAR <7, need for resuscitation or NICU admission, fetal growth restriction and fetal/early neonatal demise.	

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Rafla & Cook, (1999), UK, RCT	Study : Hypertension: 17; IUGR : 18; Diabetes: 9, Control: 193	Mean: 26 (16-36)	Mean: 34 (26-40)	Women with GH, diabetes or IUGR in the 3rd trimester.	Women were excluded from the study if they presented with severe cases of IUGR, diabetes or hypertension.	Objective, acute	After 20 minutes of rest, pregnant women were asked to exercise on an upright cycle ergometer for 5 minutes. Pedalling was kept at a constant rate of 60 revolutions per minute and the work load was increased stepwise each minute until the patient achieved 70% of her HRmax. The exercise was followed by a 30 minute rest period.	FHR did not change significantly in any group immediately following maternal exercise, however in the high-risk pregnancy group, a transient decrease from 148 (115±170) bpm to 141 (70±180) bpm was observed at 16 minutes post-exercise. There were 10 cases of fetal bradycardia following exercise in the IUGR group, however there were no adverse infant outcomes. There was no evidence of ill effect to mother or baby of exercise in women with GH.	Parent paper of: Rafla (1999). The effect of maternal exercise on umbilical artery velocimetry waveforms in intrauterine growth retardation. <i>Journal of Obstetrics and Gynaecology</i> , 19(5), 469-473. Rafla (2000). The effect of maternal exercise on umbilical artery blood flow in pregnancy-induced hypertension. <i>Journal of Obstetric</i>
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Rakhshani <i>et al.</i> , (2015), India, RCT	Yoga: 30; Control: 38	High risk pregnancies	Women with history of poor obstetrical outcomes: yoga=8, control=10; Women twin pregnancies: 4 in each group; Women with extremes of age: yoga=6, control=8; women with obesity: yoga=6, control=7, and women with family history: yoga=6, control=9.	Objective and self-reported, chronic	Women entered the intervention between weeks 13 and 28 (a total of 28 sessions). Exercise group: Women received standard care plus one-hour supervised yoga session three times a week and were instructed to practice the same routines at home. The yoga intervention was selected to include (1) yogic postures, (2) relaxation and breathing exercises, and (3) visualization with guided imagery. Control: Women received standard care plus walking for half an hour in the mornings and evenings - this was the routine antenatal exercise advised by the hospital. Both groups kept a diary of practice and daily physical activity that was checked by research staff during visits to the antenatal department.	There were no reported complaints of the exercise s taught. The visualization and guided imagery exercise s were particularly well received .	All women were able to practice the exercise s.	Women in the yoga group had significantly fewer occurrences of pregnancy induced hypertension ($P = 0.018$), preeclampsia ($P = 0.042$), gestational diabetes ($P = 0.049$), small-for-gestational age ($P = 0.033$) and intrauterine growth restriction ($P = 0.05$) compared to the control group. Additionally, APGAR scores within 1 and 5 minutes of delivery were significantly higher in the yoga group ($P = 0.006$). Three participants in the yoga group experienced PIH and none suffered from preeclampsia or eclampsia. In the control group, there were 11 subjects with PIH, 4 with preeclampsia, and 2 with eclampsia.	Parent paper of: Rakshani <i>et al.</i> , (2012). The effects of yoga in prevention of pregnancy complications in high-risk pregnancies: A randomized controlled trial. <i>Preventive Medicine.</i> 55(4); 333-40.
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Rauramo & Fors, (1988), Finland, observational	PE: 13, Diabete: 11, Chole stasis: 9; Contr ol: 28	PE: 28±4, Diabet es: 27±5, Chole stasis: 28±4; Contr ol: 27±3	PE: 38±1, Diabetes: 35±2, Cholestasi s: 36±2; Control: 35±2	Women with diabetes, PE and intrahepatic cholestasis of pregnancy	There were 8 women with T1DM and 3 with GDM. 7 women had mild PE, defined as BP >140/90 mmHg and 6 women had severe PE, defined as BP >160/110 and proteinuria. 7 of the women received hypertensive medication.	Objective, acute	Between 32 and 40 weeks of pregnancy, pregnant women completed a 6 min exercise test on a cycle ergometer. The aim of the test was to achieve a final maternal heart rate of at least 140 bpm. Measurements of maternal cardiovascular function, placental blood flow and FHR were taken before and after exercise with women lying in 14-degree left lateral recumbent position.	One pre-eclamptic participant showed a decrease in placental blood flow 30 min after exercise (51% of baseline value). She also experienced fetal bradycardia for 6.5 minutes, with a nadir of 60bpm, which was fully recovered at 30 minutes post-exercise. A healthy but IUGR infant was born the next day.	Exercise has no effects on inducing contractions in diabetic, cholestatic, and uncomplicated pregnancies, but uterine activity was elevated following exercise in women with PE. In diabetes and women with cholestasis, exercise caused a significant reduction in FHR post-exercise. FHR variability was unchanged in PE and cholestasis women after exercise, and FHR variability was increased in diabetic pregnancies following exercise. Fetal bradycardia was observed in 2 control, 2 PE, and 1 cholestatic pregnancy during and after exercise. The duration of fetal bradycardia was 3.5 to 6 min with a FHR nadir of 57 to 94 bpm. All groups experienced a non-significant increase in placental blood flow after exercise, but there was a decline in placental blood flow at 30 minutes post-exercise in the diabetic group. All groups had similar maternal cardiovascular responses to exercise, however at 30	Parent paper of: Rauramo. (1987). Effect of short-term physical exercise on foetal heart rate and uterine activity in normal and abnormal pregnancies. <i>Annales Chirurgiae et Gynaecologiae</i> ;76(5), 274-9.
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minutes post-exercise,
the diabetic group had
significantly higher
PVR and lower SV
compared to their
baseline.

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Robbe (1959), Sweden, observational	28	30±6.4 [calculated]	Studied during pregnancy, labour and postpartum	Women with heart disease including mitral stenosis (with and without incompetence), aortic stenosis (with and without incompetence), atrial septal defect, abnormal venous return, persistent ostium atrioventricular and persistent left superior vena cava, ventricular septal defect, pulmonary stenosis, operated patent ductus arteriosus, operated coarctation of the aorta, operated essential hypertension, healed myocarditis.	Objective, acute	All women completed a standardized exercise test on an electronically braked cycle ergometer during and after pregnancy. Each workload lasted for 6 minutes. HR, respiratory frequency, and ECG were monitored intermittently during stepwise increases of workload. Exercise capacity was defined as the absolute workload performed at a heart rate of 170bpm at an approximate steady state (i.e. 10 bpm or less change in HR from the 6-7 minute of work).	The exercise test was performed in all patients without complications.	The exercise capacity in the groups of patients with septal defects, pulmonary stenosis and aortic valvular disease remained approximately constant during and after pregnancy, except in 2 cases complicated by toxemia. In the group of mitral valvular disease, pure or combined with aortic valvular disease, there was a higher mean pulse-rate response to any particular workload during pregnancy as compared with that in the non-pregnant state, thus implying a diminished physical working capacity during pregnancy in these patients.
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Roman <i>et al.</i> , (2018), USA, observational	Low activity: 18, Higher activity: 14	-	23+0 to 32+0	Women with confirmed PPROM	All women received corticosteroids and latency antibiotics. Women were enrolled after third day of admission after intravenous antibiotics.	Objective, chronic	At 3 days after admission, patients were enrolled and provided a pedometer to wear for the duration of their antepartum course. Delivery was planned for 34 weeks as per protocol, unless chorioamnionitis or spontaneous PTB occurred. Women were encouraged to be active at lib and were encouraged to go to the physical therapy gymnasium. Women were then stratified in 2 groups: Low activity < 500 steps a day and Higher activity ≥ 500 steps a day.	No adverse events were identified.	Latency in days with PPROM to delivery were significantly delayed in women with maternal activity ≥ 500 steps a day. No adverse maternal or fetal outcomes were identified.
Saccone <i>et al.</i> , (2018), Italy, RCT	Study: 99; Control: 201	Study: 29.7±5.6; Control: 28.2±6.5	22.4	Women with short cervixes	Transvaginal cervical length less than 25 mm at 18 + 6 to 23 +6 weeks.	Self-reported, chronic	All groups: no activity restriction was prescribed. Women were asked about their activity at the time of randomization and during the 1 month follow up. Women were asked: 'Since the beginning of pregnancy have you exercised in your leisure time, in a supervised program or on your own?' 'If yes, how many days per week did you exercise?' and 'Taking into account the total duration of your physical exercise, how long did you exercise each day?' Women were then grouped as Exercise if they were performing exercise ≥2 days a week for ≥20 min each day and grouped as Control if they were performing exercise < 2 days a week for ≥ 20 min each day. Of the 99 women in the exercise group, 82(82.8%) performed aerobic exercise, including running/jogging, swimming, cycling, and walking, while 17(17.2%) performed anaerobic exercise, including power lifting and sprinting.		In asymptomatic singleton pregnancies with short cervix, performing exercise >2 days a week for >20 minutes does not increase the risk of PTB, but is associated with a non-significant reduction in PTB <37 weeks (adjusted OR 0.65, CI 0.33 to 1.03). There were no significant associations between exercise and NICU admission (adjusted OR 0.78, CI 0.27 to 2.21), neonatal death (adjusted OR 0.80, CI 0.77 to 8.17) or other adverse neonatal outcomes (adjusted OR 0.98, CI 0.42 to 2.30).

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Sechrist <i>et al.</i> , (2015), USA, retrospective cohort	Study : 19; Control: 12	Between 18 and 45		High risk pregnancies admitted to hospital	Women were prescribed with bed rest and hospitalized for at least 1 week. The Study group included 4 twin pregnancies and the Control group included 3 twin pregnancies and 1 triplet pregnancy	Objective, chronic	Study: The Aquatic Exercise Program sessions were conducted by an occupational therapist three times per week, for approximately one hour per session in a heated, indoor pool on the premises of the hospital. Participants were transported via wheelchair to the pool on the hospital campus. The occupational therapist provided sessions that ranged from one to four participants and guided the participants through a series of aquatic exercise, instructing women how to perform specific exercises while immersed in water (e.g., walking, leg lifts, resistive exercises using pool dumbbells). Control: Women did not participate in the program due to non-referral or patient refusal.	Women attended an average of 6 aquatic exercise program sessions (range 3 to 13).	Women who exercised had improved amniotic fluid index and length of gestation compared to those that did not exercise.
Staynova <i>et al.</i> , (2018), Bulgaria, observational	Pre-existing DM: 43, GDM: 56	Pre-existing DM: 30.98 ± 4.85 , GDM: 31.70	Pre-existing DM: T1: 10, T2: 14, T3: 19; GDM: T1: 4, T2: 15, T3: 37	Women with pre-existing T1DM or T2DM	Also included women with GDM	Self-reported, chronic	Women were asked to complete a questionnaire that included questions on sociodemographic and obstetric details, information on self-monitoring of blood glucose, eating habits and PA.		Physical inactivity was observed in both women with pre-existing DM and GDM, however, 72.1% of women with pre-existing DM reported being PA.
Szymanski & Satin, (2019), USA, Observational	10	33±4	30.7±1.4	Women with chronic hypertension	All women were on antihypertensive medication	Objective, acute	Women completed 30 minutes of moderate-intensity (40-59% of heart rate reserve) exercise on a treadmill, during which BP and FHR was observed. Exercise intensity was determined through a maximal exercise test and then individually prescribed. Women then returned to complete the moderate intensity exercise bout. The treadmill speed was 2.7 ± 0.7 mph on average, with a gradient of $0.8 \pm 0.9\%$.	Exercise was well tolerated	Pregnant women with chronic hypertension tolerated moderate-intensity exercise with no adverse changes in uterine artery or umbilical artery blood flow. FHR and biophysical profiles were reassuring after exercise and moderate exercise did not induce extremes of

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maternal blood
pressure.

Ueland <i>et al.</i> , (1972), USA, observational	Study: 21, Control: 6	Study: 23.7±6.1	20-24 weeks: 8, 28-32 weeks: 13, 38-40 weeks: 5	Women with congenital heart disease	NYHA functional status I (n=13) to II (n=8); including mitral, aortic and pulmonary stenosis, mitral or aortic insufficiency, and Starr-Edwards aortic valve.	Objective, acute	Women were studied at one or two of the following period during gestation: 20 to 24 weeks, 28 to 32 weeks, and 38 to 40 weeks. Maternal HR and respiratory rate were measured using brachial artery catheterization with the patient in the supine, lateral, sitting and sitting positions and during exercise. Exercise was completed on a bicycle ergometer at a load of 100 kpm.	Hemodynamic limitations of the women became more apparent with exercise. In normal women, there was a constant increment in cardiac output response to mild exercise (approx. 70-80% increase). In women with mitral stenosis, aortic stenosis and Starr-Edwards valves, the increase in cardiac output during exercise was markedly diminished (half or less than the increment achieved by normal pregnant women). 2 of the 3 patients with pulmonary stenosis had normal cardiac output responses to exercise. Importantly, all women showed completed hemodynamic recovery within 10 minutes of exercise cessation, regardless
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of NYHA functional class or gestational age. Additionally, all women increased their cardiac output during exercise, indicating some cardiac reserve.

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Vladimirov <i>et al.</i> , (2015), Ukraine, RCT	Study : 50, Control: 38	25.7±4.3	20 - 27	Women with 1st degree iron deficiency anemia	Objective, chronic	Study: Women in the exercise group completed medical pole walking daily for 21 days. The women completed the exercise in small groups of 10-12 in the open air and around different routes in the park of the clinic. This was followed the therapeutic exercises the control group also completed. All exercise was completed under the supervision of an instructor. Pole height was individualized according to height. Dosage of medical pole walking was done by selecting the length of the route and determining the interaction between pace of walking and the preset target of 60% maximal HR. An example route was: 1,200 m, flat terrain, walking pace 80–90 steps/min and duration of 25–30 min, followed by 15 min of therapeutic exercises. Control: Women in the control group received a standard program of physical rehabilitation that included gymnastic, walking, massage, and a special diet with iron supplements and vitamins.	110 women were originally recruited into the study, but only 88 completed. Women dropped out of both the exercise and control group due to medical (dizziness, headache, muscle weakness) and personal (dysfunctional or unpleasant feelings) conditions.	Women in the study group had significantly lower HR and BP compared to women in the control at the end of the intervention. The number of FHR accelerations significantly increased in the study group compared to the control group following the intervention. Maternal hemoglobin remained stable before and after the intervention in both control and experimental groups (p=0.651).
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Yeo <i>et al.</i> , (2002), USA, RCT	Study : 8 Contr ol: 8	30±5. 4	<14	Women with a high risk of PIH	Included women with mild hypertensi on, history of PIH, chronic hypertensi on or PE, or a family history of hypertensi ve disorders.	Objectiv e, chronic	Women were recruited before 14 weeks gestation and were randomized to exercise or control. Study: The exercise group engaged in moderate regular exercise for 10 weeks under supervision at an exercise laboratory. Women exercised on a cycle ergometer or motorized treadmill in a thermoneutral environment. Women started with a 5 minute WU followed by 30 min steady state moderate intensity exercise (RPE 13), followed by a 10 minute WD. A motorized treadmill and bicycle ergometer were alternated. Control: Women maintained their normal levels of daily PA. All: All women completed a leisure time PA questionnaire pre- and post-intervention. The questionnaire included items of the type, frequency and amount of time spent on leisure time PA.	Of the possible 30 sessions , 2 participa nts complet ed all 30. Lowest attendan ce was 23 (77%) and average attendan ce was (90%). One participa nt dropped out due to insuffici ent transpor tation.
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Regular moderate
intensity PA during
pregnancy lowered
the diastolic pressure
among pregnant
women at risk of
hypertensive
disorders.

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Zemet <i>et al.</i> , (2018), Israel, observational	Total: 49, Delivery before 37 weeks: 37, Delivery after 37 weeks: 12; Singleton: 23, Twin: 26	Delivery before 37 weeks: 26.0 (24.5±29.1), Delivery after 37 weeks: 26.5 (24.8±30.3)	Women at high risk of PTB	Included women with sonographic cervical length ≤ 20 mm or spontaneous PTB. Women with short cervix were treated with antenatal corticosteroids, vaginal progesterone and tocolysis according to protocol. Also included women with multifetal pregnancies.	Objective, chronic	PA was assessed by continuous use of a smart-band activity tracker. Women were asked to wear the smart band activity tracker continuously (including upon exposure to water), on their wrist, for at least one week including one weekend, and until 3 weeks from recruitment or delivery, whichever came first. No specific recommendations for PA were provided, however all women were asked to stop work upon discharge from hospital.	Participants wore the activity tracker for a median of 15 days (IQR 9.5±21)	The number of steps per day was low in comparison to previously published data in women with no increased risk of PTB. There were no significant differences in the number of steps per day in singleton and multifetal pregnancies. Median steps per day was independently inversely associated with preterm labour after adjustment for maternal age, BMI, gestational age at recruitment, cervical length, cervical dilation and plurality. Steps per day were borderline statistically lower in twins delivering preterm compared to those delivering after 37 weeks.	Zemet <i>et al.</i> (2016). Quantitative assessment of physical activity in pregnant women with high risk for preterm birth—objective evidence for the futility of bed rest. <i>Am J Obstet Gynecol.</i>
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Detailed supporting information

Absolute contraindications

Severe respiratory disorders

Pre-existing respiratory disorders, such as cystic fibrosis, chronic obstructive diseases (COPD) or restrictive lung disease, may increase the risk of maternal and fetal morbidity.[3,79] Specifically, exacerbations of asthma during pregnancy were associated with an increased odds of preterm birth (aOR: 1.21, 95%CI: 1.1-1.4) and hypertensive complications (aOR: 1.35, 95%CI: 1.2-1.6),[3] while the perinatal risks of more severe COPD are less well quantified. Similarly, women with cystic fibrosis may also be at an increased odds of preterm birth and gestational diabetes, but stable disease and better health at preconception may mediate these risks.[6] Restrictive lung diseases, including pulmonary fibrosis, sarcoidosis or pulmonary embolism, are uncommon during pregnancy as the typical age of diagnosis is after childbearing years in women,[7] however limited reports suggest that these women have similar pregnancy outcomes to those of otherwise healthy women.[8]

Asthma is characterized by chronic airway inflammation and affects 9.4% of pregnant women.[1] Asthma can be considered mild (symptoms of cough, wheezing on less than 8 days during previous month, FEV₁ ≥80%, not taking medication), moderate (FEV₁ 60-79%, daily inhaled medication use, symptoms on 8 or more days during previous month), and severe (FEV₁ of <60%, daily oral corticosteroid use).[80] Asthma exacerbations become more common in pregnancy, with up to 52% of pregnant women diagnosed with severe asthma experiencing an event requiring medical intervention, including hospitalisation or prescription of a corticosteroid.[80] Many exacerbations may be precipitated by patients discontinuing medication out of fear of harm to their baby, however, ACOG recommend continuation of a prescription in order to reduce the risk of an adverse asthma event.[81] During an asthma exacerbation, fetal

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hypoxia occurs and may be worsened by compensatory respiratory alkalosis and consequent reduction to placental blood flow. Through these mechanisms, asthma exacerbations may have negative consequences to fetal growth but also placental function, leading to preeclampsia.[3]

COPD is diagnosed by persistent respiratory symptoms and airflow limitation as a result of airway and alveolar abnormalities. Tobacco smoking is the most significant risk factor for the development of COPD, but the disease may also develop from exposure to other noxious particles or gases. The disease is associated with symptoms of dyspnea, cough, sputum production, wheezing and chest tightness and is diagnosed with a post-bronchodilator FEV₁/FVC less than 0.70.[82] The Global Initiative for Chronic Obstructive Lung Disease (GOLD) thresholds are often used to categorize patients based on FEV₁ (% predicted) with ≥ 80 as GOLD 1 – airflow limited but mostly asymptomatic, no physical activity restriction, 50-79 GOLD 2 – moderate – exertional dyspnea, 30-49 GOLD 3 – severe disease, physical activity limited, <30 GOLD 4 – very severe disease, with low quality of life. Additionally the COPD Assessment Test (CAT) can be used to determine the severity of the disease.[83]

Cystic fibrosis is a genetic disorder that leads to the production of thick mucus in respiratory, digestive and reproductive tracts. Previous data from the UK estimates that there are only 30 – 40 pregnancies per year (0.007% of total births) are complicated by cystic fibrosis.[4] The main complications of this disorder are respiratory failure, due to chronic infection or progressive lung destruction, and malnutrition/malabsorption due to pancreatic insufficiency that may be worsened by pregnancy. Additionally, bacterial infections such as *Burkholderia Cepacia* or *Methicillin-resistant Staphylococcus aureus* can cause significant complications for individuals diagnosed with cystic fibrosis, and as such, these individuals with bacterial presence are at greater risk than those without. Women with cystic fibrosis are also more likely to have diabetes mellitus

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at preconception or develop gestational diabetes during pregnancy.[5] As such, women with cystic fibrosis require close prenatal monitoring for clinical degradation.[79] It should be noted that women who have mild-moderate disease prior to pregnancy (i.e. FEV₁ >50%) have an increased likelihood of favourable pregnancy outcomes.[84]

Exercise in women with respiratory disorders

SOCG/CSEP[85-87] consider serious and mild/moderate respiratory disorders absolute and relative contraindications to prenatal exercise, respectively. SMA guidelines recognize only mild/moderate respiratory disorders as a relative contraindication,[88] whereas IOC[89] and ACOG[90] list bronchitis, now considered under the umbrella term of COPD, as a relative contraindication to prenatal exercise.

In general, respiratory disorders induce symptoms of dyspnea, chronic coughing and chest tightness that can be worsened with exertion. Despite this, pulmonary rehabilitation, including aerobic and resistance exercise, is well established to improve symptoms, reduce muscle weakness and exercise intolerance, as well as elevate mood and quality of life in patients with respiratory disorders.[91] Specifically, regular exercise may benefit these patients through improvements in oxidative capacity of skeletal muscles, leading to a reduced ventilatory requirement for a given workload, and subsequent reduction in dyspnea. However, there is limited data regarding the use of pulmonary rehabilitation in pregnant women. Additionally, increased metabolic demands of pregnancy result in physiological adaptation that changes respiratory function at rest and during exercise.[92] In comparison to non-pregnant women, healthy pregnant women have more exaggerated ventilatory responses (such as increased ventilatory equivalent for oxygen [VE/VO₂]) and greater dyspnea during submaximal exercise,[92] and this may be more pronounced in women with respiratory disorders.

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In a series of case reports of women with mild-moderate (FEV₁ >60% predicted) and severe (FEV₁ <60% predicted) interstitial or restrictive lung disease (6 women (7 pregnancies) with diagnoses of pulmonary fibrosis, pneumonitis, sarcoidosis, dermatomyositis, kyphoscoliosis, multiple pulmonary emboli), oxygen saturation was measured at rest and during walking during pregnancy.[93] Oxygen saturation fell by 5-50% in these women during walking exercise. The majority of pregnancies (n=5) were uneventful, however one woman developed gestational hypertension at 35 weeks (desaturation with walking by 5%) and one woman delivered preterm at 31 weeks (desaturation with walking by 50%). It should be noted that all women were given oxygen therapy to recover saturation to 94% during walking upon deterioration; however, maternal desaturation presents a significant risk of fetal hypoxia. These data demonstrate that women with severe respiratory disorders decompensate during physical activity, even in low-intensity walking. As such, oxygen saturation levels should be monitored during prenatal physical activity in any woman with severe respiratory disease, and supplemental oxygen should be readily available should desaturation occur.

There is one case study including physical activity in a pregnant woman with end-stage cystic fibrosis awaiting a lung transplant.[94] The patient participated in pulmonary rehabilitation (including breathing retraining, stretching, aerobic and resistance exercise) between weeks 7 and 23 of gestation. In the first trimester, the patient was able to walk 20-30 minutes without resting on supplemental oxygen and was able to increase the weight lifted in leg exercise by 5-10 lbs in the first trimester. However, her performance declined over the second trimester (up to 22 weeks), and she required multiple breaks and a rolling walker to complete 20 minutes of ambulation. The patient was hospitalized for 2 weeks at week 17 for cystic fibrosis exacerbation and again at week 23 for worsening dyspnea. At week 24, the patient underwent tracheostomy, and during surgery,

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had an emergency C-section. The patient remained on mechanical ventilation until bilateral lung transplant 3 months postpartum, and her infant was discharged at 4 months. It is not possible to determine as to the role, either positive or negative, of physical activity on this patient's course of pregnancy, however, these data do demonstrate that physical capacity diminished across gestation. Furthermore, pancreatic insufficiency associated with cystic fibrosis means that patients require 110-220% of recommended energy requirements for healthy populations of the same sex and age.[95] Coupled with the increased energy demand of pregnancy, women may find it difficult to meet nutritional requirements, potentially resulting in malnutrition and/or inadequate gestational weight gain (GWG).[5] It is therefore important that maternal nutrition and GWG are managed appropriately in pregnant women with cystic fibrosis.

In light of available evidence, we reinforce that severe respiratory disorders should be an absolute contraindication to prenatal exercise. Future research is required to determine the benefits and risks of physical activity in these populations; however, this should be completed under supervision (e.g. medical, kinesiologist), with monitoring (e.g. oxygen saturation, fetal wellbeing) and appropriate safety measures (e.g. supplemental oxygen, pharmacological interventions like bronchodilators, walkers, etc.), and should include exercise that does not exacerbate symptoms.

For women with mild-moderate respiratory disorders, the benefits of prenatal physical activity without a risk of harm have been demonstrated. In a study involving pregnant women with bronchitis and/or gastrointestinal disorders, the exercise group did not experience any adverse respiratory events in response to exercise or any adverse pregnancy outcomes; however, women in the non-exercise control group experienced 12 new cases of respiratory illness, two had exacerbations of illness and one delivered preterm.[96] In light of these potential benefits and limited risks of harm, women with well controlled, mild-moderate respiratory diseases and who

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are asymptomatic should be encouraged to maintain MVPA during pregnancy without contraindication. Women with mild-moderate respiratory disease who experience exacerbations or symptoms or exercise intolerance (undue shortness of breath) should reduce the intensity of exercise, but remain physically active.

Severe congenital or acquired heart disease

Congenital or acquired heart disease (HD) affects 0.4–1.5% of the general population and complicates less than 0.001% of the all pregnancies in the United States.[9,97] This includes a variety of cardiac disorders along a spectrum of severity such as: mitral stenosis (with and without incompetence), aortic stenosis (with and without incompetence), atrial septal defect, abnormal venous return, ventricular septal defects, pulmonary stenosis, operated coarctation of the aorta, healed myocarditis and arrhythmia. Patients with HD are categorized according to the severity of their symptoms using the New York Heart Association (NYHA) functional classification system (Class I – no limitation of physical activity to Class IV – unable to carry out any physical activity without discomfort).[98]

Due to progressive increases in cardiac demand across pregnancy,[99] women with HD can experience exacerbation of disease and a reduction in their NYHA functional class, as well as face increased risks of pulmonary edema, cardiac death,[11] maternal heart failure, arrhythmia, or stroke.[10] Furthermore, adverse neonatal complications, including perinatal death, respiratory distress syndrome, intraventricular hemorrhage, preterm labour, and growth restriction (SGA or IUGR), are more likely in pregnancies complicated by HD.[12] More severe risks are faced by those women with complex HD[10] or those with superimposed preeclampsia,[97] and adverse events are associated with prior cardiac events or arrhythmia, poor functional class, cyanosis, left heart obstruction, anticoagulation therapy, smoking, and multiple gestations.[11]

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Cardiac arrhythmias are the most common adverse cardiovascular event in both women with and without HD (OR: 8.3, 95%CI: 6.7-10.1).[9] Arrhythmia increases the risk of thromboembolic complications and can also trigger maladaptive processes leading to maternal heart failure, and therefore present a significant risk to pregnancy health.[97] Women with any history of arrhythmia have a significantly increased risk of adverse maternal outcomes, including perinatal death (RR: 3.4, 95%CI: 1.0-11.0) and are likely to experience a recurrence or worsening of arrhythmia, even if in sinus rhythm pre-pregnancy.[9]

As consequence of the greater risk to maternal and neonatal health and potential for deterioration of functional status, women with HD are encouraged to undergo pre-pregnancy counselling. Additionally, these women receive increased prenatal monitoring from a multidisciplinary team, including experienced obstetricians and cardiologists.[97] All patients are encouraged to seek advice from their health care provided should they experience new or worsening symptoms (such as palpitations, peripheral edema or increasing dyspnea) during pregnancy. Symptoms of HD are controlled through medication (e.g. beta-blockers), as described elsewhere.[100]

Exercise in women with hemodynamically significant heart disease

Severe and mild/moderate heart disease are considered absolute and relative contraindications, respectively, to prenatal exercise in the SOGC/CSEP guideline.[85-87] Hemodynamically significant heart disease is an absolute contraindication in the ACOG[90] and IOC[89] guidelines however, HD is not specifically listed as a reason for activity restriction in the SMA guideline.[88] Unevaluated maternal cardiac arrhythmia is also an absolute contraindication to prenatal exercise in the ACOG[90] guideline.

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With an increasing literature base demonstrating the benefits of exercise to general health and wellbeing, the American Heart Association (AHA) encourages patients with HD to engage in regular MVPA.[101] Although these recommendations do not specifically cover pregnant women with HD, suggestions for assessment, counselling and promotion provide a sensible approach to encouraging physical activity both prior to and during pregnancy. As such, the AHA statement could be used as a foundation for improving recommendations for prenatal physical activity in women with HD. Despite these recommendations, concerns regarding exercise in individuals with uncontrolled arrhythmia do remain.[101] This population face greater risks during physical activity as a result of exercise-induced changes in autonomic tone, which may lead to ventricular arrhythmias. Exercise recommendations from the European Society of Cardiology for non-pregnant populations with arrhythmias and potentially arrhythmogenic conditions do exist;[102,103] however, these may not be applicable to pregnant women due to established changes in maternal autonomic function.[104]

Hemodynamic limitations of pregnant women with HD become more apparent with exercise. A study including cycling (100 kpm) at different gestational ages (20-24, 28-32 and 38-40 weeks) in women with HD (NYHA functional class I to II – slight limitation of physical activity), demonstrated that cardiac output responses to exercise were markedly diminished (half or less than the increment achieved by normal pregnant women). Importantly, all women showed complete hemodynamic recovery within 10 minutes of exercise cessation, regardless of NYHA functional class or gestational age and all women with HD increased their cardiac output during exercise, indicating cardiac reserve.[105] In another study investigating acute exercise responses in pregnancies complicated by HD (n=28), women completed steady state cycling exercise for 6 minutes at a target heart rate of 170 bpm. All women successfully completed the test without

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complications. The exercise capacity in the groups of patients with septal defects, pulmonary stenosis and aortic valvular disease remained constant during and after pregnancy, except in two cases complicated by toxemia. In women with mitral valvular disease, pure or combined with aortic valvular disease, there was a higher mean pulse-rate response to any particular workload during pregnancy as compared with that in the non-pregnant state. This implied a diminished exercise capacity during pregnancy.[106] In a series of case studies (n=3) in women with Ebstein's anomaly (tricuspid valve insufficiency due to congenital malformation), acute low intensity physical activity (leg lifts or the 6 minute walk test) during pregnancy resulted in marked reductions in oxygen saturation. Women then underwent operative repair in the second trimester, after which responses to physical activity were not reassessed. All women experienced improvements in their NYHA functional status; however, all pregnancies were complicated by adverse neonatal outcomes and it is unclear if the procedure prevented such adverse responses to exercise.[107] These data therefore suggest that women with mild-moderate HD have unimpaired exercise tolerance during pregnancy, but those with more severe forms of HD and exercise intolerance prior to pregnancy may experience adverse responses to MVPA.

Previous research has shown that cardiopulmonary exercise testing (CPET) can provide predictive information regarding pregnancy risks in women with HD,[108,109] and as such, the Task Force on the Management of Cardiovascular Diseases during Pregnancy recommends this practice.[100] A retrospective study of women with HD who completed CPET, prior to or in the first trimester of pregnancy, found that lower peak maternal heart rate and chronotropic index in response to exercise were significantly associated with adverse maternal and neonatal events.[108] Similar findings were identified in a separate study in which a peak maternal heart rate <150 bpm and peak oxygen consumption of <22.0 ml·kg⁻¹·min⁻¹ during CPET resulted in a high probability

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of maternal cardiac and neonatal events during pregnancy (OR: 0.96, 95%CI: 0.93-1.00 and OR: 0.78, 95%CI: 0.64-0.94, respectively).[109] The inability to augment cardiovascular function in response to acute exercise prior to pregnancy highlights that these women with HD may not adapt to the increased cardiac workload of pregnancy, and are therefore face greater risk of adverse outcomes. In addition to predicting risk of complications, completing a CPET prior to pregnancy can demonstrate exercise tolerance. In women with HD who do not have an impaired exercise capacity (e.g. NYHA functional class I or II), data could be used for both preconception and early prenatal exercise prescription. Women with exercise intolerance prior to or in the first trimester of pregnancy (e.g. NYHA functional classes III or IV) should be contraindicated from prenatal physical activity. Higher NYHA functional classes are associated with more severe risks of maternal and neonatal events[10] and as pregnancy often leads to a worsening of functional status,[11] the risks of prenatal exercise in this population likely outweigh the benefits.

Women with NYHA functional class I to II HD should be encouraged to remain physically active within their tolerance levels, but tapering of exercise may be required as pregnancy progresses depending on symptomatology.[105,106] In the rare cases of pregnancy in women with NYHA functional class III to IV HD, exercise intolerance is anticipated and is more severe (e.g. oxygen desaturation, syncope, reduced uteroplacental blood flow, worsening of symptoms and/or symptomatic arrhythmia) [106,107]. As such, women with severe HD should remain contraindicated from prenatal exercise.

Placental abruption

Placental abruption is an obstetric complication in which the implanted placenta is separated from the uterus resulting in significant maternal bleeding, as well as reduced oxygen, and nutrient supply to the fetus. This adverse event occurs in 1% of all pregnancies but is significantly more common in women diagnosed with placenta previa in the third trimester.[42]

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Larger placental abruptions may cause uteroplacental insufficiency, ischemia, chronic hypoxemia or fetal death.[13]

Exercise in women with at risk of placental abruption

Excessive prenatal exercise may be a trigger to placental abruption. Specifically, previous research has demonstrated that 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.[110] However, only 54% of the population engaged in any MVPA in the week preceding placental abruption. Furthermore, the risk of placental abruption was lower among women who were habitually active compared to those who were sedentary.[110] As such, regular prenatal physical activity may mitigate the risk of placental abruption through improved blood pressure control and placental vascular function.[111,112] As such, there is some speculation as to whether avoidance of a potential trigger such as exercise, would only delay (not prevent) the inevitable outcome of placental abruption.[110,113] The understanding of the etiology of placental abruption is limited and more research is required to determine its association to prenatal exercise, but it is plausible that regular physical activity may provide a protective effect against such an event.[110] As such, women who have risk factors that are associated with placental abruption should be encouraged to maintain MVPA within recommended guidelines throughout gestation.

Upon diagnosis of placental abruption engagement in MVPA should be ceased due to the high risks of the condition to both maternal and neonatal health[14]. Any women who experiences vaginal bleeding during or following exercise must stop activity and seek advice from a healthcare provider.[85-87]

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Vasa previa

Vasa previa, affecting 1 in 2,500 births, 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.[17,114] Vasa previa presents significant risks to neonatal mortality as fetal hemorrhage can occur rapidly when membranes rupture. There are no strategies for primary prevention of vasa previa, as risks factors for this complication include *in vitro* fertilization, velamentous cord insertion, placenta previa and succenturiate-lobed and bilobed placentas.[17]

Exercise in women with vasa previa

Vasa previa is not addressed within any Guidelines as a contraindication to exercise in pregnancy, but is a considerable obstetric event that requires discussion. At present, vasa previa is managed through activity restriction and/or hospitalization to allow close surveillance for signs of labour or rupture of membranes in order to prevent fetal hemorrhage. As discussed, activity restriction, or bed rest, does not reduce, and even increases, the risk of adverse maternal and neonatal outcomes;[115-117] however, there is no physiological rationale as to why physical activity may benefit this specific disorder. In fact, the risks drastically outweigh any potential positive health effects, and as such, we recommend that vasa previa should be an absolute contraindication to prenatal exercise.

Uncontrolled type 1 diabetes mellitus

Approximately four pregnancies out of 1000 are complicated by type 1 diabetes mellitus.[18] Women with type 1 diabetes are at greater risk of preterm birth (RR: 7.0, 95%CI: 6.3–7.6), birthweight \geq 4,500 g (RR: 2.3, 95%CI: 1.9–2.9), stillbirth (RR: 4.7, 95%CI: 3.2–7.0), congenital malformations (RR: 1.7, 95%CI: 1.3–2.2) and preeclampsia (18.1% vs. 2.6% in a control population, P : <0.001) when compared to otherwise healthy pregnant women.[19] These adverse outcomes are greater in individuals with poor glycemic control during pregnancy.[19] One

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percentage point increase in first trimester HbA_{1c} levels were associated with increased odds of preterm birth (aOR: 2.5, 95%CI: 1.4–4.3) and perinatal death (aOR: 4.5, 95% CI: 1.1–18.4).[20] Additionally, other maternal factors, such as higher BMI,[20] excessive GWG and elevated triglycerides,[118] increase the risk of adverse outcomes in women with type 1 diabetes.[119] Women with type 1 diabetes who plan their pregnancies, receive pre-conception guidance and complete daily blood glucose monitoring are less likely to experience gestational complications.[19,120] As such, ensuring optimal glycemic control (e.g. HbA_{1c}, avoidance of hypo- and hyperglycemic episodes, daily glucose monitoring and regular clinical assessments of glucose profile) during pregnancy, as well as other interventions that improve overall maternal disease risk profile should be recommended to reduce the incidence adverse gestational outcomes in this population.

Exercise in pregnant women with type 1 diabetes mellitus

Well-controlled type 1 diabetes is not a contraindication to prenatal exercise; however, poorly controlled type 1 diabetes is considered an absolute contraindication in the SOGC/CSEP guideline[85-87] and a relative contraindication in the IOC,[89] SMA,[88] and ACOG[90] guidelines. Both during and after MVPA (as per current prenatal physical activity guidelines), blood glucose levels are reduced, thereby increasing the risk of hypoglycemia in women diagnosed with type 1 diabetes.[121] This is of particular concern when hypoglycemic events occur overnight, as low blood sugars may not be noticed and treated and may lead to more severe consequences such as maternal coma or seizures. As such, fear of post-exercise hypoglycemia is a limiting factor to physical activity in pregnant women with type 1 diabetes.[121] Current data regarding the incidence of post-exercise hypoglycemic events in pregnant women with type 1 diabetes is both limited and conflicting. One study identified no differences between walking (20 minutes, self-paced, after each meal) and control (activities of daily living) groups in the rate of

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hypoglycemic events.[122] In contrast, another study reported that 65% of participants experienced hypoglycemia in the 2-hours following treadmill walking (25-50 minutes, RPE ranging from 7 to 15) despite adjusting insulin dose for the prescribed activity and consumption of oral carbohydrates.[121] None of these events were considered severe (i.e. requiring intravenous dextrose treatment). At present, it is unclear as to whether regular prenatal activity increases the risk of post-exercise hypoglycemia in pregnant women with type 1 diabetes.

The Canadian Diabetes Association provide recommendations for dietary and insulin adjustments before exercise in non-pregnant populations that can reduce the risk of hypoglycemia;[123] however, these have not been verified for use in pregnant women and require further research to confirm their appropriateness in this population. Prior to initiating exercise, women with type 1 diabetes should be adequately prepared to monitor their blood glucose levels during and after activity (if not using a continuous glucose monitor) and have strategies to avoid hypoglycemia (i.e. readily available oral carbohydrates). Additionally, different modalities of physical activity have varying effects on blood glucose levels and certain exercise types may have lower risks of hypoglycemia. Specifically, a recent meta-analysis including data from non-pregnant (mainly male) individuals with type 1 diabetes demonstrated that moderate-intensity, continuous aerobic exercise caused more rapid decline of blood glucose levels (rate of change [ROC]: -4.43, 95%CI: -6.06 to -2.79, P : <0.01), whereas resistance exercise showed more constrained declines (ROC: -2.61, 95%CI: --7.55 to 2.34, P : 0.30), potentially reducing the risk of hypoglycemia.[124] This reduction in risk is hypothesized due to catecholamine release and anaerobic glycolysis, and consequent lactate production, following higher intensity resistance exercise, which inhibits insulin-mediated glucose uptake and stimulates gluconeogenesis.[125] Research in non-pregnant individuals is also investigating the associations between high-intensity

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interval training and avoidance of hypoglycemia through the aforementioned mechanisms.[125] However, data in this area is insufficient in non-pregnant populations[124] and there is minimal information regarding the safety and efficacy of high intensity exercise in otherwise healthy pregnant women. We therefore suggest that further progress must be made in non-pregnant and healthy pregnant populations before high intensity interval training is investigated in pregnant women with type 1 diabetes.

The aims of prenatal exercise in type 1 diabetes are to aid glycemic control and to improve overall health (GWG, lipid profile, vascular function, etc.), ultimately leading to the prevention of pregnancy complications. A recent meta-analysis demonstrated that exercise in non-pregnant individuals diagnosed with type 1 diabetes mellitus can significantly reduce body mass, low-density lipoprotein cholesterol and triglycerides, as well as significantly increase aerobic capacity.[126] No association between exercise and HbA_{1c} was identified in a meta-analysis (MD: -0.11, 95%CI: -0.34 to 0.13, n=473),[126] however, cohort data of 18,028 adults showed an inverse association between physical activity and HbA_{1c}, diabetic ketoacidosis, hypertension, retinopathy as well as microalbuminuria.[127] In pregnant women with type 1 diabetes, exercise alone does not appear to improve glycemic control (HbA_{1c}, mean 24-hr blood or urine glucose, total insulin dose) compared to non-exercising women with type 1 diabetes, but did significantly lower total cholesterol and triglyceride levels.[122] In a cross-over study combining exercise and a nutrition intervention, exercise significantly reduced plasma glucose levels in pregnant women with type 1 diabetes to within target ranges. Importantly, the time spent within hypoglycemic ranges was also lower in the exercise group when compared to the control arm (17 vs. 28%, respectively, $P=0.059$).[121] Although one nocturnal hypoglycemic episode was recorded following exercise, overall data for the cohort demonstrated that nocturnal glucose variability, a

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factor which when increased can elevate risk of overnight hypoglycemia, was almost halved following the exercise and nutritional intervention (0.7 mmol/L, IQR: 0.5-1.1 vs. control: 1.3 mmol/L, IQR: 1.0-1.8, $P=0.022$). Combined, these data suggest that prenatal exercise may have some benefits for blood glucose control in women with type 1 diabetes.

Prenatal exercise does not appear to increase the risk of adverse maternal or fetal outcomes in women with type 1 diabetes. In fact, one study demonstrated fewer infants with hypoglycemia, hypocalcemia, hyperbilirubinemia and macrosomia and no increase in preterm birth, gestational hypertension or premature rupture of membranes in an exercising group *vs.* control group of type 1 diabetics.[122] Additionally, another study did not identify differences in birthweight, placental weight, gestational age at delivery or APGAR score between otherwise healthy and diabetic exercising pregnant women (8 women with type 1 diabetes and 3 women with gestational diabetes mellitus).[128,129] In these women, acute fetal responses to maternal exercise were investigated and demonstrated a small but significant reduction in fetal heart rate (146 ± 6 *vs.* 140 ± 6 bpm) and placental blood flow (94 ± 18 *vs.* 83 ± 16 ml/min/100ml) at 30 minutes post-exercise (moderate intensity), however all values remained within normal ranges.[128,129]

At present, there is a paucity of data investigating the acute and chronic effects of prenatal exercise in women with type 1 diabetes on both maternal and fetal outcomes. The limited published works so far demonstrate that exercise may be beneficial for women with well-controlled type 1 diabetes in both glycemic control and overall health. Women with type 1 diabetes who are physically active may benefit from continuous glucose monitoring and/or an insulin pump to improve glycemic monitoring and control and should be adequately educated in precautionary measures to avoid both post-exercise and overnight hypoglycemia. In pregnant women with type

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1 diabetes that have unpredictable or frequent hypoglycemia, prenatal exercise should remain an absolute contraindication as the risks likely outweigh the benefits in this group.

Intrauterine growth restriction

Intrauterine growth restriction (IUGR) is diagnosed in pregnancies where estimated fetal weight is less than the 10th percentile for gestational age.[21] IUGR affects up to 10% of pregnancies[22] and leads to an increased risk of adverse fetal outcomes, including intrauterine demise, preterm birth, neonatal mortality and morbidity.[23] Furthermore, IUGR has long-term consequences to offspring, including increased risks of neurodevelopmental delays during childhood;[24] and development of cardiovascular disease in adulthood.[25] Many maternal, fetal and placental factors, including, but not limited to, hypertensive disorders of pregnancy, multiple gestation, and uteroplacental insufficiency, may cause growth restriction.[21]

Exercise in pregnant women with IUGR

IUGR is an absolute contraindication to exercise in the SOGC/CSEP,[85-87] and IOC[89] guidelines and a relative contraindication in the ACOG[90] guideline. The SMA[88] guidelines list growth restricted fetus as an absolute contraindication and IUGR as a relative contraindication to prenatal exercise. Concerns of prenatal activity in women with IUGR are related to an exercise-induced reduction in blood flow to the fetoplacental unit, which may further compound impaired fetal growth. However, previous research has shown that bed rest is not beneficial to fetal growth or pregnancy outcomes in women with IUGR.[130]

At present, there is some data regarding acute responses to prenatal exercise in women with IUGR. Immediately following 5 minutes of cycling exercise (approx. 65% max), umbilical artery pulsatility index increased in women with IUGR, whereas it decreased in otherwise healthy pregnant women.[131] In all women, values returned to pre-exercise levels 20 minutes after cessation of exercise. Additionally in this study, 10 cases of fetal bradycardia and 2 cases of absent-

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end diastolic flow in the umbilical artery were observed immediately following exercise in women with IUGR (less than 10th percentile; total n=18).[131,132] These were recovered within 20-30 seconds with no further adverse infant outcomes. Another study including women with fetuses less than 5th percentile showed that 13 minutes of moderate intensity cycling exercise resulted in negative changes in indices of fetal wellbeing.[133] Specifically, fetal aorta resistance index values, that were in the threshold or pathological range prior to exercise, did not return to normal values following exercise and fetal middle cerebral artery resistance index took a longer duration to return to normal levels when compared to healthy pregnancies. However, there were no differences in fetal heart rate in response to exercise or between groups. After exercise, umbilical artery resistance index was at 'threshold' in one patient, and 'pathological' in four patients in the IUGR group, however, no differences in uterine artery resistance were observed. Of note, there were three women with 'pathological' umbilical artery resistance index before exercise, and when excluded from analysis, there were no differences following exercise in the remainder of the IUGR group (n=7). In contrast to the above two studies, no significant differences in fetal heart rate or umbilical artery systolic/diastolic (S/D) ratio following a graded treadmill exercise test (target maternal heart rate 150 bpm, average duration: 8.8±2.8 mins) were observed between healthy pregnant women and women with fetuses that had an estimated weight 1.5 standard deviations below mean weight (n=17 and 7, respectively).[134]

Uteroplacental insufficiency is associated with IUGR. In a study focused solely on pregnancies complicated by uteroplacental insufficiency between 22 and 26 weeks (n=12), women completed cycling exercise on a recumbent cycle ergometer at 10% and 15% of peak power output for 5 minutes. In the group with uteroplacental insufficiency, mean umbilical artery pulsatility index increased in response to exercise whereas it was decreased in the control group of otherwise

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healthy women. Furthermore, three of the women with uteroplacental insufficiency developed transient absent end-diastolic flow in the umbilical arteries after each level of exercise, and two of these pregnancies were later complicated by early-onset IUGR before delivery. In comparison to the control group of women with otherwise healthy pregnancies, women with uteroplacental insufficiency had significantly greater incidence of adverse neonatal and maternal outcomes including IUGR, hypertensive complications, and earlier delivery (40 ± 1.4 vs. 33 ± 3.7 weeks, respectively).[135]

The prevailing literature indicates that some women prenatal exercise may have transient negative consequences to uteroplacental function and indices of fetal wellbeing. Therefore, the risks of prenatal exercise in women with IUGR outweigh the benefits and should be contraindicated from MVPA. However, these women should maintain activities of daily living. In contrast, women with a small for gestational age fetus without evidence of placental pathology may continue to participate in prenatal exercise but close observation for growth restriction or fetal decompensation is required.

Active preterm labour

Preterm birth, affecting 11.1% of livebirths worldwide,[26] is defined as delivery before 37 weeks of gestation and may be result of spontaneous labour, premature rupture of membranes or induction of labour/caesarean delivery for maternal or fetal indications.[36] Infants born preterm face significant acute and chronic health consequences and given the risk of lifelong impairment, is considered one of the largest single chronic health conditions in the World Health Organization Global Burden of Disease.[27] During pregnancy, at least 50% of neonatal deaths are attributed directly to preterm delivery, and additional indirect consequences of prematurity, such as neonatal infections, can further increase the risk of mortality.[27] While the majority of preterm births (60-

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70%) occur between 34 to 36 weeks, more severe prematurity (less than 33 weeks) substantially increases the risk of negative health outcomes for the infant.[27] Regardless, all infants born preterm have an increased risk of chronic lung disease, cardiovascular disease, sensory impairments and impaired neurodevelopment.[27]

The etiology of preterm labour is not well understood, but is considered to be result of multiple mechanisms including infection and inflammation, uteroplacental ischemia, haemorrhage, over distension of the uterus (as experiencing in multiple pregnancies), and stress.[36] Risk factors for preterm labour include prior history of preterm delivery, short cervical length, other pregnancy complications (such as chronic hypertension and preeclampsia) and lifestyle behaviours such as smoking.[53,136] At present, women at risk for preterm labour are recommended progesterone supplementation and receive additional screening and monitoring,[136] but there is no other treatment to prevent this adverse event. Activity restriction may be recommended, but has been consistently demonstrated to be ineffective at reducing risk of negative maternal and neonatal outcomes,[115-117,137] and can even increase the risk of preterm labour in women in developed countries.[117]

Exercise in women with or at risk of preterm labour

Preterm labour is an absolute contraindication to prenatal exercise in all Guidelines.[85-90] Additionally, a history of spontaneous preterm birth is considered a relative contraindication in some guidelines.[85-89] ACOG recommend that women with such a history of preterm birth reduce their physical activity in the second and third trimester.[90] Uterine contraction increases across the course of normal pregnancy;[138] however, regular and painful premature contractions are a precursor to preterm labour. Women experiencing regular and painful uterine contractions should cease exercise and seek advice from a healthcare provider.[85-87]

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Despite having many known maternal benefits for the mother, early researchers suggested that prenatal exercise may increase the risk of spontaneous preterm labour; however this has not been clearly evidenced in the literature. A recent meta-analysis including over 10,000 women demonstrated no association between prenatal exercise and the odds of preterm birth (OR: 1.00, 95%CI: 0.85-1.18).[139] There have been four reports of threatened preterm labour during or following physical activity,[140] however, no association has been identified between spontaneous preterm labour and exercise in the 72 hours prior to the event.[141] Furthermore, there were no changes in uterine activity following acute exercise in women with preterm labour.[142] In contrast, a study using recall data demonstrated that the immediate risk spontaneous preterm delivery was significantly greater within an hour of MVPA (RR: 5.82, 95%CI: 4.29-7.36) compared to light exertion or rest.[143]

Prenatal exercise was theorized to cause spontaneous preterm labour through decreased uteroplacental blood flow and/or increased uterine activity via exercise-induced release of catecholamines, as well as mechanical stimulation of the uterus.[144] In contrast, a meta-analysis of empirical data in otherwise healthy pregnant women demonstrated no significant changes in umbilical or uterine blood flow during or following acute and chronic exercise;[145] however, these responses may differ in women with complicated pregnancies.[131,132]

Data regarding the effect of exercise on uterine activity is conflicting. A previous investigation in otherwise healthy women at term have demonstrated a 5.5-fold increase in uterine contraction frequency and pressure during strenuous activity (20 minutes, 140 bpm, cycling)[144] and maximal exercise[146] with rapid return to baseline values in recovery. Modest, but significant increases in uterine contraction frequency in the third trimester, have also been observed in low-intensity physical activity, such as walking.[147] Under more scrutiny, the mode of exercise may

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influence uterine contractions. In low-risk pregnant women, exercise completed at the same relative intensity resulted in greater incidence of elevated uterine activity in upright cycling (50% sessions), treadmill exercise (40% sessions) and rowing ergometer (10% sessions), but not during recumbent cycling and arm ergometry (0% sessions).[148] In high-risk women admitted to hospital, a randomized controlled trial comparing rest to an exercise intervention including whole-body isometric and isotonic resistance exercises completed in the supine or lateral position did not induce any changes in uterine contraction frequency.[149] These findings were also supported by an observational study including a similar population and similar exercise.[150] Furthermore, other pathology may increase the risk of uterine contractions in pregnant women. Acute cycling exercise (6 minutes, 140 bpm) increased uterine activity in preeclamptic women, but not in women with uncomplicated, diabetic or cholestatic pregnancies.[128] As such, low-impact, reclined exercise may be more appropriate for those with premature contractions. Regarding the influence of exercise-induced catecholamine release on uterine activity, previous research in otherwise healthy pregnant women has shown that acute increases in contractions during exercise, that increased in relation to intensity,[151] were recovered to resting values post-exercise[152,153] and were not associated with increased uterine contraction.[151] As such, current data lead to the suggestion that mechanical stimulation of the uterus during prenatal exercise may lead to increased contractions.

A recent observational study of physical activity in women at risk for spontaneous preterm labour (including women with short cervix and previous spontaneous preterm birth) found that steps per day were significantly lower in women who delivered before 37 weeks, compared to those who delivered after 37 weeks.[154] Furthermore, activity restriction in women between 23 and 33 weeks with documented uterine contractions >6/hour at admission had no beneficial effect

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on reducing adverse maternal and neonatal outcomes in comparison to no activity restriction.[137] These data support that activity restriction does not reduce the risk of spontaneous preterm labour,[115,116] and that ambulation may prolong gestation and reduce the risk of adverse neonatal outcomes.

Indeed, women who are in active preterm labour should be contraindicated from prenatal exercise; however, physical activity does not increase the odds of spontaneous delivery before 37 weeks, and may even prolong gestation in women at high risk for preterm labour. As such, we recommend that women at risk of spontaneous preterm labour (including those with a history of preterm birth), but without conditions that could be further exacerbated by exercise, should be encouraged to remain physically active. Further research, including randomized controlled trials, is required to elucidate the benefits and/or risks of increasing ambulation and low-intensity exercise (such as recumbent cycling or resistance exercise) in women at risk for preterm birth.

Severe preeclampsia

Preeclampsia is the development of hypertension with proteinuria, maternal organ dysfunction or uteroplacental dysfunction.[155] Preeclampsia affects up to 8% of all pregnancies[28] and occurs as a consequence of inadequate placentation in early pregnancy. The syndrome has a spectrum of severity, with more significant consequences to maternal and fetal health when diagnosed at an earlier gestational age at diagnosis and/or with increasing symptoms such as eclampsia, abnormal liver enzymes or platelet counts.[28,156] After diagnosis, the only “cure” for preeclampsia is delivery; and as such, infants of women diagnosed with preeclampsia are more likely to be delivered small for gestational age (aOR: 2.81, 95%CI: 1.89-4.18), preterm (aOR: 7.05, 95%CI: 5.14-9.68)[31] and also require admission to the neonatal intensive care unit.[32] Additionally, diagnoses of preeclampsia are associated with increased risk of maternal

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cardiovascular morbidity in the 5-15 years following delivery (including future heart failure [RR: 4.19, 95%CI: 2.09–8.38] and stroke [RR: 1.81, 95%CI: 1.29–2.55]), [29,30] as well as adverse childhood outcomes such as lower cognitive functioning.[33] Avoiding the progression to, and reducing the impact of preeclampsia is imperative to the health of two generations.

Exercise in pregnant women with hypertensive disorders of pregnancy

Preeclampsia is an absolute contraindication to prenatal exercise in all Guidelines.[85-90] However, the Canadian Hypertensive Disorders of Pregnancy Working Group stated that strict bed rest in women with preeclampsia who are hospitalized should not be recommended.[157] This shift in management of preeclampsia leads to further consideration of physical activity in this population.

A small number of studies have assessed maternal and fetal outcomes following prenatal exercise in women with preeclampsia. An RCT including hospitalized women with preeclampsia, as well as other conditions such as gestational hypertension, IUGR, multiple pregnancies or threatened preterm birth demonstrated that muscle conditioning exercise did not cause any adverse changes in maternal blood pressure, uterine contractions or vaginal bleeding when compared to women who did not exercise.[150] Furthermore, an observational study including women with mild to severe preeclampsia found that post-exercise diastolic blood pressure was significantly reduced below resting values and uterine clearance rate was improved following 10-16 minutes of cycling.[158] Additionally, maternal cycling exercise (6 mins; target maternal heart rate: 140 bpm) in women with preeclampsia (n=13) did not affect mean fetal heart rate, but increased uterine blood flow, although non-significantly. However, in this study, fetal bradycardia was observed in five women out of the total 61 participants: two women in the control group, two women with preeclampsia and one woman with cholestasis, but fetal heart rate fully recovered after 6 minutes.[128,129] One of these preeclamptic women also experienced a reduction in placental

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blood flow at 30 minutes post-exercise (51% of baseline value) and the patient delivered a healthy but IUGR infant the next day. The overall data suggests that some women with mild-moderate preeclampsia (i.e. absence of IUGR) may benefit from prenatal exercise without compromise to fetal wellbeing; however, it must be reinforced that a minority of women with severe forms of the syndrome (i.e. with IUGR) may experience transient adverse outcomes following physical activity. In support of this, data from another study including women with chronic hypertension, preeclampsia and/or small for gestational age infants showed that complicated pregnancies with abnormal uteroplacental waveforms at rest had significantly greater uteroplacental resistance following cycling exercise at 50 W when compared to complicated pregnancies with normal resting waveforms.[159] As such, future work is required to assess uteroplacental and fetal outcomes in response to maternal exercise in women with preeclampsia.

Animal models of preeclampsia have shown that prenatal exercise creates a pro-angiogenic state, improves placental efficiency and lowers blood pressure through alterations in the renin-angiotensin system.[160] Similar effects of regular physical activity have been observed in normotensive pregnant women,[111,161] although these investigations have not yet been completed in women with preeclampsia. At present, more research regarding prenatal exercise in women with preeclampsia is desperately needed: focus on fetal and uteroplacental responses to acute exercise, as well as chronic effects on health outcomes for both mother and baby should be prioritized. Until better-designed studies are conducted in this population, severe preeclampsia should remain an absolute contraindication to prenatal exercise. However, in line with Canadian Hypertensive Disorders of Pregnancy Working Group recommendation to avoid bed rest, women should be encouraged to maintain activities of daily living at minimum.

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doi:10.1136/bjsports-2020-102042**Cervical insufficiency**

Cervical insufficiency describes a structural and functional deficit of the cervix that is typically characterized 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. This cervical dilation can lead to pre-viable delivery and as such, presents significant risks to fetal health.[34,35] This complication is typically characterized by painless cervical dilation occurring in the absence of other pathology (e.g. ruptured membranes or bleeding) in an otherwise normal pregnancy.[162] Contemporary diagnosis of cervical insufficiency requires a cervical length <25 mm before 24 weeks of singleton pregnancy and with 1 or more prior spontaneous preterm births; however, traditionally, there was no consistent definition and was diagnosed as any cervical dilation.[162] Cervical insufficiency arises from a variety of acquired (uterine activity, overdistension, intraamniotic inflammation and/or prior surgery) and congenital causes (collagen vascular disorders or genetic factors).[162] Additionally, prior diagnosis of cervical insufficiency increases the recurrence rate in subsequent pregnancies.

Exercise in women with short cervix

All Guidelines consider cervical insufficiency (in some form) as an absolute contraindication, however the definition of this varies between each governing body: incompetent cervix or cerclage in ACOG,[90] cervical insufficiency or cerclage in IOC[89], and incompetent cervix in the SMA[88] and SOGC/CSEP[85-87] guidelines. We recommend that future Guidelines should consistently use ‘cervical insufficiency’ in accordance with updated diagnostic criteria.[162]

A concern of prenatal physical activity in women with cervical insufficiency is the induction of spontaneous preterm labour, and as such, activity restriction has been recommended.

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There is no data investigating the effect of prenatal physical activity on outcomes in women with cervical insufficiency. As such, without any evidence of benefit and substantial potential risk of harm, women with this complication should avoid MVPA during pregnancy.

Cervical cerclage is also mentioned by some Guidelines as a contraindication to prenatal physical activity. Cerclage provides mechanical support to the cervix and has been shown to prolong pregnancy,[163,164] and as such, is considered a treatment option for women with cervical insufficiency.[165] Heavy physical exertion or impact exercise may indeed present a theoretical risk of stitch rupture and as such, should be avoided. However, women with cervical insufficiency should be advised to maintain activities of daily living, and potentially, to complete light upper-body resistance exercise or stretching, but avoid MVPA. These recommendations would also apply to women with a prophylactic or rescue cervical cerclage in place.

Relative contraindications

Preterm premature rupture of membranes

Preterm premature rupture of membranes (PPROM), occurring in up to 3% of all pregnancies, is defined as spontaneous rupture of the membranes before 37 weeks' gestation at least 1 h before the onset of labour.[36,37] After PPRM, most women begin spontaneous labour within several days, and as such, up to 40% of preterm births are preceded by membrane rupture.[39] PPRM, especially at earlier gestations, can lead to severe neonatal morbidity, including pulmonary hypoplasia, and mortality associated with prematurity.[40] Furthermore, intraamniotic infection, a cause of PPRM, can increase the risk of long term complications in infants, such as cerebral palsy (OR: 2.42; 95%CI: 1.52–3.84).[38] Women who experience PPRM undergo expectant management, involving prolonging latency until approximately 32

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weeks through corticosteroids and antibiotics, as well as other treatments to promote fetal neurodevelopment.[39]

Exercise in women with PPRM

Women with persistent loss of fluid from the vagina (indicating rupture of the membranes) should stop exercise and seek immediate advice from a healthcare provider.[85-87] Ruptured membranes are an absolute contraindication to prenatal exercise in the IOC[89], ACOG,[90] SMA,[88] and SOGC/CSEP guidelines.[85-87]

In relation to the development of PPRM, risk factors include intraamniotic infection, a history of ruptured membranes or preterm labour, short cervix, second and third trimester bleeding, as well as smoking.[166] Intraamniotic infection, which is polymicrobial in origin,[39] is unlikely to be influenced by prenatal physical activity. As discussed in previous sections, regular prenatal exercise may be beneficial for women with some of these complications. As such, regular physical activity could reduce the incidence of PPRM mediated through these pathways and women with these risk factors should remain physically active throughout pregnancy. In support of this, an observational study including women with a history of spontaneous preterm birth and/or PPRM demonstrated no association between prenatal exercise and risk of preterm labour.[141]

As part of expectant management for women with PPRM, activity restriction was often recommended under the basis that it may promote amniotic fluid accumulation and thereby, prolong latency.[37] However, a randomized controlled trial comparing bed rest (activity restriction) and physical activity (no activity restriction; recommended to walk 20 mins at least 3 times per day) found no differences in amniotic fluid index, latency or maternal and neonatal outcomes between groups.[37] In this study, physical activity had no negative impact on pregnancy outcomes, and activity restriction had no beneficial effect. In contrast, an observational study of

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women with confirmed PPROM demonstrated a significantly longer latency in women with some physical activity (≥ 500 steps per day) compared to those with lower activity (< 500 steps per day), and again, no adverse maternal or fetal outcomes were identified.[167] MVPA is also speculated to induce PPROM through an increase in the release of inflammatory cytokines, shear stress and oxidative stress.[143] However, low intensity, longer duration activity, such as walking, is not associated with such acute responses in other non-pregnant populations,[168,169] although this would need to be verified in pregnant populations. As such, there is some evidence to support that low-intensity prenatal physical activity, such as walking, in women with PPROM does not increase the risk of adverse pregnancy outcomes. We therefore suggest that women with PPROM (after full clinical evaluation and without other absolute contraindications) should maintain activities of daily living and low intensity physical activity until delivery.

Placenta previa after 28 weeks

Placenta previa describes a placental implantation that overlies or is within 2 cm of the internal cervical os and 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).[170] Placenta previa is typically resolved by 28 weeks; however, 0.4% of all pregnancies are diagnosed with placenta previa in the third trimester and at this stage in gestation, presents significant risks to both maternal and fetal health. Women with placenta previa are 51.6% (95%CI: 42.7-60.6) more likely to have antepartum and intrapartum hemorrhage that may occur from the placental site, lesions of the cervix and occasionally, the fetus.[171] Additionally, women with placenta previa in the third trimester are 13 times more likely to experience placental abruption (OR: 13.1, 95%CI: 8.2-20.7),[42] and therefore, are at increased risk of preterm birth.

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Placenta previa is an absolute contraindication to prenatal exercise when diagnosed after 28 weeks in the SOGC/CSEP[85-87] and SMA[88] guidelines, and after 26 weeks in the IOC[89] and ACOG[90] guidelines.

Women with placenta previa after 28 weeks face a significantly higher risk of spontaneous labour, and as such, there are no studies investigating physical activity in this population. Given that placental abruption is a significant risk to women with placenta previa in the third trimester, the data discussed previously suggests that regular physical activity may offer a preventative effect.[110] Additionally, it has been demonstrated that bed rest does not reduce the risk of preterm birth,[115,116] and even increases these odds of an earlier delivery in women in developed countries.[117] As such, women with placenta previa in the third trimester (and in the absence of other complications that may be worsened by physical activity) could be recommended low-intensity activity, such as walking to achieve health benefits, without the potential risk of MVPA.

Women with placenta previa and without vaginal bleeding may continue to participate in MVPA until 28 weeks gestation. At 28 weeks, if a repeat ultrasound demonstrates they no longer have placenta previa, women should continue to exercise within current guidelines. However, women with placenta previa after 28 weeks gestation are at risk for spontaneous labour and should refrain from MVPA. However, continuing to engage in activities of daily living and low-intensity activity (i.e. walking) is encouraged.

Untreated thyroid disease

Thyroid disease is the second most common endocrine disorder affecting women of reproductive age after diabetes.[43] Thyroid disease can present as hypothyroidism, where the thyroid gland is not able to produce enough thyroid hormone (up to 0.5% of pregnancies), or as

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hyperthyroidism, where excess thyroid is produced (approximately 0.2% of pregnancies).[43] Interestingly, the symptoms of pregnancy mimic that of thyroid disease, which can mask the development of these disorders. Symptoms of hypothyroidism include: weight gain, decreased exercise capacity, and constipation whereas clinical symptoms of hyperthyroidism include: tachycardia, sweating, increased bowel movements and decreased exercise tolerance.[43] Pregnant women with subclinical and clinical hypothyroidism and/or the presence of thyroid antibodies are associated with an increased risk of preeclampsia (OR: 1.7, 95%CI: 1.1 to 2.6), preterm birth (OR: 1.9, 95%CI: 1.1 to 3.5), and fetal mortality (OR: 2.7, 95%CI: 1.6-4.7) compared to women with normal thyroid function.[44] Clinical hyperthyroidism, although far more uncommon, is associated with GH, maternal congestive heart failure, pregnancy loss, preterm birth, low birthweight, and IUGR;[45] however women with subclinical hyperthyroidism are not at risk of adverse pregnancy outcomes.[172]

Exercise in women with thyroid disease

Well controlled thyroid disease is not a contraindication to prenatal exercise, but uncontrolled thyroid disease is considered an absolute contraindication in the SOGC/CSEP guideline[85-87] and a relative contraindication in the SMA[88] and ACOG[90] guidelines. It is not considered a contraindication to prenatal exercise in the IOC guideline.[89] Main concerns of prenatal exercise in this population arise from the symptoms of thyroid diseases (i.e. chronic fatigue and exercise intolerance) as well as impairments in heart rate (HR) kinetics and muscle dysfunction. In combination with the additional demands of pregnancy, hyperthyroidism-related tachycardia and elevated myocardial workload at rest may lead to maternal heart failure if uncontrolled. In patients with hypothyroidism in which bradycardia is more likely, women may be unable to respond adequately to additional circulatory demands of exercise and of the fetoplacental

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unit. In both instances, maternal cardiac and metabolic function may be impaired and reduce oxygen and nutrient delivery to the developing fetus; however, this has not been investigated.

Previous studies in non-pregnant groups have demonstrated that individuals with subclinical hyperthyroidism have increased resting HR, a reduced cardiac reserve and a higher recovery HR following exercise. As such, these patients will have a reduced exercise capacity and higher perceptions of fatigue.[173] In contrast, patients with subclinical hypothyroidism have significantly lower resting and recovery HR as well as impaired HR kinetics in response to exercise when compared to age- and sex-matched controls.[173,174] The impaired regulatory adjustments to incremental effort may therefore cause women with hypothyroidism to take longer to reach steady state during exercise.[175] Thyroid disease is also associated with weakness in respiratory and skeletal muscles via dysregulation of muscle bioenergetics which may increase perception of effort through elevated breathing intensity.[176] In addition to this, reduced cardiovascular performance may result in impaired oxygen delivery to skeletal muscles, increasing anaerobic glycolysis and elevating metabolites that also contribute to perceptions of fatigue during exercise.[175]

However, thyroid disease is easily treated and managed with medication, removing the potential limitations or concerns of physical activity. As such, women with treated thyroid disease should be encouraged to meet MVPA guidelines. Women with untreated thyroid disease should receive appropriate treatment, and when well controlled, should be encouraged to meet current recommendations.

Eating disorders

Eating disorders, including illnesses such as anorexia nervosa, bulimia nervosa, binge-eating disorder and eating disorders not otherwise specified, affect up to 9% of pregnant

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women.[48] Symptoms of anorexia nervosa and bulimia nervosa, that can be improved, maintained or worsened during pregnancy, lead to both caloric and nutritional deficiencies *in utero* that impair fetal, infant and child development.[50,177] In comparison to otherwise healthy women, both current and previous diagnosis of an eating disorder increased the odds of IUGR (OR: 1.6, 95%CI: 1.3–1.8), SGA (OR: 1.5, 95%CI: 1.2–1.9),[50] postnatal depression (OR: 2.8, 95%CI: 1.2-6.2) and preterm birth (OR: 3.3, 95%CI: 1.3– 8.8).[49]

Exercise in pregnant women with eating disorders

Eating disorders are recognized as a relative contraindication to exercise during pregnancy in the SOGC/CSEP[85-87] and SMA guidelines.[88] Additionally, a BMI of below 12 kg/m² is a relative contraindication by ACOG[90] (one of the diagnostic criteria for anorexia nervosa is BMI below 17.5 kg/m²)[178] and ‘extreme underweight’ is a relative contraindication by IOC.[89] Although the majority of women with current eating disorders are able to reduce their symptoms during pregnancy, in rare cases, some women still exhibit restrictive or compensatory behaviours, including the use of excessive exercise, to control weight and/or to counter binge eating.[179,180] Previous work has shown that high levels of exercise (>1 hour per day of MVPA) are more common in women with current or past eating disorders in the first 18 weeks of pregnancy compared to women without (OR: 1.8, 95%CI: 1.0-3.3 and OR: 1.7, 95%CI: 1.3-2.1, respectively).[181] Treatment of eating disorders during pregnancy therefore requires sensitive and individualized care to reduce or manage symptoms.

Prenatal physical activity may offer general health benefits for women with a past eating disorder, providing that no relapse occurs during gestation. However, the activity levels of women with current severe eating disorders (approx. 0.7% of diagnosed),[48] should be closely monitored across gestation. In such instances or in women with significant symptoms and/or health considerations (i.e. inappropriate GWG), there is considerable concern of the risk of prenatal

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exercise in further caloric restriction for both mother and baby and practitioners should enforce the contraindication.

At present, there is a distinct lack of information regarding the risks of prenatal exercise in women with current or previous eating disorders. As eating disorders are becoming more common in young women, the future number of pregnant women with current or previous diagnoses will increase,[182] therefore, this area requires considerable research to adequately support both the mothers and infants of this population. At present, most data arises from case studies and/or does not investigate the associations between prenatal activity, eating disorder status/symptoms and maternal/fetal outcomes. Future research should objectively quantify physical activity behaviours in pregnant women with symptomatic eating disorders and look to identify if prescribed exercise could be used as a therapeutic approach for illness symptoms (i.e. reduced prenatal depression, improved body image). For women with asymptomatic eating disorders who wish to maintain MVPA during pregnancy, indicating that they should not exercise may exacerbate stress and mental health disorders directly affecting overall health and wellbeing. As such, we suggest that symptomatic eating disorders (i.e. those in which women have inadequate GWG, and are exhibiting excessive restrictive or compensatory behaviours) should be a relative contraindication to prenatal exercise, but physical activity should be encouraged in women with asymptomatic eating disorders.

Malnutrition

Malnutrition in pregnancy presents a considerable risk to maternal and fetal morbidity and mortality.[183] In low-middle income countries, malnutrition may be the result of undernutrition, whereas women in high-income countries may have poor or imbalanced diets, or overnutrition, and such complications arise through a variety of factors including socioeconomic status and food insecurity.[183] As such, malnutrition includes under- and over-nutrition, women in all BMI

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categories (including obesity) and women who have nutrient deficiencies (such as anemia). From each perspective, malnutrition results in adverse outcomes during pregnancy. As over-nutrition (obesity) and nutrient deficiencies (anemia) are discussed later in this manuscript, we will focus on the impact of prenatal under-nutrition in this section. Women with macro- and micro-nutrient deficiencies have elevated cortisol levels and oxidative stress that may contribute to complications such as preterm birth, anemia, pre-eclampsia, maternal hemorrhage, IUGR as well as long term health outcomes for both mother and baby.[183]

Exercise in undernourished pregnant women

Malnutrition is recognized as a relative contraindication to prenatal exercise in the SOGC/CSEP[85-87] and SMA,[88] guidelines. As previously, a BMI of below 12 kg/m² and ‘extreme underweight’ are considered relative contraindications by ACOG[90] and IOC,[89] respectively. Women suffering from multiple deficiencies or chronic under-nutrition are at higher risk for complications and therefore require nutritional intervention.[184] In situations where malnourished women are able to make dietary adjustments or take supplements to receive adequate nutrients, and do not have any other health complications, prenatal physical activity could be recommended. However, in reality, improving nutritional status for many women may not be possible without external support and improvements in food access and availability. Without consideration of nutritional status or overall activity levels on an individualized basis, it is difficult to provide recommendations for prenatal exercise.

As there is significant evidence demonstrating the safety and efficacy of prenatal exercise in women with over-nutrition (or those categorized as overweight and obese), we recommend that undernutrition should be considered a relative contraindication and not the umbrella term of “malnutrition.”

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Smoking during pregnancy is associated with significantly increased risks of stillbirth (OR: 1.47, 95%CI: 1.37-1.57),[52] preterm birth (adjusted OR: 1.8, 95%CI: 1.6-2.0) as well as longer-term adverse health outcomes for offspring such as childhood obesity (OR: 1.55, 95%CI: 1.40-1.73).[53] Data from a recent meta-analysis estimated the prevalence of smoking during pregnancy to be 1.7% (95%CI: 0.0–4.5) of the global population.[51] Of women that did smoke during pregnancy, 72.5% (95%CI: 70.4–75.0) were daily smokers.[51]

One of the most prominent negative effects of maternal smoking is growth restriction of the fetus. Maternal smoking reduces fetal oxyhemoglobin as carbon monoxide has a greater binding affinity to hemoglobin. The increased concentration of fetal carboxyhemoglobin following maternal smoking results in impaired oxygen transport and delivery to fetoplacental tissues, chronic carbon monoxide poisoning and reduced fetal growth.[54] Simultaneously, nicotine causes vasoconstriction and reduced blood flow to the placenta via increased systemic vascular resistance.[185] Consequently, the developing fetus will likely experience hypoxia and subsequent delays to growth and development that lead to significant negative neonatal and childhood health outcomes.[186] Indeed, smoking at any point during pregnancy decreases birthweight by approximately 10–12 g per cigarette/day[55] with the greatest impact in the third trimester (27g for every additional cigarette smoked per day).[187]

Exercise in currently smoking pregnant women

Heavy smoking (> 20 cigarettes per day) is regarded as a relative contraindication to prenatal exercise by ACOG,[90] but is not recognized by other Guidelines around the world. Some previous research has investigated the use of prenatal exercise as a smoking cessation strategy in pregnant women and its success, in comparison to usual care, remains unclear (RR 1.20, 95% CI 0.72 to 2.01).[188] In a RCT, women completing exercise and receiving behavioural

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support for smoking cessation showed no differences in abstinence from smoking, physical activity levels, or adverse health outcomes when compared to women completing behavioural support alone.[189] In addition to the questioned success of exercise as an cessation strategy, previous cohort data demonstrated that women who smoked and exercised during pregnancy had a 30% greater risk of fetal death compared to non-smoking women who did not exercise (87,930 women, adjusted hazard ratio [aHR] 1.3, 95 % confidence interval [CI] 1.03, 1.65); however this analyses was not adjusted for other factors that increase the risk of fetal death such as birthweight and other comorbidities.[190] Additionally, there was no statistical interaction between prenatal exercise and smoking and risk of fetal death on the additive risk scale.

Prenatal exercise can improve placental vascular function as previously discussed,[111] and could be suggested to mitigate the negative consequences of maternal smoking. In contrast to this hypothesis, previous data suggests that placental vascular function is not improved following acute exercise in pregnant women who are current smokers. In a study including non-smoking and smoking women with IUGR (n= 10 and 8, respectively), smokers had higher umbilical resistance both before and following 5 minutes of upright cycling exercise.[131] At present, there is a considerable lack of evidence to support whether prenatal exercise may or may not counteract the physiological impact of continued maternal smoking.[190]

In light of limited evidence of benefit and some evidence of potential harm, 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 fetal growth restriction. In light of this, we recommend that women who are heavy smokers (>20 cigarettes per day) and/or have other comorbidities who wish to participate in MVPA require close observation for the development of fetal growth restriction.

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doi:10.1136/bjsports-2020-102042**Not a contraindication****Chronic hypertension**

Chronic hypertension, defined as blood pressure $\geq 140/90$ mmHg diagnosed prior to pregnancy or up to 19 weeks gestation, complicates 3% to 5% of pregnancies.[56] Diagnosis of chronic hypertension increases a woman's risk of developing preeclampsia (up to 25%),[56] preterm birth (OR: 5.5, 95%CI: 3.2-9.4),[57] placental abruption (RR: 2.4, 95%CI: 2.3–2.5)[58] and congenital malformations (OR: 1.3; 95%CI 1.2-1.5).[59] As such, chronic hypertension during pregnancy is associated with significant risks to both maternal and fetal morbidity. The front-line therapy to treat limit episodes of severe maternal hypertension are antihypertensive drugs.[56] However, despite the benefits of antihypertensive drugs on maternal blood pressure control, the use of such medications do not reduce the risk of pregnancy complications such as preeclampsia (average RR: 0.92, 95%CI: 0.75-1.14) or preterm birth (average RR: 0.96, 95%CI 0.83-1.12).[191] In fact, aggressive anti-hypertensive treatment can increase the risk of fetal growth restriction.[192,193] As such, there is a considerable need for other therapies to manage maternal blood pressure during pregnancies complicated by chronic hypertension.

Exercise in pregnant women with chronic hypertension

Poorly controlled hypertension is considered an absolute contraindication by IOC[89] and SOGC/CSEP[85-87] guidelines, and a relative contraindication in the SMA[88] and ACOG[90] guidelines. This contraindication, however, is not founded on empirical evidence, and does not take into account the well established blood pressure-lowering benefits of exercise in non-pregnant hypertensive individuals.[194,195] In other hypertensive clinical groups, regular physical activity is regarded as a cornerstone therapy for the prevention, treatment and control of hypertension.[195]

Regular prenatal exercise is associated with a ~40% reduction in the odds of developing preeclampsia or hypertension in otherwise healthy women,[196] and exercise is not a contraindication for women who have controlled chronic hypertension during pregnancy.[85-

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88,90] Although the impact of exercise in pregnant women with uncontrolled hypertension has not been examined we can draw some information from non-pregnant hypertensive populations. Acute bouts of physical activity are well established to result in a transient increase in blood pressure, followed by a sustained decrease in blood pressure of approximately 10/7 mmHg for up to 2 hours following cessation of exercise.[197] We postulate that this post-exercise reduction in blood pressure will minimise the duration and exposure of high blood pressures in pregnant women with chronic hypertension, helping to reduce the odds of adverse events. Furthermore, this effect can be achieved following as little as 10 minutes of moderate intensity aerobic exercise[198] with a dose-response relationship.[197]

Previous concerns about exercise in pregnant women with chronic hypertension arise from a study completed by Hackett *et al.*[159] In this study, women with complicated pregnancies (including chronic hypertension, preeclampsia and small for gestational age) had abnormal uteroplacental blood flows following acute cycling exercise (50 W). However, evidence that is more recent has demonstrated no adverse changes in maternal blood pressure, uterine artery or umbilical artery blood flow following moderate-intensity treadmill exercise (30 minutes at 40-59% heart rate reserve) in pregnant women with chronic hypertension only. Furthermore, fetal heart rate and biophysical profiles were reassuring after exercise.[199] These conflicting findings were both reported in very small sample sizes and following acute exercise only; however, a recent meta-analysis demonstrated that regular prenatal activity in women with chronic hypertension did not alter the odds of pregnancy complications such as low birthweight, preeclampsia or preterm birth.[200]

Women with chronic hypertension face an elevated risk of developing co-morbidities, including preeclampsia, of which the underlying pathology may be improved with prenatal

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exercise. Exercise has been suggested to decrease the risk of preeclampsia through increased endothelial NOS expression and NO production and decreased reactive oxygen species in human placenta, thereby improving placental vascular function.[111] In addition, risks factors for preeclampsia, such as maternal obesity, excessive GWG[201] and improvements in skeletal muscle insulin sensitivity and glucose uptake[202] are positively influenced by regular physical prenatal physical activity. As such, the lack of research focus on prenatal exercise in women diagnosed with chronic hypertension is currently impeding its possible therapeutic use in this population.

Worldwide, the prevalence of chronic hypertension in pregnant women is increasing.[56] Many risk factors contributing to both the prevalence of chronic hypertension and associated complications during pregnancy are modifiable through physical activity. With conflicting and low quality evidence in this population, more research is required to determine if prenatal exercise in women with chronic hypertension could benefit both maternal and fetal health outcomes.

Gestational hypertension

Gestational hypertension is defined as systolic or diastolic blood pressure ≥ 140 or 90 mmHg measured after 20 weeks' gestation[155] and affects 30 women in every 1000 deliveries.[60] Women with gestational hypertension have an increased odds of preterm delivery (aOR: 1.82, 95%CI: 1.23-2.68) compared to otherwise healthy pregnant women.[31] Recommendations for management of gestational hypertension include controlling blood pressure levels within a target (systolic between 110 and 140 mmHg; diastolic < 85 mmHg) using antihypertensive medication (limitations discussed previously) as well as regular monitoring for advancing symptoms.[155] In 17% of women diagnosed with gestational hypertension, their disease will progress to preeclampsia,[61] and this advancement is associated with far greater maternal and neonatal consequences.

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Exercise in pregnant women with hypertensive disorders of pregnancy

Gestational hypertension is considered a relative contraindication to prenatal exercise in the SOGC/CSEP guideline,[85-87] but an absolute contraindication in the SMA,[88] ACOG,[90] and IOC[89] guidelines. As discussed in the ‘*Chronic hypertension*’ section, regular physical activity is an important non-pharmaceutical therapy for blood pressure control, and as such, may also benefit women diagnosed with gestational hypertension.[195]

In women with gestational hypertension, no adverse short- or long-term maternal or fetal outcomes (maternal blood pressure, fetal heart rate, umbilical blood flow, birthweight) were observed following 5 minutes of upright cycling at 70% heart rate max.[132,203] In further support, an RCT including hospitalized women with gestational hypertension, preeclampsia, IUGR, multiple pregnancies or threatened preterm birth demonstrated that muscle conditioning exercise did not cause any adverse changes in maternal blood pressure, uterine contractions or vaginal bleeding when compared to women who did not exercise.[150]

In addition to the potential management of blood pressure during pregnancy, these women will also experience the established benefits of prenatal exercise on overall cardiovascular risk profile (e.g. blood glucose) and other co-morbidities (excessive GWG). As such, exercise in women with gestational hypertension may have the potential to prevent disease progression to preeclampsia. The accumulating evidence appears to show that prenatal exercise offers maternal and fetal health benefits, without increased risk of harm, in women with gestational hypertension. We therefore recommend that women with gestational hypertension should not be contraindicated from prenatal physical activity within recommended guidelines.

Obesity

Globally, the proportion of women categorized as overweight or obese has increased drastically over the past 30 years (1980: 29.8%, 95% uncertainty interval [UI]: 29.3-30.2 vs. 2013:

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38.0%, 95%UI: 37.5-38.5).[204] Although the global prevalence of obesity in women is approximately 13%, the number of women with a BMI > 30 kg/m² is significantly greater in developed countries such as the United States (33.9%), Canada (20.5%) and United Kingdom (25.4%).[204] Of particular interest, rapid weight gain is most likely to occur between the ages of 20 and 40 years, reflecting the typical childbearing period in women.[67,204] As such, recent data from the United States shows that 22% of women have obesity during pregnancy.[205]

In women with obesity, primary prevention of comorbidities, such as type 2 diabetes mellitus and hypertension, is a target for lifestyle intervention. However, during pregnancy, the focus of such interventions are realigned to avoid short- and long-term adverse outcomes for both mother and baby.[206] Women with obesity have a significantly greater odds of developing gestational diabetes mellitus (OR: 3.56, 95CI%: 3.05–4.21),[63] gestational hypertension (aOR: 2.5, 95%CI: 2.1-3.0), preeclampsia (aOR: 1.6, 95%CI: 1.1-2.25), and macrosomia (aOR: 1.7, 95%CI: 1.4-2.0) compared to women of a healthy weight.[64] These odds are further increased in women with morbid obesity.[63,64] As such, interventions that reduce the burden of maternal disease and fetal complications in pregnant women with obesity are critical.

Exercise in pregnant obese women

Morbid obesity (BMI > 40 kg/m²) is considered a relative contraindication to prenatal exercise by the ACOG[90] guideline, whereas SMA[88] recognizes this limitation in women at a BMI > 30 kg/m². Obesity is not considered a contraindication to prenatal exercise by IOC[89] or SOGC/CSEP.[85-87] In fact, this Guideline has a strong recommendation that women categorized as overweight or obese (BMI > 25 kg/m²) should be physically active throughout pregnancy due to low quality evidence from randomised controlled trials that regular physical activity evidence leads to improvements in GWG and blood glucose in this population.[85-87]

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In women who are obese prior to pregnancy, the Institute of Medicine recommend a GWG of 5.0–9.0 kg, at a rate of 0.2 kg/week in the second and third trimester.[207] A recent meta-analysis (including data from women with various BMI) demonstrated that regular prenatal physical activity can reduce the odds of excessive GWG (OR: 0.68, 95%CI: 0.59 to 0.78), total GWG (MD: -0.9 kg, 95% CI -1.16, 0.65 kg), and postpartum weight retention (MD: -0.85 kg, 95%CI: -1.46, -0.25).[201] It is possible that prenatal physical activity may be an effective method of weight management in women with obesity through an attenuated positive energy balance.

In addition to the prevention of excessive GWG, prenatal physical activity may reduce the increased risk of gestational complications associated with obesity. A recent meta-analysis including data from women categorized as overweight or obese during pregnancy demonstrated that regular physical activity reduced the risk of preterm birth (RR: 0.62, 95%CI: 0.41–0.95) and gestational diabetes (RR: 0.61: 95%CI: 0.41–0.90) without any risk of adverse fetal outcomes such as low birthweight or stillbirth.[208] The risk of such adverse outcomes may be result of exercise-related improvements in maternal blood glucose control via skeletal muscle uptake and insulin sensitivity,[209] placental growth and vascular function[111,210] as well as reductions in oxidative stress.[112] In addition to these evidence-based benefits, no adverse outcomes of prenatal exercise have been reported in pregnant women with obesity.[206] As such, obese pregnant women should be encouraged to complete regular prenatal physical activity.

Due to hormonally mediated alterations in joint laxity as well as biomechanical stress of gestation (e.g. change in the centre of gravity, isolated anterior loading), pregnant women are more likely to suffer from low back or pelvic girdle pain.[211] This risk may be higher in pregnant women with obesity, as body adiposity is linked to a greater risk of musculoskeletal pain and injury

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in the back, hip, knee ankle and foot due to chronic overloading of connective-tissue structures.[212] As such, exercise that is non-weight bearing, such as aquatic or cycling exercise, should be recommended for pregnant women with obesity experiencing musculoskeletal pain. In support of this suggestion, data from pregnant women categorized as normal weight and overweight demonstrated a substantial reduction in apparent weight when immersed in water up to xiphoid process depth ($82.9 \pm 6.5\%$ less than actual body mass). Additionally, the ground reaction forces measured during water-based exercises in this population were considered low risk for musculoskeletal injuries.[213] However, in the absence of musculoskeletal pain weight bearing exercise may be utilized as previous exercise studies including pregnant women with obesity have used weight-bearing exercise modalities (e.g., walking) without reports of musculoskeletal injury or pain.

Despite the reported health benefits and lack of reported adverse effects of prenatal exercise in this population, previous data has suggested that only 4% of women with obesity meet physical activity recommendations during pregnancy.[206] This very low number may be consequence of the restrictive relative contraindication imposed by SMA[214] and ACOG[90] guidelines; a lack of counselling on physical activity from physicians; as well as poor motivation or compliance to exercise.[206] Firstly, we suggest that obesity, in the absence of other comorbidities that may be negatively influenced by prenatal exercise, should not be considered a contraindication to physical activity during pregnancy. Secondly, further guidance and training on physical activity recommendations specific to this population should be provided for care providers. In dose-response analysis, it was demonstrated that engaging in any prenatal physical activity was associated with health benefits; every minute counts![196,201,215] Finally, in light of the many

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potential benefits of regular exercise in pregnant women with obesity, further research is required to understand how to improve motivation and compliance to physical activity during pregnancy.

Recurrent miscarriage and pregnancy loss

Recurrent miscarriage, defined as the loss of three or more consecutive pregnancies before 24 weeks, affects 1% of couples trying to conceive.[65] Recurrent miscarriages are attributed to genetic, structural, endocrine, immune, thrombophilic or unexplained causes and result in significant burden for women and their partners.[66]

Exercise in women with recurrent pregnancy loss

Recurrent pregnancy loss is a relative contraindication to prenatal exercise in the SOGC/CSEP[85-87] guideline and previous spontaneous abortion is a relative contraindication in the SMA[88] guideline. Fear of miscarriage has been reported as a barrier to prenatal exercise in early pregnancy;[216] however, a recent meta-analysis demonstrated no increased odds of miscarriage (OR: 0.88, 95%CI: 0.63-1.21) or perinatal mortality (OR: 0.86, 95%CI: 0.49-1.52) in pregnant women who exercised compared to those who did not.[217] It should be noted that this included data of spontaneous miscarriage, and not specifically, in women with 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,[65] are non-modifiable, and as such, would not be affected by prenatal exercise.[218] Insulin resistance and increased thyroid antibodies have been observed in women with recurrent pregnancy loss; however, as discussed, prenatal exercise may benefit both of these concerns, as well as reduce overall morbidity risk. Antiphospholipid syndrome is a treatable cause of recurrent miscarriage (i.e., heparin and aspirin). Data from non-pregnant populations suggests such patients have a reduced physical capacity, but still achieve considerable health benefits from exercise.

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Provided women with antiphospholipid syndrome are receiving appropriate treatment, regular physical activity could be maintained.

There is 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 would increase the risk of a loss in this population. Many research studies including prenatal exercise exclude women with recurrent miscarriage as this complication is listed as a contraindication; future studies should remove this restriction. Furthermore, epidemiological research could be used to establish the relationship between prenatal exercise, recurrent pregnancy loss and maternal/fetal outcomes. Additionally, prenatal exercise may benefit factors that increase the risk of miscarriage, such as obesity;^[219] as well as improve general maternal health. In consideration of the above, women with recurrent pregnancy loss should not be contraindicated from prenatal exercise, however, it should be noted that these women might avoid activity due to fear of further miscarriage.

Short cervix

Short cervical length (diagnosed as <25 mm) can increase the odds of spontaneous preterm labour (<26 mm, RR: 9.49, 95%CI: 5.95-15.15);^[35] however, cervical cerclage (stitch) can reduce this risk in both singleton (RR: 0.77, 95%CI: 0.66-0.89)^[163] and twin pregnancies (OR: 0.22, 95%CI: 0.06-0.83).^[164] In isolation, short cervical length in the second trimester is not considered cervical insufficiency, although it would have been included in previous definitions of the complication^[165] and this has led to inconsistencies in diagnosis and prenatal physical activity guideline development.

Exercise in women with short cervix

Terminology surrounding the diagnosis of short cervix, incompetent cervix and cervical insufficiency is inconsistent. Incompetent cervix or cervical weakness is a contraindication in the

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ACOG,[90] SMA[88], and SOGC/CSEP[85-87] guidelines. In previous years, activity restriction was also recommended, but is now discouraged as no beneficial effect has been proven for women with short cervix.[220]

We recommend that healthcare providers differentiate ‘cervical insufficiency’ (diagnosed using updated criteria)[162] from short cervix. A RCT investigating progesterone administration for the prevention of preterm birth in women with short cervix (<30 mm) identified that nearly 40% of asymptomatic women were recommended some form of activity restriction by their healthcare provider.[220] Importantly, activity restriction did not reduce the rate of preterm birth in women with a short cervix, in fact, preterm birth was more common in these women (aOR: 2.37, 95%CI: 1.60–3.53).[220] In further support of these findings, performing exercise >2 days a week for >20 minutes did not increase the risk of preterm birth in women with short cervix (<25mm), but was associated with a non-significant reduction in delivery before 37 weeks (aOR: 0.65, 95%CI: 0.33-1.03). Additionally, a recent observational study found that physical activity (measured in steps per day) was significantly lower in women at risk for preterm birth (including those with cervix <20 mm) who delivered before 37 weeks, compared to those who delivered after 37 weeks (median: 3576 vs. 4544 steps per day, $P=0.02$, respectively).[154] As such, there is a developing base of evidence demonstrating that physical activity has no adverse affect in women with short cervix, and could even delay delivery. More research is required to determine the impact of prenatal exercise on women with cervical insufficiency, as according to strict diagnostic criteria.

We suggest that women with short cervix should be advised to avoid high impact or strenuous physical exertion as a precautionary measure, but in the absence of other complications, should be encouraged to meet current physical activity recommendations in low impact, moderate intensity exercise.

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In the United States, multiple pregnancies made up 3.5% of all pregnancies in 2013 (137,024 out of total 3,923,181), representing a considerable proportion of the pregnant population.[67] Of multiple pregnancies, twins are the most common (96.57%, n=132,324), with the incidence decreasing as the number of multiples increases (triplets: 3.18%, n=4,364; quadruplets and higher: 0.25%, n=336). While the number of women with twin pregnancies is increasing attributed to assistive reproductive therapies the number of higher-order multiple births is reducing as a result of reductions in the number of embryos transferred during *in vitro* fertilization.[221,222] Regardless of multiplicity, women with high-order pregnancies face a significantly greater risk of maternal and infant morbidity and mortality.[221] In comparison to women with singleton pregnancies, women pregnant with twins have double the odds of developing a hypertensive complication,[68] 60% greater odds of postpartum depression,[69] and are 12-times more likely to deliver preterm.[67] Risks of adverse outcomes are even greater in women pregnant with triplets, quadruplets or greater.[70] As such, women with multiple pregnancies are considered high-risk patients.

Exercise in women with multiple pregnancies

Women with multiple pregnancies are contraindicated from prenatal exercise to varying degrees across global Guidelines. Multiple pregnancies at risk of premature labour are considered an absolute contraindication to prenatal exercise by IOC[89] and ACOG,[90] high-order pregnancies (i.e. triplets and above) are an absolute contraindication by SOCG/CSEP,[85-87] whereas twin pregnancy after 28 weeks gestation is considered a relative contraindication for prenatal exercise by SOCG/CSEP[85-87] and SMA guidelines.[88]

Prenatal physical activity is established to have many health benefits to women with singleton pregnancies[139,196,201,215,217,223-226] and similar advantages may be experienced

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by women with multiple pregnancies. Within previous literature, one case study showed that intense exercise in a competitive marathon runner, pregnant with twins, had no adverse effects on either maternal or infant outcomes.[227,228] Additionally, 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). In a study by Sechrist *et al.*, four women with twin pregnancies that were prescribed bed rest by their primary care physician were included in an intervention including an aquatic exercise program. The exercise group had improved amniotic fluid index and longer gestation compared to the control group (that included three twin pregnancies and one triplet pregnancy).[229] Additionally, 26 women with twin pregnancies were included in an assessment of physical activity in women at high risk of preterm birth. In this study, steps per day were lower in twins delivering preterm compared to those delivering after 37 weeks, although this was not significant ($p = 0.09$), likely due to a lack of statistical power.[154] Despite these positive reports, there are additional considerations regarding prenatal activity in twin pregnancy.

Previous reports, although limited, support that physical activity in twin pregnancy may offer health benefits and reduce risks of gestational complications; however, well-controlled investigations into both acute responses and chronic outcomes following exercise in this population are desperately needed. Of note, in each of the studies presented, women with twin pregnancies were physically active beyond 28 weeks gestation.[154,227-229] This is highly important as 92% of obstetricians will prophylactically prescribe activity restriction for women with twin pregnancies.[230] In comparison to normal daily activity, bed rest in twin pregnancy had no beneficial effect on preterm birth, perinatal mortality, premature rupture of membranes, or low birthweight.[115] Furthermore, in addition to the many known adverse effects of activity

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restriction,[230] pregnant women on bed rest were more likely to experience depression and psychological distress.[115] As such, and 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 generalized aches and pains may limit their exercise levels.

At present, there is no published data regarding higher-order multiple pregnancies and prenatal physical activity. This is likely due in combination to the low, and reducing, prevalence of such pregnancies combined with the greater concerns regarding maternal and fetal health.[67] Women with high-order pregnancies may benefit from maintaining their physical activity, but their extreme risk of preterm birth,[70], anatomical (large extended abdomen) and physiological (excessive fatigue and musculoskeletal pain) constraints of higher-order pregnancies must be considered. More research, even through the presentation of case studies, is required to understand the impact of prenatal physical activity in high-order multiple pregnancies. Women with higher-order multiple pregnancies are unlikely to engage in prenatal exercise, but should be encouraged to maintain activities of daily living.

Epilepsy

Approximately 0.3 to 0.5% of pregnancies occur in women diagnosed with epilepsy.[71] Pregnant women with epilepsy should receive frequent monitoring and re-evaluation of anti-epileptic drug therapy to avoid seizures during pregnancy, but in most well controlled cases, epileptic episodes are likely to be unchanged by gestation.[231] When compared to otherwise healthy women, pregnant women with epilepsy have an increased odds of developing hypertensive disorders (OR: 1.37, 95%CI: 1.21-1.55), preterm birth (OR: 1.16, 95%CI: 1.01-1.34) and fetal

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growth restriction (OR: 1.26, 95%CI: 1.20-1.33); however, the development of these complications may be related to the use of anti-epileptic drugs.[72]

Prenatal exercise in women with epilepsy

Regular physical activity is recommended for non-pregnant individuals diagnosed with epilepsy,[232] but poorly controlled seizures are recognized as a relative contraindication to prenatal exercise by IOC[89] and ACOG guidelines.[90]

Physical activity is increasingly viewed as a complementary therapy for epileptic seizure control, although mechanisms behind this benefit remain unclear in humans and may be related to a reduction in epileptiform discharges following exercise,[233] as well as reductions in comorbidities associated with epilepsy.[234] A considerable concern of exercise in women with epilepsy is an increased risk of falling and or traumatic injury to the fetus because of tonic-clonic or atonic seizures and/or those that result in a transient loss of consciousness. In order to reduce a risk of falling, pregnant women with poorly controlled epilepsy should be encouraged to complete their physical activity in a suitable environment, under supervision and using weight-supported activities such as stationary cycling.[235] At present, there is no evidence to suggest that prenatal exercise in pregnant women with epilepsy would have any untoward effect on maternal or neonatal outcomes. In fact, it is likely that this population would experience general, pregnancy- and epilepsy-specific health benefits of regular physical activity. As such, management of the disorder should be prioritized in women with poorly controlled epilepsy, but prenatal exercise should not be contraindicated if appropriate precautions are taken.

Anemia

Iron is a functional component of hemoglobin and myoglobin, and is essential in many physiological functions including respiration, energy production and cell proliferation.[236] Up to 38% (95%CI: 34-43%) of women will experience mild physiologic anemia and/or iron deficiency

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during their pregnancies.[73] Symptoms include fatigue, dyspnea, pallor, weakness, tachycardia or presyncope with more severe symptoms increasing the risk of adverse health outcomes. Iron-deficiency anemia during pregnancy has been associated with preterm birth (RR: 1.56, 95%CI: 1.25–1.95),[75] low birthweight (OR: 1.42, 95%CI: 1.31–1.55), perinatal mortality (OR: 1.73, 95%CI: 1.32–2.26),[76] and placental abruption.[74] Despite these associations, a recent review of randomized controlled trials identified that routine iron supplementation had no or small effects on maternal or fetal outcomes.[237,238] As such, the specific mechanisms behind adverse outcomes in pregnant women with iron-deficiency anemia are not well understood. It should be noted that presence of anemia may indicate other nutritional deficiencies that increase the risk of maternal and fetal complications.[236]

Exercise in pregnant women with anemia

Anemia is considered a relative contraindication to exercise during pregnancy in most guidelines,[85-88] however ‘severe’ anemia is also listed as an absolute contraindication by IOC[89] and ACOG.[90] The relative restriction on maternal physical activity is recommended if a pregnant woman has a hemoglobin concentration of less than 100 g/L [214] or ‘symptomatic’ anemia.[85-87] Concerns regarding prenatal exercise in women diagnosed with iron-deficiency anemia arise from potential limitations in maternal oxygen carrying capacity and consequent oxygen delivery to the fetus. However, these concerns remain to be substantiated within literature.

Evidence remains conflicting as to whether iron deficiency anemia is more prevalent in physically active non-pregnant women compared to their sedentary counterparts.[239] In a randomized controlled trial including resistance exercise 3 times per week in otherwise healthy pregnant women found no differences in the incidence rates of anemia between exercise and control groups.[240] All women included in the trial were taking a 60 mg ferrous iron supplement, and no acute adverse effects of exercise or pregnancy complications were noted in the exercising

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subjects, including those with anemia. It is therefore unlikely that anemia risk and/or symptoms in pregnant women will be worsened acutely or chronically by prenatal physical activity.

During exercise, iron may be lost through sweating, hematuria, hemolysis or gastrointestinal bleeding.[241] However, these consequences may occur as a result of strenuous, prolonged or impact exercise, or exercise in a hot environment, all of which can be avoided during pregnancy. For example, to reduce the risk of exercise-induced hemolysis, women with anemia should avoid running or impact exercise, and complete non-weight bearing exercise such as stationary cycling or swimming. In addition to these potential activity-induced losses in iron, regulation of iron via the peptide hormone, hepcidin, is also influenced in response to exercise. The main function of hepcidin is to reduce plasma iron levels and its production is stimulated by high levels of iron as well as in response to inflammatory markers released during exercise.[236,242] As such, exercise may lead to reduced iron transport and uptake in iron-deficient women via the upregulation of hepcidin. Previous work has shown that normalization of iron stores through supplementation prior to exercise can blunt the exercise-induced hepcidin increase and therefore ameliorate this effect.[242] Strenuous or prolonged exercise can significantly elevate cytokines, a mediator of hepcidin production, whereas shorter duration, less intense activity does not have the same effect.[243] Therefore, prenatal exercise within recommended guidelines (i.e. moderate intensity, 30 minutes per day) is unlikely to increase iron loss or decrease iron availability in anemic pregnant women. However, longer duration high impact exercise such as distance running that substantially exceeds the guideline may exacerbate symptoms in pregnant women with anemia.

At present, there is limited supporting or theoretical evidence to uphold anemia as a contraindication to exercise in pregnancy. Women with a haemoglobin level <100 g/L should

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receive oral iron supplementation and if asymptomatic, should be encouraged to maintain MVPA. If women are symptomatic, they may consider reducing the intensity of prenatal exercise, but should remain physically active to derive health benefits.

Orthopedic limitations

Pregnancy is associated with an increased incidence of orthopedic limitations: up to 25% of women will experience lumbopelvic pain during gestation.[211] This is diagnosed as a dull ache in the lower back or posterior pelvic region that is worsened by repetitive movement.[244] There are many factors leading to the development of lumbopelvic pain during pregnancy, including altered centre of gravity, increased anterior loading and reduced joint stability.[244] Management of this condition typically involves manual massage therapy, stabilization and strengthening exercises for the gluteal muscles, hip extensors and abductors, as well as patient education on the importance of safe exercises and stretching, even in the presence of pain.[244]

Exercise in pregnant women with orthopedic limitations

Orthopedic limitations are considered a relative contraindication to prenatal exercise in the IOC,[89] and ACOG[90] guidelines, but are not listed in SOGC/CSEP[85-87] and SMA[88] guidelines. Previous reports have shown that when lumbopelvic pain is diagnosed during pregnancy, women are less likely to engage with regular physical activity.[245] However, appropriate and considered prenatal exercise can be used as a self-managed therapy to reduce the severity of lumbopelvic pain in these women.[223] Although risk of injury can be increased as a result of orthopedic limitations, movement including stabilisation and strengthening exercises is an important part of pain management for these conditions.[244] Further research is required to determine the most effective prenatal exercise for such orthopedic limitations, however, women should not be discouraged from maintaining activities of daily living at minimum, and could also be encouraged to engage with exercise that avoids loading, develops muscle strength and joint

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stabilization, thereby improving spinal alignment and segmental motion.[223] We thereby suggest that orthopedic limitations should not be a contraindication to prenatal exercise, but a consideration in the prescription of physical activity to women suffering from lumbopelvic pain.

History of extremely sedentary lifestyle

Physical inactivity, or sedentary behavior, is a lack of daily movement and muscular contraction that is associated with prolonged sitting and/or lying. Over 95% of adults in Western countries are insufficiently active [246] and this is associated with increased cardiovascular mortality and morbidity.[247] A recent systematic review identified that pregnant women spent more than 50% of their time engaged in sedentary behaviours, and increasing levels of sedentary behaviour were significantly associated with higher C Reactive Protein, LDL Cholesterol, macrosomia and greater newborn abdominal circumference.[248]

Exercise in pregnant women with history of extremely sedentary lifestyle

Women with a history of extremely sedentary lifestyle are encouraged to start prenatal exercise after consultation with a medical professional by both the ACOG[90] guideline. In contrast, the SOGC/CSEP,[85-87] SMA[88] and IOC[89] guidelines, history of extremely sedentary lifestyle is not a contraindication to prenatal exercise. In fact, the SOGC/CSEP[85-87] guideline has a strong recommendation from moderate-quality evidence that women who were previously inactive should be physically active during pregnancy. Previously inactive women were encouraged to start physical activity in pregnancy but begin gradually, at a reduced intensity and duration, and attempt to meet guidelines as pregnancy progresses.

It is now well established that even a small increase in physical activity in a sedentary individual yields a large risk reduction in cardiovascular disease risk.[249] Thus, ‘any physical activity is better than none.’[249] Therefore, regardless of prior activity status, all women without

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comorbidities or other complications that may preclude them from exercise should engage in physical activity throughout pregnancy.

History of spontaneous preterm labour or fetal growth restriction

Exercise in pregnant women with history of spontaneous preterm labour

History of spontaneous preterm labour is considered a relative contraindication to prenatal exercise in the SOGC/CSEP,[85-87] SMA,[88] and IOC[89] guidelines. History of fetal growth restriction is considered a relative contraindication to prenatal exercise in the IOC[89] guideline.

The previous risks for women with current IUGR or preterm labour have been discussed previously within this review, yet at present, there is no empirical data specifically investigating the association between prenatal exercise in women with a history of spontaneous preterm labour and/or fetal growth restriction. As these factors have previously been listed as contraindications to prenatal exercise, studies have excluded such women from participating in research. More data is required to fully understand the risks of regular physical activity in pregnant women with a history of spontaneous preterm labour or fetal growth restriction and as such, and as such, future studies should remove this restriction. Furthermore, epidemiological or retrospective questionnaire-based research could be used to establish the relationship between prenatal exercise, history of spontaneous preterm labour and/or fetal growth restriction and maternal/fetal outcomes in current pregnancy. In consideration of the above, women with history of spontaneous preterm labour and/or fetal growth restriction should not be contraindicated from prenatal physical activity, but should avoid excessive heavy lifting or high intensity exercise without further evidence of safety.

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Search strategies

Databases

The following databases were searched up to April 5 2019:

- Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R)
- Ovid EMBASE
- Ovid All EBM [Evidence-Based Medicine] Reviews: Cochrane Database of Systematic and Cochrane Central Register of Controlled Trials
- Ovid PsycInfo 1806-Present
- EBSCO CINAHL Plus with Full-text, 1937-Present
- EBSCO Sport Discus with Full-text. 1975-Present
- Scopus, 1960-Present
- Web of Science Core Collection (including Emerging Sources Citation Index) , 1900-Present
- Clinicaltrials.gov

Additionally, the reference lists of all full-text article reviews were screened for relevant information.

Search strategy

OVID (used in Medline, PsycINFO and EMBASE):

1. exp Exercise/ or Athletes/ or exp Exercise Movement Techniques/ or Physical Exertion/ or exp Exercise Therapy/ or exp Sports/ or Motor Activity/ or Sedentary Lifestyle/ or (exercise or physical* activ* or strenuous activit* or physical* inactiv* or sedentary or running or plyometric* or yoga or tai chi or weight training or resistance training or swim* or sport* or athlet* or walk or walking or mvpa or ltpa or stretching or aerobic capacity).ti,kf. or exercise.ab. /freq=2 or physical* activ*.ab. /freq=2 or (weight* adj2 lift*).ti,kf. or ((muscle or muscular or strength*) adj2 conditioning).ti,kf.
2. Pregnancy/ or Pregnant women/ or pregnan*.ti,hw,kf. or exp Pregnancy Trimesters/ or Peripartum Period/ or Postpartum Period/ or (antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper* or primigravid* or primiparous or multiparous or nulliparous or multigravid* or trimester* or obstetric*).ti,kf.
3. 1 and 2
4. ((pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper*) adj5 (exercise or physical* activ* or strenuous activit* or physical inactiv* or sedentary or running or plyometric* or yoga or tai chi or weight training or resistance training or (weight* adj2 lift*) or swim* or sport* or athlet* or walk or walking or ((muscle or muscular or strength*) adj2 conditioning))).ab.
5. 3 or 4
6. pregnancy complications, cardiovascular/ or heart diseases/ or exp heart defects, congenital/ or exp heart valve diseases/ or exp coronary disease/ or exp Arrhythmias, Cardiac/ or hypertension/ or hypertension, pregnancy-induced/
7. (heart disease* or h?emodynamic* or arrhythmia* or coronary or valve insufficiency or hypertensi* or pre-eclampsia or preeclampsia or blood pressure or (heart* adj2 defect*).ti,ab,kf.
8. Uterine Cervical Incompetence/ or (incompeten* adj2 (uterine or uterus or cervix or cervical)).ti,ab,kf.
9. exp Obstetric Labor, Premature/ or ((premature or preterm or pre-term) adj2 (labo?r or birth)).ti,ab,kf.
10. Placenta Previa/ or placenta pr?evia.ti,ab,kf.
11. ((tear* or ruptur* or hemorrhage*) adj2 (placent* or vagin* or membran* or periton*)).mp.
12. (bleed* or hemorrhage).mp.
13. exp abortion, spontaneous/ or (spontaneous abortion or miscarr*).ti,ab,kf.

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14. anemia.sh. or (an?emia or iron deficien*).ti,ab,kf.
15. exp Lung Diseases/
16. exp malnutrition/ or bulimia nervosa/ or anorexia nervosa/ or anorexia/ or bulimia/ or (malnutrition or bulimi* or anorexi*).ti,ab,kf.
17. (((lung or pulmonary) adj2 (disease* or restriction*)) or copd or bronchitis or asthma*).ti,ab,kf.
18. Fetal Growth Retardation/ or ((f?etal or f?etus or intrauterine) adj2 (growth or restrict*).ti,ab,kf.
19. multiple birth offspring/ or quadruplets/ or quintuplets/ or triplets/ or twins.mp. or exp pregnancy, multiple/ or (multiple birth or multiple pregnancy or triplet* or quadruplet* or quintuplet* or twin*).ti,ab,kf.
20. exp Diabetes Mellitus, Type 1/ or pregnancy in diabetics.sh. or ((type 1 or type one) adj diabet*).ti,ab,kf.
21. Hyperthyroid*.ti,ab,kf. or exp HYPERTHYROIDISM/
22. or/6-21
23. 5 and 22
24. Pregnancy Complications.sh. or exp Pregnancy Outcome/
25. 5 and 24
26. 23 or 25
27. (contraindicat* or contra-indicat* or complication* or risk* or safe* or harm* or adverse).ti,ab,kf.
28. 26 and 27
29. animals/ not (animals/ and humans/)
30. 28 not 29

Cochrane Library

- #1 MeSH descriptor: [Exercise] explode all trees
- #2 MeSH descriptor: [Athletes] explode all trees
- #3 MeSH descriptor: [Sports] explode all trees
- #4 MeSH descriptor: [Exercise Movement Techniques] explode all trees
- #5 MeSH descriptor: [Exercise Therapy] explode all trees
- #6 MeSH descriptor: [undefined] explode all trees
- #7 MeSH descriptor: [Motor Activity] this term only
- #8 MeSH descriptor: [Sedentary Behavior] this term only
- #9 (exercise or physical* activ* or strenuous activit* or physical* inactiv* or sedentary or running or plyometric* or yoga or tai chi or weight training or resistance training or swim* or sport* or athlet* or walk or walking or mvpa or ltpa or stretching or aerobic capacity):ti,ab,kw (Word variations have been searched)
- #10 (muscle or muscular or strength*) NEAR2 conditioning
- #11 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10
- #12 MeSH descriptor: [Pregnancy Trimesters] explode all trees
- #13 MeSH descriptor: [Peripartum Period] explode all trees
- #14 MeSH descriptor: [Postpartum Period] this term only
- #15 antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper* or primigravid* or primiparous or multiparous or nulliparous or multigravid* or trimester* or obstetric*
- #16 #12 or #13 or #14 or #15
- #17 #11 and #16
- #18 (weight* near2 lift*) or swim* or sport* or athlet* or walk or walking or ((muscle or muscular or strength*) near2 conditioning)
- #19 MeSH descriptor: [Pregnancy Complications, Cardiovascular] explode all trees

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- #20 MeSH descriptor: [Heart Diseases] this term only
- #21 MeSH descriptor: [Heart Defects, Congenital] explode all trees
- #22 MeSH descriptor: [Heart Valve Diseases] explode all trees
- #23 MeSH descriptor: [Coronary Disease] explode all trees
- #24 MeSH descriptor: [Arrhythmias, Cardiac] explode all trees
- #25 MeSH descriptor: [Hypertension, Pregnancy-Induced] explode all trees
- #26 MeSH descriptor: [Hypertension] this term only
- #27 heart disease* or h?emodynamic* or arrhythmia* or coronary or valve insufficiency or hypertensi* or pre-eclampsia or preeclampsia or blood pressure or (heart* NEAR2 defect*)
- #28 incompeten* NEAR2 (uterine or uterus or cervix or cervical)
- #29 MeSH descriptor: [Uterine Cervical Incompetence] this term only
- #30 MeSH descriptor: [Obstetric Labor, Premature] explode all trees 1803
- #31 (premature or preterm or pre-term) NEAR2 (labor or labour or birth)
- #32 MeSH descriptor: [Placenta Previa] this term only
- #33 placenta previa or placenta praevia
- #34 (tear* or ruptur* or hemorrhage*) NEAR2 (placent* or vagin* or membran* or periton*)
- #35 bleed* or hemorrag* or haemorrhag*
- #36 spontaneous abortion or miscarr*
- #37 MeSH descriptor: [Abortion, Spontaneous] 1 tree(s) exploded
- #38 anemi* or anaemi* or iron deficien*
- #39 MeSH descriptor: [Anemia] explode all trees
- #40 MeSH descriptor: [Lung Diseases] explode all trees
- #41 MeSH descriptor: [Malnutrition] explode all trees
- #42 MeSH descriptor: [Anorexia Nervosa] explode all trees
- #43 MeSH descriptor: [Bulimia Nervosa] explode all trees
- #44 malnutrition or bulimi* or anorexi*
- #45 ((lung or pulmonary) NEAR2 (disease* or restriction*)) or copd or bronchitis or asthma*
- #46 MeSH descriptor: [Fetal Growth Retardation] explode all trees
- #47 (fetal or fetus or foetal or foetus or intrauterine) NEAR2 (growth or restrict*)
- #48 multiple birth* or multiple pregnanc* or triplet* or quadruplet* or quintuplet* or twin*
- #49 MeSH descriptor: [Multiple Birth Offspring] explode all trees
- #50 MeSH descriptor: [Quadruplets] explode all trees
- #51 MeSH descriptor: [Quintuplets] explode all trees
- #52 MeSH descriptor: [Triplets] explode all trees
- #53 MeSH descriptor: [Twins] explode all trees
- #54 MeSH descriptor: [Pregnancy in Diabetics] explode all trees
- #55 (type 1 or type one) NEAR1 diabet*
- #56 hyperthyroid*
- #57 MeSH descriptor: [Hyperthyroidism] explode all trees
- #58 #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57
- #59 #58 and #17
- #60 MeSH descriptor: [Pregnancy Complications] this term only
- #61 MeSH descriptor: [Pregnancy Outcome] 2 tree(s) exploded
- #62 #61 or #60
- #63 #17 and #62

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#64 #62 or #63
 #65 contraindicat* or contra-indicat* or complication* or risk* or safe* or harm* or adverse
 #66 #64 and #65
 #67 animal* or rat*
 #68 #66 NOT #67

SCOPUS

((TITLE-ABS({cardio* pregnancy complication*} OR {heart disease*} OR {congenital heart defect*} OR {heart valve disease*} OR {coronary disease} OR {cardiac Arrhythmia} OR hypertension OR hemodynamic OR coronary OR {valve insufficiency} OR pre-eclampsia OR preeclampsia OR {blood pressure} OR {Cervical Incompetence} OR {uterine incompetence} OR {premature labor} OR {preterm labor} OR {pre term labor} OR {preterm birth} OR {pre term birth} OR {placenta previa} OR hemorrhag* OR bleed OR {spontaneous abortion} OR {spontaneous miscarriage} OR anemi* OR {lung disease} OR malnutrition OR bulimi* OR anorexi* OR copd OR bronchitis OR {pulmonary restriction} OR {pulmonary disease} OR {lung restriction} OR {fetal growth retardation} OR {fetal growth} OR {fetus growth} OR {intrauterine growth} OR {fetal restrict} OR {fetus restrict} OR {intrauterine restric} OR [250] OR quadruplet* OR quintuplet* OR triplet* OR twin* OR {multiple pregnanc*} OR {type 1 diabet*} OR {type one diabet*} OR hyperthyroid)) AND(TITLE-ABS(exercise OR athlet* OR {Exercise Movement Technique*} OR {Physical Exertion} OR {Exercise Therapy} OR sport* OR {Motor Activity} OR sedentary OR [251] OR {strenuous activit*} OR {physical* inactiv*} OR running OR plyometric* OR yoga OR {tai chi} OR {weight training} OR {resistance training} OR swim* OR sport* OR athlet* OR walk OR walking OR mvpa OR ltpa OR stretching OR {aerobic capacity} OR {muscular strength*} OR {muscular* condition})) and (TITLE-ABS(pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or puerper* or {ante partum} or {post partum} or {post natal} or {ante natal} or {pre natal} or {pre-natal} or {post-natal} or {pre-partum} or {pre partum})) OR (TITLE-ABS(primigravid or primiparous or multiparous or nulliparous or multigravid or trimester or obstetric*))AND NOT (TITLE-ABS-KEY(animal or rat or dog))

CINAHL

1. MH (“Exercise+” or “Athletes+” or “Exercise Movement Techniques+” or “Physical Exertion+” or “Exercise Therapy+” or “Sports+” or “Motor Activity+” or “Sedentary Lifestyle+”) or AB (exercise or physical* activ* or strenuous activit* or physical* inactiv* or sedentary or running or plyometric* or yoga or tai chi or weight training or resistance training or swim* or sport* or athlet* or walk or walking or mvpa or ltpa or stretching or aerobic capacity or (weight* n2 lift*) or (muscle or muscular or strength* n2 conditioning)) or TI (exercise or physical* activ* or strenuous activit* or physical* inactiv* or sedentary or running or plyometric* or yoga or tai chi or weight training or resistance training or swim* or sport* or athlet* or walk or walking or mvpa or ltpa or stretching or aerobic capacity or (weight* n2 lift*) or (muscle or muscular or strength* n2 conditioning))

2. (MH (“Pregnancy+” or “Pregnant women+” or “pregnancy trimesters+” or peripartum period or postpartum period)) or (TI (pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper* or primigravid* or primiparous or multiparous or nulliparous or multigravid* or trimester* or obstetric*)) or (MW (pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper* or primigravid* or primiparous or multiparous or nulliparous or multigravid* or trimester* or obstetric*)) or ((AB (pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper* or

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- primigravid* or primiparous or multiparous or nulliparous or multigravid* or trimester* or obstetric*))
3. 1 and 2
4. ((pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper*) W5 (exercise or physical* activ* or strenuous activit* or physical inactiv* or sedentary or running or plyometric* or yoga or tai chi or weight training or resistance training or (weight* W2 lift*) or swim* or sport* or athlet* or walk or walking or ((muscle or muscular or strength*) W2 conditioning)))
5. 3 or 4
6. MH (Pregnancy Complications, Cardiovascular+ or heart diseases or heart defects, congenital+ or heart valve diseases+ or coronary disease+ or Arrhythmias, Cardiac+ or hypertension or hypertension, pregnancy-induced)
7. TI (heart disease* or h?emodynamic* or arrhythmia* or coronary or valve insufficiency or hypertensi* or pre-eclampsia or preeclampsia or blood pressure or (heart* W2 defect*)) or AB (heart disease* or h?emodynamic* or arrhythmia* or coronary or valve insufficiency or hypertensi* or pre-eclampsia or preeclampsia or blood pressure or (heart* W2 defect*)) OR MW (Hypertension, Pregnancy-Induced or heart disease* or h?emodynamic* or arrhythmia* or coronary or valve insufficiency or hypertensi* or pre-eclampsia or preeclampsia or blood pressure or (heart* W2 defect*))
8. (MH (Uterine Cervical Incompetence)) or TI (incompeten* w2 (uterine or uterus or cervix or cervical)) or AB (incompeten* w2 (uterine or uterus or cervix or cervical)) or MW (incompeten* w2 (uterine or uterus or cervix or cervical))
9. (MH (Obstetric Labor, Premature+)) or TI ((premature or preterm or pre-term) w2 (labo?r or birth)) or AB ((premature or preterm or pre-term) w2 (labo?r or birth)) or MW ((premature or preterm or pre-term) w2 (labo?r or birth))
10. (MH (Placenta Previa)) or TI (placenta pr?evia) or AB (placenta pr?evia) or MW (placenta pr?evia)
11. ((tear* or ruptur* or hemorrhage*) w2 (placent* or vagin* or membran* or periton*))
12. bleed* or hemorrhage
13. (MH (abortion, spontaneous+)) or TI (spontaneous abortion or miscarr*) or AB (spontaneous abortion or miscarr*) or MW (spontaneous abortion or miscarr*)
14. MH (anemia) or TI (an?emia or iron deficien*) or AB (an?emia or iron deficien*) or MW (an?emia or iron deficien*)
15. MH (Lung Diseases+)
16. MH (malnutrition+ or bulimia nervosa+ or anorexia nervosa+ or anorexia+ or bulimia+) or TI (malnutrition or bulimi* or anorexi*) or AB (malnutrition or bulimi* or anorexi*) or MW (malnutrition or bulimi* or anorexi*)
17. (((lung or pulmonary) w2 (disease* or restriction*)) or copd or bronchitis or asthma*)
18. MH (Fetal Growth Retardation) or TI ((f?etal or f?etus or intrauterine) W2 (growth or restrict*)) or AB ((f?etal or f?etus or intrauterine) W2 (growth or restrict*)) or MW ((f?etal or f?etus or intrauterine) W2 (growth or restrict*))
19. MH (multiple birth offspring or quadruplets or quintuplets or triplets or twins or pregnancy, multiple+) or TI (multiple birth or multiple pregnancy or triplet* or quadruplet* or quintuplet* or twin*) or AB (multiple birth or multiple pregnancy or triplet* or quadruplet* or quintuplet* or twin*) or MW (multiple birth or multiple pregnancy or triplet* or quadruplet* or quintuplet* or twin*)

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20. MH (Diabetes Mellitus, Type 1+ or Pregnancy in Diabetics) or (TI ((type 1 or type one) w1 diabet*) or (AB ((type 1 or type one) w1 diabet*) or (MW ((type 1 or type one) w1 diabet*)
21. TI hyperthyroidism OR AB hyperthyroidism or MW hyperthyroidism or MH (HYPERTHYROIDISM+)
22. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21
23. 5 and 22
24. MH (Pregnancy Complications+ or Pregnancy Outcome+)
25. 5 and 24
26. 23 or 25
27. TI (contraindicat* or contra-indicat* or complication* or risk* or safe* or harm* or adverse) or AB (contraindicat* or contra-indicat* or complication* or risk* or safe* or harm* or adverse) or MW (contraindicat* or contra-indicat* or complication* or risk* or safe* or harm* or adverse)
28. (S26 AND S27) NOT SU animal*

SPORTDiscus

1. SU (“Exercise+” or “Athletes+” or “Exercise Movement Techniques+” or “Physical Exertion+” or “Exercise Therapy+” or “Sports+” or “Motor Activity+” or “Sedentary Lifestyle+”) or (exercise or physical* activ* or strenuous activit* or physical* inactiv* or sedentary or running or plyometric* or yoga or tai chi or weight training or resistance training or swim* or sport* or athlet* or walk or walking or mvpa or ltpa or stretching or aerobic capacity or (weight* n2 lift*) or (muscle or muscular or strength* n2 conditioning)) or TI (exercise or physical* activ* or strenuous activit* or physical* inactiv* or sedentary or running or plyometric* or yoga or tai chi or weight training or resistance training or swim* or sport* or athlet* or walk or walking or mvpa or ltpa or stretching or aerobic capacity or (weight* n2 lift*) or (muscle or muscular or strength* n2 conditioning))
2. (SU (“Pregnancy+” or “Pregnant women+” or “pregnancy trimesters+” or peripartum period or postpartum period)) or (TI (pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper* or primigravid* or primiparous or multiparous or nulliparous or multigravid* or trimester* or obstetric*)) or (SU (pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper* or primigravid* or primiparous or multiparous or nulliparous or multigravid* or trimester* or obstetric*)) or ((AB (pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper* or primigravid* or primiparous or multiparous or nulliparous or multigravid* or trimester* or obstetric*))
3. 1 and 2
4. ((pregnan* or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper*) n5 (exercise or physical* activ* or strenuous activit* or physical inactiv* or sedentary or running or plyometric* or yoga or tai chi or weight training or resistance training or (weight* n2 lift*) or swim* or sport* or athlet* or walk or walking or ((muscle or muscular or strength*) n2 conditioning)))
5. 3 or 4

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6. SU (Pregnancy Complications, Cardiovascular+ or heart diseases or heart defects, congenital+ or heart valve diseases+ or coronary disease+ or Arrhythmias, Cardiac+ or hypertension or hypertension, pregnancy-induced)
7. TI (heart disease* or h?emodynamic* or arrhythmia* or coronary or valve insufficiency or hypertensi* or pre-eclampsia or preeclampsia or blood pressure or (heart* W2 defect*)) or AB (heart disease* or h?emodynamic* or arrhythmia* or coronary or valve insufficiency or hypertensi* or pre-eclampsia or preeclampsia or blood pressure or (heart* W2 defect*)) OR SU (Hypertension, Pregnancy-Induced or heart disease* or h?emodynamic* or arrhythmia* or coronary or valve insufficiency or hypertensi* or pre-eclampsia or preeclampsia or blood pressure or (heart* W2 defect*))
8. (SU (Uterine Cervical Incompetence)) or TI (incompeten* w2 (uterine or uterus or cervix or cervical)) or AB (incompeten* w2 (uterine or uterus or cervix or cervical)) or MW (incompeten* w2 (uterine or uterus or cervix or cervical))
9. (SU (Obstetric Labor, Premature+)) or TI ((premature or preterm or pre-term) w2 (labo?r or birth)) or AB ((premature or preterm or pre-term) w2 (labo?r or birth)) or KW ((premature or preterm or pre-term) w2 (labo?r or birth))
10. (SU (Placenta Previa)) or TI (placenta pr?evia) or AB (placenta pr?evia) or KW (placenta pr?evia)
11. ((tear* or ruptur* or hemorrhage*) w2 (placent* or vagin* or membran* or periton*))
12. bleed* or hemorrhage
13. (SU (abortion, spontaneous+)) or TI (spontaneous abortion or miscarr*) or AB (spontaneous abortion or miscarr*) or KW (spontaneous abortion or miscarr*)
14. Su (anemia) or TI (an?emia or iron deficien*) or AB (an?emia or iron deficien*) or su (an?emia or iron deficien*)
15. Su (Lung Diseases+)
16. SU (malnutrition+ or bulimia nervosa+ or anorexia nervosa+ or anorexia+ or bulimia+) or TI (malnutrition or bulimi* or anorexi*) or AB (malnutrition or bulimi* or anorexi*) or KW (malnutrition or bulimi* or anorexi*)
17. (((lung or pulmonary) w2 (disease* or restriction*)) or copd or bronchitis or asthma*)
18. SU (Fetal Growth Retardation) or TI ((f?etal or f?etus or intrauterine) W2 (growth or restrict*)) or AB ((f?etal or f?etus or intrauterine) W2 (growth or restrict*)) or MW ((f?etal or f?etus or intrauterine) W2 (growth or restrict*))
19. SU (multiple birth offspring or quadruplets or quintuplets or triplets or twins or pregnancy, multiple+) or TI (multiple birth* or multiple pregnanc* or triplet* or quadruplet* or quintuplet* or twin*) or AB (multiple birth or multiple pregnancy or triplet* or quadruplet* or quintuplet* or twin*) or kw (multiple birth* or multiple pregnanc* or triplet* or quadruplet* or quintuplet* or twin*)
20. su (Diabetes Mellitus, Type 1+ or Pregnancy in Diabetics) or (TI ((type 1 or type one) w1 diabet*) or (AB ((type 1 or type one) w1 diabet*) or (KW ((type 1 or type one) w1 diabet*))
21. TI hyperthyroid* OR AB hyperthyroid* or kw hyperthyroid* or su (HYPERTHYROIDISM+)
22. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21
23. 5 and 22
24. SU (Pregnancy Complications+ or Pregnancy Outcome+)
25. 5 and 24
26. 23 or 25

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27. TI (contraindicat* or contra-indicat* or complication* or risk* or safe* or harm* or adverse) or AB (contraindicat* or contra-indicat* or complication* or risk* or safe* or harm* or adverse) or KW (contraindicat* or contra-indicat* or complication* or risk* or safe* or harm* or adverse)
28. (S26 AND S27) NOT SU animal*

Web of Science (Core Collection)

TS=(exercise or "physical* activ*" or "physical* exert*" or "motor activit*" or "Physical* inactiv*" or sedentary or running or plyometric* or yoga or tai chi or "weight training" or "resistance training" or swim* or sport* or athlet* or walk or walking or mvpa or ltpa or stretching or "aerobic capacity" or "weight lift*" or "muscular condition*" or "muscle condition*") AND TS=(Pregnan* or trimester* or Peripartum or Postpartum or antenatal or prenatal or perinatal or postnatal or prepartum or antepartum or postpartum or pre partum or ante partum or post partum or puerper* or primigravid* or primiparous or multiparous or nulliparous or multigravid* or trimester* or obstetric*) NOT TS=(animal* or rat*) NOT TI=(animal* or rat*)

TS=("cardiovascular Pregnancy Complications" or "heart disease*" or "congenital heart defect*" or "heart valve disease*" or "coronary disease" or "cardiac Arrhythmia*" or hypertension) OR TS=(arrhythmia* or coronary or "valve insufficiency" or hypertensi* or pre-eclampsia or preeclampsia or "blood pressure") OR TS=((uterine or uterus or cervix or cervical) AND incompeten*) OR TS=((premature or preterm or pre-term) AND (birth or labor or labour)) OR TS=("placenta previa" or bleed* or haemorrhag* or hemorrhag* or "spontaneous abortion" or "spontaneous miscarriage") OR TS=((tear* or ruptur* or hemorrhage*) AND (placent* or vagin* or membran* or periton*)) OR TS=(anemi* or anaemi* or "iron deficienc*" or "iron-deficien*") OR TS=(malnutrition or bulimi* or anorexi*) OR TS=("lung disease*")OR TS=("multiple birth*" or "multiple pregnanc*" or triplet* or quadruplet* or quintuplet* or twin*)OR TS=((f?etal or f?etus or intrauterine) AND (growth or restrict*)) OR TS=("diabet* mellitus" or "type 1 diabet*" or "type one diabet*") OR TS=(hyperthyroid*)

TI=(contraindicat* or contra-indicat* or complication* or risk* or safe* or harm* or adverse) OR TS=("pregnancy complication*" or "pregnancy outcome*")

1 and 2 and 3

ClinicalTrials.gov

Exercise therapy / pregnancy = 265

Exercise Therapy | Pre-Eclampsia = 14

Exercise Therapy | Exercise Therapy and pregnancy | Hypertension = 23

Exercise Therapy | Heart Diseases in Pregnancy or heart disease | pregnant or pregnancy = 7

Exercise Therapy | Congenital Heart Defect | pregnant or pregnancy = 0

Exercise Therapy and pregnancy | Heart Valve Diseases = 1

Exercise Therapy | Coronary Disease | pregnant or pregnancy = 0

Exercise Therapy | Cardiac Arrhythmia | pregnant or pregnancy = 0

Exercise Therapy | Haemodynamic Instability | pregnant or pregnancy = 0

Exercise Therapy | Valve Incompetence, Pulmonary | pregnant or pregnancy = 0

Exercise Therapy | Blood Pressure | pregnant or pregnancy = 8 (1 is duplicate/ didn't download)

Exercise Therapy | Uterine Cervical Incompetence | pregnant or pregnancy = 0

/ premature birth =12

/premature labor =7

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Preterm labor = 6
Exercise Therapy and pregnancy | Preterm Birth = 12
/placenta previa = 0
/vaginal tear = 0
/vaginal hemorrhage = 0
/peritoneal hemorrhage = 0
/bleeding = 0
hemorrhage=0
/spontaneous abortion = 1
/anemia = 3
/lung diseases = 4
Malnutrition = 3
/anorexia or bulimia = 0
/pulmonary restrictive disease = 0
copd=0
/bronchitis=0
/asthma=0
/fetal growth retardation=3
/intrauterine growth restriction=3 (duplicates, not downloaded)
Twins or triplets or multiple birth or quintuplets or quadruplets=0
Diabetes mellitus, type 1=2
/hyperthyroidism=0
/pregnancy complications = 87
Exercise and pregnancy | Pregnancy Complications=133
/asthma =3

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