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Guideline No. 391-Pregnancy and Maternal Obesity Part 1: Pre-conception and Prenatal Care

This Clinical Practice Guideline has been prepared by the authors and reviewed by the Society of Obstetricians and Gynaecologists of Canada (SOGC)'s Maternal-Fetal Medicine Committee*, Family Physician Advisory Committee, and Guideline Management and Oversight Committee; and approved by the Board of the SOGC. Parts 1 and 2 of this Clinical Practice Guideline supersede the original version (#239) that was published in February 2010.

Note: Team Planning for Delivery and Postpartum Care is covered in Part 2.

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CHANGES IN PRACTICE

1. Aspirin prophylaxis
2. Increased surveillance following bariatric surgery
3. Delivery by term

KEY MESSAGES

1. Pregnancy care requires maternal medical assessment
2. Team planning enhances care and reduces risks for patients and caregivers
3. Increased awareness is needed for weight bias in obstetrics

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Abstract

Objective: This guideline will review key aspects in the pregnancy care of women with obesity. Part I will focus on pre-conception and pregnancy care. Part II will focus on team planning for delivery and Postpartum Care.

Intended Users: All health care providers (obstetricians, family doctors, midwives, nurses, anaesthesiologists) who provide pregnancy-related care to women with obesity.

Target Population: Women with obesity who are pregnant or planning pregnancies.

Evidence: Literature was retrieved through searches of Statistics Canada, Medline, and The Cochrane Library on the impact of obesity in pregnancy on antepartum and intrapartum care, maternal morbidity and mortality, obstetrical anaesthesia, and perinatal morbidity and mortality. Results were restricted to systematic reviews, randomized controlled trials/controlled clinical trials, and observational studies. There were no date or language restrictions. Searches were updated on a regular basis and incorporated in the guideline to September 2018. Grey (unpublished) literature was identified through searching the websites of health technology assessment and related agencies, clinical practice guideline collections, clinical trial registries, and national and international medical specialty societies.

Validation Methods: The content and recommendations were drafted and agreed upon by the authors. Then the Maternal-Fetal Medicine Committee peer reviewed the content and submitted comments for consideration, and the Board of the Society of Obstetricians and Gynaecologists of Canada (SOGC) approved the final draft for publication. Areas of disagreement were discussed during meetings, at which time consensus was reached. The level of evidence and quality of the recommendation made were described using the Evaluation of Evidence criteria of the Canadian Task Force on Preventive Health Care.

Benefits, Harms, and Costs: Implementation of the recommendations in these guidelines may increase obstetrical provider recognition of the issues affected pregnant individuals with obesity, including clinical prevention strategies, communication between the health care team, the patient and family as well as equipment and human resource planning. It is hoped that regional, provincial and federal agencies will assist in the education and support of coordinated care for pregnant individuals with obesity.

Guideline Update: SOGC guidelines will be automatically reviewed 5 years after publication. However, authors can propose another review date if they feel that 5 years is too short/long based on their expert knowledge of the subject matter.

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Summary Statements:

1. Maternal obesity carries both maternal and fetal risks (II-2).
2. There are limited options for weight loss and management during pregnancy (II-2).
3. Guidelines can assist with individualized recommendations regarding maternal gestational weight gain and calorie and nutrient intake during pregnancy (II-2).
4. Maternal obesity is a risk factor for fetal macrosomia (II-2).
5. The accuracy of fetal imaging for pregnancy dating, anatomical assessment, and fetal weight estimates is reduced in the setting of maternal obesity (II-2).
6. Stillbirth is more common with maternal obesity (II-1).
7. Multiple gestations carry additional risks in pregnancies complicated by maternal obesity (II-2).
8. Weight loss surgery before pregnancy, while generally conferring benefits to mother and fetus, also carries rare and serious morbidity during gestation (II-1).

Recommendations:

1. Weight management strategies prior to pregnancy may include dietary, exercise, medical, and surgical approaches. When pursued before pregnancy, health benefits may carry forward into future pregnancies (III B).
2. As obesity carries many medical risks, assessment for conditions of the cardiac, pulmonary, renal, endocrine, and skin systems, as well as obstructive sleep apnea, is warranted in the pre-pregnancy period (II-3 B).
3. Folic acid supplementation in the 3 months prior to conception is warranted given the increased risks of congenital abnormalities of the fetal heart and neural tube related to maternal obesity (II-2 A).
4. It is recommended that both monitoring of gestational weight gain and approaches for gestational weight gain management be formally integrated into routine prenatal care (III A).
5. There is good evidence to support the role of exercise in pregnancy (I A).
6. There is good evidence to support supplementation with folic acid (at least 0.4 mg) and vitamin D (400 IU) during pregnancy (II-2 A).
7. Fetal macrosomia may be altered by well-controlled maternal gestational weight gain (II-2 A).
8. Increased fetal surveillance for well-being is suggested in the third trimester if the reduced fetal movements are reported, given the increased rate of stillbirth (II-3).
9. Aspirin prophylaxis can be recommended for women with obesity when other risk factors are present for the prevention of preeclampsia (I A).
10. It is recommended that delivery be considered at 39–40 weeks gestation for women with a body mass index of 40 kg/m^2 or greater given the increased rate of stillbirth (II-2 A).
11. Multiple gestations in women with obesity require increased surveillance and may benefit from consultation with a Maternal-Fetal Medicine consultant, especially in the setting of monochorionic gestations (II-2 A).
12. Pregnancy after weight loss surgery may benefit from Maternal-Fetal Medicine consultation given the potential for significant albeit rare maternal morbidity (III B).

Table 1. Key to evidence statements and grading of recommendations, using the ranking of the Canadian Task Force on Preventative Health Care

Quality of Evidence Assessment[a]	Classification of Recommendations[b]
I: Evidence obtained from at least 1 properly randomized controlled trial	A. There is good evidence to recommend the clinical preventive action.
II-1: Evidence from well-designed controlled trials without randomization	B. There is fair evidence to recommend the clinical preventive action.
II-2: Evidence from well-designed cohort (prospective or retrospective) or case-control studies, preferably from more than 1 centre or research group	C. The existing evidence is conflicting and does not allow to make a recommendation for or against use of the clinical preventive action; however, other factors may influence decision making.
II-3: Evidence obtained from comparisons between times or places with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of treatment with penicillin in the 1940s) could also be included in the category.	D. There is fair evidence to recommend against the clinical preventive action.
III: Opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees	E. There is good evidence to recommend against the clinical preventive action
	I. There is insufficient evidence (in quantity or quality) to make a recommendation; however, other factors may influence decision making.

[a] The quality of evidence reported in these guidelines has been adapted from The Evaluation of Evidence criteria described in the Canadian Task Force on Preventive Health Care.

[b] Recommendations included in these guidelines have been adapted from the classification of recommendations criteria described in The Canadian Task Force on Preventive Health Care.

INTRODUCTION

Successful outcomes are possible for pregnancies affected by maternal obesity. There are a number of considerations for all obstetrical care providers, pregnant patients, and their families (Table 1 is a key to evidence statements and grading of recommendations). For example, there has been an alarming increase in obesity (body mass index [BMI] >30 kg/m^2) and overweight (BMI 25−29.9 kg/m^2) globally; in 2014, 40% of Canadians reported a BMI as overweight or obese.[1,2] Maternal weight during pregnancy has a profound impact on the health of both mothers and their offspring. Women with obesity have greater difficulty achieving a term pregnancy as they are at higher risk of miscarriage.[3] They are at higher risk of adverse pregnancy outcomes including development of gestational diabetes,[4−7] hypertension,[4,6−8] preeclampsia,[5−9] and thromboembolism.[10] Women with obesity are more likely to have increased interventions, including induction of labour[5,11] and Caesarean birth[4,11] (Table 2).[5−14] They have a significantly elevated risk of infant mortality[9,15−17] (Table 3).[5−7,9,14−20] The perinatal risks associated with maternal obesity include stillbirth,[5,7,9,17] macrosomia,[5−7,9,14] shoulder dystocia,[7,9,14] and meconium aspiration.[14] The newborns are also more likely to require medical intervention following delivery[14] and admission to the neonatal intensive care unit[8,14] (Table 3). Children born to mothers with obesity[21] are at increased risk of obesity themselves, as well as associated disease states including diabetes and cardiovascular disease.[7]

Definition of Obesity

The most widely accepted guidelines for the classification of obesity are produced by the World Health Organization.[19] As demonstrated in Table 4, obesity is classified as a BMI ≥30 kg/m^2. Obesity can subsequently be further classified by class I, II, and III (the term "morbidly obese" is to be avoided).[4] The published literature does not consistently use these classifications when reporting study results, demonstrating a limitation of current scientific evidence.

REFERS TO SUMMARY STATEMENT 1

PRE-CONCEPTION COUNSELLING, EVALUATION, AND MANAGEMENT

Excess amounts of adipose tissue can impair vascular, metabolic, and inflammatory pathways in many organs, thereby leading to adverse pregnancy outcomes.[20] Women with obesity should thus be informed of the benefits of weight loss before conception, notably on reproductive function, obstetrical outcome, and overall maternal health.[22] Though weight management strategies implemented during pregnancy have some effect in reducing maternal and neonatal complications, the effect is limited. Therefore, it is recommended that a weight-control program including diet, exercise, and behavioral modification be encouraged in the pre-pregnancy period.[23,24] In fact, a moderate weight

Table 2. Maternal risks associated with obesity as compared with normal weight

	Odds ratio/adjusted odds ratio compared to women with normal weight BMI <25 kg/m^2		
	Overweight BMI 25–29.9 kg/m^2	Obese I–II BMI 30–39.9 kg/m^2	Obese III BMI ≥40 kg/m^2
Gestational diabetes	1.68–4.25[5,6]	2.60–6.28[5–7]	7.44[4]
Hypertension	1.74–2.15[4,6,12]	2.50–6.31[4–8]	4.87[4]
Preeclampsia	1.44[5] 1.91[6] 1.44–1.91[5,6]	2.14–3.90[5–7,9]	4.82[9]
Venous thromboembolism in pregnancy	1.80[12]	9.70[10]	
Placental abruption		1.40[8]	
Spontaneous miscarriage	1.67[8,13]	1.20[3]	
Recurrent miscarriage		3.50[3]	
Hemorrhage/blood loss >500 ml	1.16[5]	1.39–1.50[5,14]	
Genital tract infection	1.24[5]	1.30[5]	
Urinary tract infection	1.17[5]	1.39–1.90[5,14]	
Wound infection	1.27[5]	2.24[5]	
Induction of labour	1.27[5]	1.60–1.70[5,11]	
Failure to progress in labour		2.60[8]	
Caesarean birth	1.50[4]	1.60–2.02[4,11]	2.54[4]
Emergency Caesarean birth	1.30–1.52[5–6]	2.02[4] 1.91[6] 1.83[5] 2.00[15] 1.83–2.02[5,6,14]	2.54[4]
Instrumental delivery		1.16[9] 1.18[9] 1.60[14]	1.34[9]
Failed instrumental delivery		1.75[11]	
Breastfeeding issues	0.86[5]	0.58[5]	

BMI: body mass index.

loss of 5% to 10% in non-pregnant women has led to an amelioration of obesity-associated metabolic disorders, including renal function and blood sugars,[25–29] and has the potential to improve maternal as well as fetal obstetrical outcomes.[30] Proper nutritional counselling, including dietary changes aiming to modify BMI and ensure adequate micronutrient intake, is suggested as optimal diet is required for a healthy immune balance.[31–33]

Weight Management

Weight management strategies should address adjunctive medical therapy or weight loss surgery when appropriate. Pharmacotherapy can be considered in patients with a BMI ≥30 kg/m^2 or a BMI ≥27 kg/m^2 with comorbidities.[34] In Canada, there are 2 main drug therapies: orlistat and liraglutide 3.0 mg. Neither is approved during pregnancy and both should be discontinued prior to conception when possible. Orlistat has a half-life of 2 hours and works by blocking lipase activity, which prevents about 30% of dietary fat from being broken down into free fatty acids and causes it to be excreted in the feces.[35] Many large studies have shown that most patients on orlistat for 1 year lost significantly more weight than those on placebo.[36–38] Between 5.8%[37] and 8.5%[36] of initial body weight was lost in those without type 2 diabetes, and an average of 6.2%[38] was lost in those with associated diabetes mellitus.

On the other hand, liraglutide has a half-life of 13 hours and acts as a glucagon-like peptide-1 (GLP-1) receptor stimulator, suppressing appetite[39] and reducing gastric emptying, which slows the digestion of nutrients and decreases the post-prandial serum glucose load.[40] Randomized controlled trials entitled the Satiety and Clinical Adiposity – Liraglutide Evidence in individuals with and

Table 3. Neonatal risks associated with maternal obesity

	Odds ratio/adjusted odds ratio (95% confidence interval)		
	Overweight BMI 25–29.9kg/m^2	Obese BMI 30–40 kg/m^2	Obese BMI ≥40 kg/m^2
Stillbirth		1.40–3.10[5,7,9,17]	2.79[9]
Shoulder dystocia		2.14–3.60[7,9,14]	3.14[9]
Meconium aspiration		1.64–2.87[9]	2.85[9]
Fetal distress		1.61–2.13[9]	2.52[9]
Mortality	1.25[15]	1.37–2.70[9,15–17]	2.44–3.41[9,15]
Large for gestational age/macrosomia	1.57[5] 1.69[6]	2.36[5] 2.97[6] 2.30[7] 2.15[9] 3.03[9] 2.10[14] 2.10–3.03[5–7,9,14]	3.55[9]
Major congenital anomalies/birth defect	1.05[18]	1.12–1.58[4,19]	1.37–3.41[4,19]
Neural tube defects	1.20[11]		
Spinal bifida		1.80–2.60[7,11]	
Congenital cardiac anomalies	1.05–1.17[11,19]	1.15–1.30[7,11,19,20]	1.44[18]
Nervous system defects	1.15[18]	1.44–1.65[19]	1.88[18]
Omphalocele		3.30[7]	
Anencephaly		1.39[11]	
Cleft palate		1.20[11]	
Late term birth (>41 weeks)		1.40[11]	
Preterm birth		1.50[7]	2.13[4]
NICU admission		1.20–1.50[8,14]	2.77[4]
Hypoglycemia		2.57[4]	7.14[4]
Jaundice			2.13[4]
Low Apgar scores	1.16[5]	1.45[5]	
Gastric tube		1.50[14]	
Neonatal trauma		1.50[14]	

BMI: body mass index; NICU: neonatal intensive care unit.

without obesity (SCALE) have examined its use as an adjunctive therapy. Two of these trials showed that patients without type 2 diabetes lost 8.0% of their initial body weight[41] and those with type 2 diabetes lost 6.0%.[42]

Table 4. World Health Organization classification of body mass index (BMI)[19]

BMI kg/m^2	Classification
<18.5	Underweight
18.5–24.99	Normal weight
25.00–29.99	Overweight
≥30.00	Obese
30.00–34.99	Obese class I
35.00–39.99	Obese class II
≥40.00	Obese class III

Weight loss surgery is an option for patients with a BMI ≥40 kg/m^2 or a BMI ≥35 kg/m^2 with comorbidities and who have not been successful with other weight management options.[34] It has the best long-term result regarding quantity of weight lost,[43] and as of 2014, sleeve gastrectomy (SG) is the most common bariatric procedure performed worldwide (45.9%), followed by Roux-en-Y gastric bypass (39.6%), adjustable gastric banding (7.4%), and biliopancreatic diversion (1.1%)[44] (Table 5).[43,45–60] In general, weight loss surgery decreases the risk of women with obesity developing hypertensive disorders in pregnancy by as much as 75%,[45,61–64] with a meta-analysis published in 2014 demonstrating that bariatric surgery could reduce the risk of preeclampsia in itself by 50% (odds ratio [OR] 0.45; 95% confidence interval [CI] 0.25–0.80).[64] Furthermore, malabsorptive weight loss surgery has also been associated

Table 5. Types of weight loss surgery and their effects

Surgery type	Mechanism of action	Excess body weight loss 12 months post procedure	Likelihood of nutritional deficiencies
SG	Transection of the stomach, produces volume restriction[46]	38%–70%[47–49]	Low
RYGB	Mechanical restriction and malabsorption through creation of 15-mL gastric pouch[43]	68%–77%[50-52]	High Especially fat soluble vitamins[53,54,a]
AGB	Gastric capacity restriction[55,56]	41%–54%[43,57,58]	Low[b]
BD	Gastric capacity restriction and malabsorption[45]	66%–74%[57,58]	Moderate

AGB: adjustable gastric banding; BD: biliopancreatic diversion; RYGB: Roux-en-Y gastric bypass; SG: sleeve gastrectomy.

[a] Suggest supplementation of iron, folate, calcium, vitamin B_{12}, and vitamin D.

[b] Suggest adjustment of the band during pregnancy in the context of hyperemesis gravidarum or abnormal weight gain.[58–60]

with a reduction in the risk of large for gestational age fetuses (OR 0.46; 95% CI 0.34–0.62), though there is evidence to suggest an increased risk of small for gestational age fetuses (OR 1.93; 95% CI 1.52–2.44).[64] This is likely related to post-surgical malabsorption issues and/or poor maternal nutrition; hence, health care providers should consider screening for inadequate nutrition (and micronutrient deficiencies) and perform serial growth ultrasounds in the third trimester.

Of note, time-to-conception interval following bariatric surgery has been a recent subject of debate. A large population-based study published in 2016 showed a time-to-birth interval of less than 2 years to be associated with increased rates of neonatal intensive care unit admissions (12.1% vs. 17.7%; Relative Risk RR, 1.54; 95% CI 1.05–2.25), preterm delivery (11.8% vs. 17.2%; RR, 1.48; 95% CI 1.00–2.19), and small for gestational age status (9.2% vs. 12.7%; RR, 1.51; 95% CI 0.94–2.42).[65] Therefore, it is suggested that patients wait a minimum of 24 months following bariatric surgery before trying to conceive.

Pre-pregnancy Counselling and Screening

Pre-pregnancy counselling constitutes the ideal time for health care providers to screen the woman with obesity for associated comorbidities, as weight loss can improve many of these conditions.[66] More particularly, obesity is associated with an increased risk of chronic hypertension, type 2 diabetes mellitus, dyslipidemia, cardiovascular disease, arrhythmias, stroke, osteoarthritis, non-alcoholic fatty liver disease, chronic kidney disease, depression, obstructive sleep apnea (OSA), and venous thromboembolism.[66,67] In fact, the major contributor to type 2 diabetes mellitus is excess weight,[68] and the degree of insulin resistance is highest with central/abdominal obesity, defined as a pre-pregnancy waist circumference ≥88 cm in women.[69] Hypertension occurs in approximately 40% of individuals who have obesity,[70] and blood pressure cuffs should be properly calibrated. Spirometry has also shown that in non-pregnant individuals with obesity, lung volumes decrease as BMI increases, with conditions such as asthma, obesity hypoventilation syndrome, and OSA being more prevalent.[71] OSA is characterized by repetitive episodes of upper airway obstruction during sleep leading to reduced airflow as well as hypoxemia, and normal physiologic changes in pregnancy can exacerbate the condition. Prevalence is not well defined, but in a prospective study of 175 pregnant women with obesity who had in-home portable polysomnogram studies, 15.4% were diagnosed with OSA.[72] In a large U.S. national database study between 1998 and 2009, women with OSA had a higher risk of preeclampsia (OR 2.5; 95% CI 2.2–2.9), eclampsia (OR 5.4; 95% CI 3.3–8.9), cardiomyopathy (OR 9.0; 95% CI 7.5–10.9), as well as gestational diabetes (OR 1.9; 95% CI 1.7–2.1) and were found to have a 5-fold increased odds of dying in hospital, when adjusted for comorbidities, age, ethnicity and socioeconomic status.[73] Treatment is mainly by way of continuous positive airway pressure.

Baseline screening where indicated could include renal function (with screening for proteinuria and serum creatinine levels), liver function tests, cholesterol, triglycerides, thyroid stimulating hormone, diabetes screen, electrocardiogram, pulmonary function tests if there are any respiratory concerns on anamnesis/examination, OSA studies if the patient screens positive on the Berlin questionnaire,[74] and an echocardiogram to evaluate global heart function and left ventricular function in those with a history of chronic hypertension of 5 or more years.[75] Consultations to appropriate specialists could also be ordered, smoking cessation encouraged, and supplementation with a minimum of 0.4 mg/day of folic acid (with consideration of up to 5 mg as maternal obesity may be considered "high risk" in some cases) should be commenced 3 months prior to conceiving in light of an increased risk

for neural tube defects in the obese population.[76] Careful physical examination should include evaluation of excess adipose tissue distribution; cardiorespiratory assessment; and screening for signs of venous thromboembolism, abdominal hernias, pressure wounds, or intertriginous infection.

During pre-pregnancy discussions, the patient should also be informed of the potential pregnancy complications associated with obesity, more particularly gestational diabetes mellitus and hypertensive disorders of pregnancy. The use of metformin to improve insulin sensitivity in pregnancy has also been studied given its theoretical benefit. A meta-analysis of 2 randomized trials[77,78] in women with obesity but without pre-existing diabetes showed a statistically significant reduction in maternal gestational weight gain (GWG). However, there was no benefit regarding the development of gestational diabetes mellitus, large for gestational age fetuses, or adverse neonatal outcomes; as such, use of metformin to decrease adverse pregnancy outcomes in non-diabetic women with obesity is not recommended.[79] Furthermore, as previously discussed, obesity is an independent risk factor for gestational hypertension both with and without proteinuria, and those with a BMI >30 kg/m^2 should start taking aspirin prior to 16 weeks gestation to prevent placentally mediated complications if additional risk factors are present (see Table 8).[80–82]

REFERS TO SUMMARY STATEMENT 2 & RECOMMEDATIONS 1, 2, AND 3

PREGNANCY CARE

Weight Management

It is well accepted that weight gain during pregnancy can influence pregnancy outcomes, with both too much and too little weight gain being detrimental. Excessive GWG is associated with increased risks of gestational hypertension, preeclampsia and diabetes, fetal overgrowth, operative delivery, and postpartum weight retention. Inadequate GWG is associated with fetal growth restriction.[83]

GWG is a dynamic process—the "right" amount of weight gain in pregnancy should be individualized among women with obesity. For a singleton pregnancy, the Institute of Medicine recommends that women with a pre-pregnancy or first trimester BMI of ≥30 kg/m^2 gain 5.0–9.0 kg (11–20 pounds).[84] The timing of this weight gain is important, with evidence showing that minimizing GWG in the first half of pregnancy may be beneficial for women with obesity. There is some evidence that women with class III obesity could gain less weight without increasing the risk of adverse pregnancy outcomes.[85] Close surveillance of fetal growth is advised in this scenario.

Many women with obesity are unaware that excessive GWG is a concern or that excessive GWG is associated with pregnancy and neonatal complications.[86,87] Women want to receive this information,[88,89] but studies show that maternity care providers usually do not provide it.[90]

Simple strategies that may improve the achievement of ideal GWG include setting a clear goal for GWG, deliberately planning meals and snacks, decreasing sedentary behavior, and self-weighing.[91,92] Furthermore, adequate sleep patterns have been shown to be associated with improved GWG, and good sleep hygiene should be encouraged.[93] In addition to counselling, evidence shows that supervised physical activity (PA) programs or personalized prescription/goals improve adherence to GWG targets. Evidence is mounting that intensive lifestyle interventions can be effectively delivered using newer technologies, such as mobile phones,[94] a strategy that could decrease burden on maternity care providers.

Maternal Nutrition in Pregnancies Affected by Obesity

Management of maternal nutrition in pregnancies complicated by obesity is both complex and challenging. Ideally, multidisciplinary care including a nutritionist should be available to these patients. It is recognized that the majority of Canadian maternity care sites do not have access to such resources. The information presented in this section is not comprehensive but is meant to provide some general information to both care providers and expectant mothers.

Macronutrients

All fetuses need access to macronutrients (carbohydrates, fat, and protein) to develop and grow optimally. It is generally accepted that an additional 100 kilocalories (kcal) per day are needed in the first half of pregnancy, increasing to 300 kcal per day beyond 20 weeks gestation. For most women with obesity, a baseline caloric intake of 2100 kcal is sufficient in the first half of pregnancy, increasing to 2400 kcal daily after 20 weeks.[95] The presence of coexisting diabetes, whether diagnosed prior to pregnancy or gestational diabetes, will require additional dietary modifications.

Carbohydrate intake in pregnancy should focus on high-quality, minimally processed sources in appropriate portion sizes and constitute 40% to 55% of daily calories. Higher

maternal intake of carbohydrates,[96] specifically sugar, is associated with unfavourable infant and child BMI peak characteristics.[97] In particular, the consumption of sugar-sweetened beverages should be avoided.[98–100]

Fat intake in pregnancy should comprise 25% to 30% of daily caloric intake, with monounsaturated fats preferred. Saturated fat should be limited to 10% of daily caloric intake.[98]

During pregnancy, women require a minimum of 60 g of protein a day, which accounts for 20% to 25% of the daily caloric intake. A variety of protein sources are recommended, including legumes; nuts; and lean animal protein sources, including eggs, dairy, fish, poultry, and red meat.

Women should be advised to consume 20–35 g of fiber each day.[96]

Micronutrients

It is recommended that all pregnant women take a prenatal vitamin that contains at least 400 μg of folic acid every day.[101] Multivitamin use has been associated with reduced risks of congenital anomalies and preeclampsia.[102] Women with obesity may be less likely to consume multivitamins before and during pregnancy, so the importance should be reinforced by both primary and maternity care providers.[103]

Folic acid supplementation is discussed in the Pre-pregnancy Counselling and Screening section of this guideline. Women with obesity may benefit from an increased dose of daily folic acid beginning at least 3 months before pregnancy and continuing until the end of the first trimester.[104,105]

Obesity is associated with lower vitamin D status, a problem that is further exacerbated in pregnancy.[106] A Swedish study has shown that 50% of pregnant women with obesity had suboptimal vitamin D status.[104] Women with pre-pregnancy obesity should be advised to take a total daily supplementation of 400 IU of vitamin D during pregnancy and while breastfeeding.[107]

Obesity has also been reported to be associated with iron deficiency.[108] During pregnancy, it is recommended that women with obesity have their hemoglobin, mean corpuscular volume, ferritin, and vitamin B_{12} levels assessed, with reflex supplementation as needed.

The World Health Organization also recommends daily supplementation with a total of 1.5–2.0 g of elemental calcium a day, which is equivalent to 2.5 g of calcium carbonate or 4 g of calcium citrate. This recommendation was based on reducing the risk of gestational hypertension but may also reduce the risk of dental carries in children at 7 years of age.

Probiotics

Studies have shown that women with obesity have an altered microbiome, compared with women of normal weight. Probiotics have been defined as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host."[109] At the present time, there is insufficient evidence to recommend probiotic supplementation to women with obesity during pregnancy, although the results from several large trials are anticipated in the future.

Omega-3/Fish Oil

Inflammation, whether chronic, low grade, or metabolic, is central to obesity-related insulin resistance. Currently, supplementation with omega-3 fatty acids shows mixed effects on inflammatory markers.[110] There is insufficient evidence to recommend omega-3 supplementation at this time.

Physical Activity

The benefits of regular physical activity during uncomplicated pregnancy are well documented. Ideally, women who are pregnant and have obesity should have access to care that promotes awareness of a healthy lifestyle and addresses barriers to lifestyle changes and personalized solutions to engaging in physical activity.[111] Healthy women with obesity who engage in regular physical activity have improved pregnancy outcomes and healthier GWG, without increasing the risk of preterm birth.[112–117] Furthermore, there may be positive downstream effects on childhood weight and health.[118]

Recommendations for physical activity are reviewed in Table 6. The safety of structured walking activities has been demonstrated in women with obesity.[119] Women with obesity who engaged in regular physical activity pre-pregnancy should be encouraged to maintain their current level of activity with modifications as needed, depending on their medical status, comfort, and ability. Modest physical activity prescription can be provided for healthy, previously sedentary women with overweight and obesity, with heart rate target zones of 102–124 beats per minute for women aged 20 to 29 and 101–120 for women aged 30 to 39.[120] Walking appears to be the most common activity for pregnant women and has the ability to improve aerobic capacity.[119,121] Pregnant women with overweight and obesity may have medical pre-screening

Table 6. Physical activity recommendations for pregnant women with obesity

Review contraindications	Screen woman with PARmed-X for Pregnancy tool to ensure she is safely able to participate in physical activity.
Information review	Review the potential benefits of physical activity during pregnancy. Discuss risks and reasons to stop activity and seek medical attention.
Determine type of physical activity	Walking program (though stationary cycling, water aerobics, and swimming are also acceptable and may be preferred)
	Reminder to avoid vigorous activity, activities that involve risk of falling, balance loss or abdominal trauma, and the supine position after 16 weeks of pregnancy
Timing of initiation	If previously sedentary, begin activity in early second trimester.
Frequency of physical activity	If previously sedentary, begin with walking 3 days per week on non-consecutive days and increase up to 4 days per week.
	Reminder to obtain 11 000 steps per day
Intensity of physical activity	If previously sedentary, start at low intensity; if already active, maintain moderate-intensity activities;
	low intensity: 102−124 beats/minute (20−29 years of age); 101−120 beats/minute (30−39 years of age)
	Advise on the "talk test," which is defined as being able to maintain a conversation during physical activity.
Improve adherence	Recommend keeping track of activities and/or a heart rate monitor.
	Ask about physical activity at each antenatal visit, answer questions, and provide encouragement.

Adapted from Seneviratne et al.[124]

using the PARMed-X for Pregnancy tool[122]; if cleared, a structured walking program should be recommended, beginning in the early second trimester with 25 minutes, adding 2 minutes per session per week until 40 minutes per session is reached.[97] Special support may be needed for women who have back or joint pain or persistent nausea and vomiting of pregnancy.[123]

Devices such as pedometers or Fitbits have been shown to increase physical activity levels.[125,126] In addition to the preceding recommendation, women should be advised to take 11 000 steps per day.[127] Further recommendations on exercise in pregnancy can be found in the latest pregnancy guideleins by the Society of Obstetricians and Gynaecologists of Canada.[128]

The Impact of Maternal Obesity on Fetal Growth

Maternal obesity is often associated with fetal overgrowth, thought to be secondary to altered glucose metabolism and higher fetal insulin levels. Furthermore, maternal obesity has been shown to be associated with both third trimester placental and fetal adipocyte proliferation and storage of lipids in the third trimester.[129] A large longitudinal cohort study of the impact of maternal obesity on fetal growth showed that fetuses of women with obesity have higher weights than fetuses of women without obesity as early as 32 weeks gestation.[130] Prior to this point, fetal weights are similar between the 2 groups.

It is well recognized that maternal obesity is associated with fetal macrosomia, with newer evidence demonstrating an independent effect on fetal growth. In a recent meta-analysis of 16 studies, it was shown that a maternal pre-pregnancy BMI ≥30 kg/m^2 is associated with an adjusted OR for fetal macrosomia (birth weight ≥4.0 kg and ≥4.5 kg) of 1.93 (95% CI 1.65−2.27).[131]

Maternal GWG is an important modifying factor for fetal macrosomia in women with obesity. In a prospective cohort of euglycemic women with obesity, increasing GWG significantly increased the risk of macrosomia (birth weight >4 kg) and significantly correlated with umbilical cord C-peptide levels (reflect insulin secretory activity of pancreatic beta cells).[132] For every kilogram increase in GWG, there was a significant increase in risk of macrosomia, defined as birth weight >4.0 kg, with an OR of 1.139 (95% CI 1.033−1.256).

In contrast to fetal overgrowth, the identification fetal growth restriction, defined as failure of the fetus to reach its growth potential, is challenging in women with obesity. Because fetuses of mothers with obesity are heavier as a group, it has been proposed that customized growth curves may be needed to identify those fetuses at increased risk of perinatal morbidity and mortality.[133,134]

Fetal Assessment in Pregnancies Affected by Maternal Obesity

Imaging is challenging in pregnancies affected by obesity because the quality of the ultrasound image is inversely proportional to the depth at which the imaging is being conducted.[135] Some suggestions of optimization of scanning are presented in Table 7.

Table 7. Strategies to improve ultrasound quality in pregnancies affected by obesity

1. Improve the signal-to-noise ratio (compound imaging, speckle-reduction filters, pre- and post-processing, tissue harmonics).
2. Ensure the maternal bladder is full.
3. Use the umbilicus as an acoustic window.
4. Ask the patient to sit up and image above the panniculus.
5. Assist the patient into Sims position and image from flank or groin.
6. Scan transvaginally.

Establishing gestational age

The most accurate means of establishing pregnancy dating is by transvaginal measurement of the crown–rump length between 7 and 14 weeks gestation.[136] Increased maternal BMI has been shown to be associated with postponement of the Estimated Date Of Delivery (EDD), with the fetus being more likely to measure smaller by ultrasound than the menstrual dates suggest.[136,137] Accurate ascertainment of gestational age is essential for optimizing pregnancy outcome, particularly with respect to assessing fetal growth, conducting aneuploidy screening, and ensuring fetal maturity when timing delivery.

Prenatal screening

It has been noted that maternal obesity may increase the odds of giving birth to an infant with trisomy 21, with a lower likelihood of prenatal diagnosis.[138–140]

Failure rates for measuring the nuchal translucency increase with maternal weight.[141] Transvaginal assessment may increase the odds of success. However, the risk estimate for trisomy 21 provided by first trimester combined screening is not affected by BMI.[138]

Non-invasive prenatal screening is becoming an increasingly prevalent option. The risk of non-invasive prenatal screening test failure increases with maternal weight, from 3.8% with normal weight to 24.3% with obesity, irrespective of gestational age.[142]

Assessing fetal anatomy

Fetuses affected by maternal obesity are more likely to have congenital anomalies, specifically neural tube defects (OR 1.87; 95% CI 1.62–2.15), cardiac anomalies (OR 1.30; 95% CI 1.12–1.51), anal atresia (OR 1.48; 95% CI 1.12–1.97), and limb reduction anomalies (OR 1.34; 95% CI 1.03–1.73).[143] This may be related partially to the reduced odds of detecting congenital anomalies in the presence of maternal obesity (adjusted OR 0.77; 95% CI 0.60-0.46).[144]

The likelihood of completing an adequate morphology assessment in a single attempt is reduced with increasing BMI, from 97.5% in women with normal BMI to 74% in women with BMI >30 kg/m^2 and 41% when BMI is >40 kg/m^2.[145,146] The probability of poor visualization of the heart (37% vs. 19%) and spine (43% vs. 29%) was increased in women with obesity compared with women of normal weight.[147] Other fetal structures that are particularly difficult to image in obese women include the face, genitalia, and extremities.[148] The optimal gestational age to conduct a complete anatomy ultrasound has been found to be 22–24 weeks (93% completion rate, OR 41.3; 95% CI 7.89–215.8).[148] It is recommended that the morphology ultrasound be performed at a minimum of 20 weeks in women with obesity. Health care providers should consider timely referral (i.e., 1–2 weeks) for reassessment of fetal anatomy deemed incomplete. Consideration may also be given to assessment of fetal anatomy in the first and second trimesters in women with obesity as an adjunct to routine second trimester anatomy.[149,150] As the majority of fetal organs can be visualized late in the first trimester, it is possible to detect fetal anomalies in the 13–16-week range.[151,152] Considerations include availability of experienced sonographers (this approach may not be available in all centres), as well as the use of transvaginal scanning in addition to transabdominal scanning.[149,150]

The quality of images can be improved in women with obesity using the techniques presented in Table 7.[135]

Measuring fetal growth

Estimation of fetal weight is challenging in the setting of maternal adiposity. Screening for fetal weight using symphysis fundal height measurement is not recommended because it has not been shown to be predictive in women with obesity.[151] The increased maternal body mass is thought to lead to falsely elevated symphysis fundal height, which may overestimate macrosomia and underestimate growth restriction.[151]

Several techniques of improving the accuracy of fetal weight prediction have been evaluated in pregnancy.

The use of the GAP method (gestation-adjusted projection method) has been shown to be an accurate aid in delivery planning for women who have a BMI ≥40 kg/m^2.[152] This strategy capitalizes on the concept that an ultrasound performed between 34^0 and 36^6 weeks provides a more accurate assessment of fetal weight than one performed at 37 weeks or later, using extrapolation to provide an expected birth weight at term. The mean absolute percent error of this technique ranged from 7.4% to 7.9%, in a

population that included women with diabetes.[146] As for women of all BMI categories, the option of elective Caesarean birth can then be considered for fetuses with a projected birth weight of ≥4500 g and ≥5000 g in women with and without diabetes, respectively.[153]

Maternal Assessment of Fetal Well-Being

Women with obesity are more likely to present for assessment for decreased fetal movement (OR 1.6; 95% CI 1.27−1.92) but do not have reduced perception of movement compared with women of normal weight, according to a recent systematic review.[154,155] The authors also found that among women with decreased fetal movement, increased maternal body size was associated with increased risk of stillbirth and fetal growth restriction. Thus, additional consideration should be given to women with obesity who report decreased fetal movement.

Clinical Surveillance of Fetal Well-Being

Adequate external monitoring of the fetal heart rate using both hand-held Doppler and cardiotocography is less likely in women with obesity.[156] The role for non-stress tests (NSTs) in surveillance of well-being in this population is uncertain.

In a large retrospective cohort of 2002 sonograms in 1164 pregnant women with BMI >30 kg/m^2 as the only comorbidity, abnormalities of amniotic fluid and growth were seldom made prior to 32 weeks gestation.[157] Beyond 36 weeks, 7 scans (95% CI 6−8) were needed to diagnose any abnormality of fluid (oligohydramnios or polyhydramnios) or growth (small or large for gestational age).[157] Based on this information, it is recommended that serial assessments of growth be conducted at 28, 32, and 36 weeks. Assessment of fetal well-being is then recommended weekly from 37 weeks until delivery.

It has been shown that maternal BMI and pulsatility index of both the umbilical artery and the maternal uterine artery are positively correlated and associated with adverse pregnancy outcomes, secondary to effects on fetal-placental vessels.[158,159] The presence of abnormal findings, with or without co-existing medical complications (such as diabetes or hypertension), should prompt increased fetal surveillance.

Prevention of Maternal Pregnancy Complications in the Presence of Obesity

Because obesity is a known risk factor for gestational hypertension/preeclampsia and gestational diabetes, consideration should be given to evidence-based preventative strategies. Optimization of GWG, diet, and physical activity is associated with lowered risk of such complications.

Preeclampsia prevention with aspirin

Table 8 reviews the recommendations for prophylactic acetylsalicylic acid (ASA) use during pregnancy, as advised by the U.S. Preventive Task Force.[160]

Aspirin should be initiated after diagnosis of pregnancy and ideally before 16 weeks gestation, taken in a low dose (75−162 mg/day), administered at bedtime, and considered for continuation until term.[161]

Calcium

Evidence supports the use of calcium supplementation to prevent preeclampsia. At this time, there are no specific

Table 8. Clinical risk assessment for preeclampsia and recommendations for prophylactic acetylsalicylic acid (ASA)

Risk level	Risk factors	Recommendation
High	• History of preeclampsia, especially when accompanied by an adverse outcome • Multifetal gestation • Chronic hypertension • Type 1 or 2 diabetes • Renal disease • Autoimmune disease (e.g., systemic lupus erythematosus, antiphospholipid syndrome)	Recommend low-dose aspirin if the patient has ≥1 of these high-risk factors.
Moderate	• Nulliparity • Obesity (BMI >30 kg/m^2) • Family history of preeclampsia (mother or sister) • Sociodemographic characteristics (e.g., African American race, low socioeconomic status) • Age ≥35 years • Personal history factors (e.g., low birth weight or small for gestational age, previous adverse pregnancy outcome, >10-year pregnancy interval)	Consider low-dose aspirin if the patient has more than 2 risk factors.
Low	BMI <30 kg/m^2, no other risk factors	Do not recommend low-dose aspirin.

BMI: body mass index.

recommendations for women with obesity. Women who have an adequate dietary calcium intake should be advised to take a supplement of 1 g of calcium daily, in addition to the prenatal vitamin.[162] Women with low dietary calcium intake should be advised to take 1.5−2 g of calcium daily, in addition to the prenatal vitamin.[157]

Gestational Diabetes Prevention: Metformin and Myo-inositol

The use of metformin has not been shown to decrease the risk of gestational diabetes.[77,78]

A number of studies have now investigated a role for myo-inositol supplementation of women with obesity. Myo-inositol is a precursor of insulin that has insulin sensitizing effects. Daily supplementation with 2 g of myo-inositol has been shown to reduce the risk of gestational diabetes, by 67% compared with placebo (11.6% vs. 27.4%; OR 0.34; 95% CI 0.17−0.68) in 1 study.[163,164] While preliminary data are encouraging, further study is needed before myo-inositol supplementation can be routinely recommended.

Maternal Obesity and Stillbirth

Stillbirth is associated with maternal BMI, with a U-shaped curve demonstrating higher risk at both low and high BMIs. At 40 weeks, the risk of stillbirth is estimated to be 3 to 8 times higher in women with obesity >30 mg/kg^2 compared with normal weight women. Multiple mechanisms link obesity and stillbirth, with a notable increase in the risk of placental disease (abnormal spiral arterial modification, placental hypertrophy) and maternal hypertension in particular, but also fetal genetic or structural abnormalities, umbilical cord abnormalities, and antepartum infections.[129,165,166] A triple risk model has been proposed for stillbirth in general that proposes an interplay of (1) maternal risk factors (e.g., obesity, smoking, maternal age), (2) fetal and placental factors (e.g., placental insufficiency, fetal growth restriction), and (3) a stressor (e.g., veno-caval compression due to maternal supine sleep position, sleep-disordered breathing).[167]

GWG is a modifiable risk factor that can be targeted to reduce stillbirth risk.[168] As with women in lower BMI categories, suboptimal GWG (whether too much or too little) places pregnancies at an increased risk of adverse pregnancy outcomes, including stillbirth.

For women with a BMI of ≥40 kg/m^2, it has been shown that delivery before 38 weeks minimizes perinatal mortality.[134] In a computational cost-effectiveness study, it was shown that routine induction of labour at 39 weeks minimizes stillbirth, Caesarean birth, and delivery-related health care costs.[169] In a hypothetical population of 100 000 term pregnancies affected by obesity where a vaginal delivery is planned, routine induction of labour at 39 weeks would avoid 387 stillbirths compared with induction at 42 weeks. Furthermore, in the same population, elective induction at 39 weeks compared with induction at 41 weeks would avoid 9234 Caesarean sections at a health care cost savings of $30 million.

Multiple Gestations and Maternal Obesity

Obesity and multiple gestations are both conditions that significantly increase the risk of pregnancy complications, including gestational diabetes and hypertension. Compared with multiple pregnancy in women of normal weight, multiple pregnancy in women with obesity is further adversely influenced by high maternal pre-pregnancy BMI.[170] Specifically, preeclampsia is more common in women who are obese and having multiples (OR 4.72; 95% CI 2.83−7.89), as is gestational diabetes (OR 2.19; 95% CI 1.03−4.68).[171] Optimizing GWG in this population is recommended, with the suggested target range of 13.2−17.3 kg or 29−38 pounds.[172,173]

The risk of delivering prior to 34 weeks gestation is increased in women who have obesity compared with women of normal weight (OR 1.65; 95% CI 1.10−2.48).[174] Furthermore, there is a dose-dependent increase in the risk of preterm birth at <28, <32, and <37 weeks with increasing BMI.[175] For women with a BMI ≥35 kg/m^2, the corresponding risks are 1.7%, 3.6%, and 16.4%, while for women of normal weight, the risks are 0.6%, 1.5%, and 10.3%.[171] The risk is even higher in multiple gestations conceived through in vitro fertilization, where the risk of delivery <32 weeks is 6.1% and the risk of delivery <37 weeks is 11.5%.[171] Based on this information, it is recommended that pregnancy care for multiple pregnancies include an obstetrical provider with experience in managing maternal obesity.

Serial estimation of fetal weight by ultrasound is recommended in all multiple pregnancies. There is conflicting evidence on the effect of maternal obesity on the accuracy of fetal weight estimation. In 1 Canadian study, the accuracy of fetal weight estimation for multiples was decreased compared to normal weight women with multiples.[170] In a larger Irish study, accuracy was not adversely affected.[176]

There appears to be an increase in the risk of stillbirth in multiple pregnancies complicated by maternal obesity for same-sex but not opposite-sex multiples, suggesting an association with monozygosity.[177] Monochorionic multiple pregnancies in mothers who have obesity may benefit

from increased surveillance including the involvement of a Maternal-Fetal Medicine consultant.

Pregnancy Care After Weight Loss Surgery

Pregnancies after weight loss surgery are becoming increasingly common, and the risks and benefits of these procedures for mother and fetus during subsequent pregnancies are discussed earlier in this guideline. Many women experience dumping syndrome post weight loss surgery and may not be able to tolerate glucose challenge testing during pregnancy. Alternative approaches to diabetes evaluation may include fasting glucose testing and assessment of hemoglobin A_{1c} in this setting. Additional considerations include increased risk of gastrointestinal bleeding, severe anemia, small bowel volvulus, obstruction, and subsequent internal herniation.[178] Given this potential complexity, involvement of a maternal-fetal medicine consultant for pregnancy care is suggested.

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