

Excess Gestational Weight Gain in Pregnancy and the Role of Lifestyle Intervention

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Abstract

With increasingly adverse lifestyles, young women in many countries have rapid weight gain and rising obesity. In keeping with this, most pregnant women exceed recommended gestational weight gain (GWG) and then retain weight postpartum. The consequences of excess GWG include maternal risks during pregnancy, neonatal risks and maternal obesity and chronic disease longer term, presenting a significant public health and economic burden worldwide. This article discusses the adverse maternal and infant risks with excess GWG apparent from observational studies, summarizes the existing guidelines for optimal GWG and highlights the need for further research to identify optimal GWG recommendations across the different ethnicities and weight ranges.

Keywords

- ▶ gestational weight gain (GWG)
- ▶ outcomes
- ▶ intervention
- ▶ body mass index (BMI)

We also review the evidence for lifestyle interventions in pregnancy to prevent excess GWG and highlighting the work underway to integrate large scale meta-analyses of individual patient data from lifestyle intervention studies to inform clinical practice beyond current observational data. Finally, we address the need to implement lifestyle interventions into routine pregnancy care to improve short and long term maternal health outcomes.

Obesity secondary to adverse lifestyle presents a major public health and economic burden worldwide. Established obesity requires intensive, multidisciplinary and costly treatment. Once obesity is established, lifestyle induced weight loss is largely unsustainable due to physiological adaptation which drives weight regain.^{1,2} In contrast, prevention of weight gain is feasible with minor lifestyle changes^{3,4} and small energy balance adjustments (~220kJ/day),³ conveying long term health benefits. In this context, the World Health Organization (WHO) global strategy for the prevention of non-com-

municable diseases notes obesity as a preventable condition and recommends to aim to increase physical activity and improve diet⁵ to prevent obesity. This is therefore now a high priority internationally.⁶

The health implications of weight gain are major and the risks increase with each kg gained across all weight categories, making prevention a priority for all women. Diabetes risk increases above BMI of 22 kg/m² with 18% affected in normal weight, 35% in overweight and 75% in obese women.⁷ Cardiovascular disease is the number one cause of mortality from

non-communicable disease in women and increases by 3% for each kilo gained.⁸ As 55% of deaths are lifestyle or weight related, the imperative for effective obesity prevention interventions is critical.⁹

Pregnancy is a key driver of weight gain, with most women in developed countries exceeding recommended gestational weight gain (GWG) with a mean 2–5 kg retained per pregnancy.^{10–13} Excess GWG is directly related to long-term obesity across all weight categories.¹⁴ Longitudinal data shows a 300% increase in obesity risk long term if GWG exceeds guidelines.¹² Excess GWG thus drives long term obesity and chronic disease.¹² Pregnancy therefore offers significant opportunities for obesity prevention⁶ and reproductive aged women are now targeted as a high risk group with recommendations to limit GWG and encourage postpartum weight loss.¹⁵

In addition to driving maternal obesity, excess GWG also worsens pregnancy complications for both mothers and babies.¹⁶ GWG is an independent predictor of large for gestational age babies and related complications.¹⁷ The Institute of Medicine (IOM) in the USA has made recommendations for optimal GWG¹⁸ based on maternal BMI, although the observational cohorts underpinning these recommendations were from the USA in 1980 with limited obesity and little ethnic diversity.

With regards to lifestyle interventions, leading researchers in the field and the WHO have recognized that the environmental and societal factors driving obesity must be addressed for effective widespread obesity prevention.^{19,20} However environmental and societal changes have proven slow to change with WHO noting that obesity is one of today's most blatantly visible – yet most neglected – public health problems. Ultimately however, individual behavior change, ideally enabled by societal and environmental change is needed to prevent and manage obesity. The evidence on individually targeted lifestyle initiatives is reviewed here, while acknowledging the need for concomitant broader societal and environmental approaches to support individual lifestyle change.²⁰

There is currently no literature on healthy lifestyle interventions preconception, despite education opportunities in this life phase. Adopting healthy lifestyle interventions in pregnancy with positive changes to dietary intake and physical activity prevents excess GWG gain and may reduce pregnancy complications based on systematic review and meta-analysis.²¹ They do not impact on birth weight, or result in safety concerns for the fetus.²¹ Factors associated with intervention success include focusing on diet or combined interventions, using behavioral strategies and using technology to support delivery.^{21–24} However, despite the clear health needs and evidence for the efficacy of lifestyle interventions in pregnancy, a major gap persists with inadequate translation of healthy lifestyle change integrated into routine preconception and antenatal care.

Barriers to incorporating a focus on healthy lifestyle behaviors into pregnancy care include women's limited knowledge and awareness of healthy GWG and adverse effects of excess GWG on long term health; inadequate health

professional skills, support and training²⁵; sociocultural challenges for health professionals and women, limited accessibility of evidence based programs and resources, inadequate staff time and health system challenges.²⁶ Enablers include the “teachable moment” with pregnant women more motivated to accept healthy behaviors in pregnancy^{26–29} for the health of their child, and health system engagement with frequent antenatal visits. However, there is inadequate existing implementation research addressing these barriers and leveraging off these enablers.

Currently, extensive international individual patient data meta-analysis of lifestyle interventions in pregnancy is underway and this data will enable us to answer key questions on the efficacy of lifestyle interventions, including diet, physical activity and mixed interventions in pregnancy for prevention of GWG.³⁰ It will also allow exploration of lifestyle intervention impact on maternal and neonatal outcomes, and their relative efficacy across the BMI range and different ethnicities.

Here, we consider opportunities for education on diet and lifestyle preconception. We then review the relevant literature on the adverse health outcomes of excess maternal GWG and recommendations for optimal GWG and controversies around existing Institute of Medicine Guidelines for GWG. We also review the literature on lifestyle interventions in pregnancy and outline the pending large scale international individual patient data meta-analysis in this area. We then close with a discussion around next steps toward implementation of healthy lifestyle into routine pregnancy care to prevent excess gestational weight gain.

Preconception Intervention Opportunities to Prevent Weight Gain

Most women do not engage in maternity care until late in their first trimester. Therefore, pre-conception offers an opportune time for screening for risk factors that may impact on fertility, pregnancy and the future child. There is no evidence from randomized controlled trials (RCT) to support specific interventions or specific models of care pre-conception to improve pregnancy outcomes in overweight or obese women.³¹ However, the preconception period provides an opportunity to assess for and manage weight associated maternal chronic conditions including diabetes, hypertension, sleep apnoea and polycystic ovary syndrome.^{32–34} It is also an ideal time to discuss and offer an individualized diet and physical activity as weight loss pre-conception will improve fertility and pregnancy outcomes in overweight or obese women. Diet and physical activity pre-conception may also improve GWG; a community based RCT of a 6 group session intervention on physical activity, diet, stress and health behaviors pre-conception and inter-conception showed changes in diet, self-efficacy and reported physical activity preconception.³⁵ They then followed up women and assessed them across BMI categories; those who were in the intervention group had lower BMI at 12 month follow up and a trend to lower pregnancy GWG after adjustment for pre-pregnancy BMI.³⁶ Increased levels of physical activity

pre-conception are also associated with trends in decreased GWG.³⁷ Preconception lifestyle interventions also have the potential to limit first trimester GWG. Until further evidence emerges on the role of preconception interventions for limiting excess GWG, as per National Centre for Clinical Excellence guidelines, addressing chronic conditions and lifestyle factors related to weight in overweight and obese women should be considered.³⁸

Adverse Health Outcomes of Excess Maternal GWG: Observational Data

In the US, Europe and Australia, 20–50% of women gain more than the recommended GWG during pregnancy.³⁹ GWG has major implications in pregnancy, independent of maternal obesity, with every kilo above recommended, linked to 10% increase in adverse outcomes.¹⁶ The combination of excess GWG and obesity is concerning and preventing excess GWG across all BMI categories is imperative.

Excess GWG drives some well-recognized short-term adverse maternal outcomes reported in population-based cohort studies (► **Table 1**), including pre-term birth^{13,40} and caesarean section.^{13,40–44} Other outcomes are more debated, including gestational diabetes (GDM)^{17,45} and gestational hypertension/pre-eclampsia.^{42,44} Short-term infant outcomes include increased birth weight,^{13,40,42,44,46} LGA and reduced risk for SGA.^{13,40,41,43,46}

In the long term, excess GWG increases maternal postpartum weight retention at six,⁴³ twelve months⁴¹ and eighteen months⁴³ and predicts long-term obesity,^{47,48} which in turn indirectly predicts diabetes, heart disease⁴⁹ and chronic disease.⁴⁸ Childhood overweight/obesity is also linked strongly to excess GWG on observational studies.^{41,50} Recent literature has also described the association of increased maternal GWG and an adverse adolescent metabolic profile.^{51,52}

It is difficult to make meaningful comparisons of the severity and frequency of these outcomes across the observational studies in this area due to differing classification of BMI and GWG categories, differing outcome definitions, inconsistent control for confounding factors and variable study methods. Refinement of core outcome sets and standard endpoint definitions for research in this area is needed, along with intervention research linked to long term cohort studies to explore health outcomes for mothers and children.

Recommendations for Optimal GWG: Observational Data

As noted, to create comprehensive guidelines regarding ideal GWG, there should be a consensus on core outcome sets and agreed definitions on core endpoints. Currently, this is lacking and guidelines base recommendations on inconsistently applied and defined outcomes from observational studies. Approaches such as that used by Thangaratnam²¹ with a two round Delphi survey of experienced clinicians to rank outcomes for importance in their meta-analysis of interventions in pregnancy is progressing this area and we look forward to clearly defined core outcomes sets in future.

Healthy GWG is not equal across the BMI spectrum. All guidelines allow greater GWG in women who are underweight at the onset of pregnancy. Nohr⁴³ found that underweight women can have high GWG without the consequences of adverse maternal and infant outcomes, hence their weight gain allowance is more generous. Most guidelines recommend lower weight gain for overweight and obese women, and across ethnicities, these women are more likely to exceed recommended weight gain, even though their mean weight gain during pregnancy is less than normal weight women.^{17,41,53}

► **Table 2** summarizes the key guidelines. Presently, the IOM 2009¹³ guidelines are most commonly used. They are an updated version from the 1990 guidelines, where the 1990 emphasis was on avoiding the consequences of low GWG rather than high GWG, with respect to infant outcomes only. They differ from the 1990 guidelines because they are based on the WHO cut points for maternal BMI categories and include a new narrow range of GWG for obese women. The 2009 guidelines identified maternal and infant outcomes that were based on the Agency for Healthcare research and Quality (AHRQ) systematic review from 2008⁴⁰ and commissioned additional analyses. However the 2009 IOM guidelines still derived recommendations from the same original dataset of US based largely Caucasian women in the 1980's when overweight and obesity in pregnancy was relatively uncommon and GWG was more limited. Infant outcomes were SGA, LGA, preterm birth and childhood obesity. Maternal outcomes selected included postpartum weight retention, caesarean section, GDM, gestational hypertension; however, GDM and gestational hypertension were removed from analysis due to lack of sufficient evidence from methodologically

Table 1 Risks of excess GWG

	Short term	Long term
Maternal outcomes	GDM	Post partum weight retention
	Pre-eclampsia/ gestational hypertension	Obesity
	Pre-term birth	
	C section	
Infant outcomes	Increased birth weight	Childhood obesity
	LGA	
	Low risk of SGA	

flawed observational studies. Strengths of IOM are that the severity and the frequency of the outcomes have been considered in building the guidelines, which other guidelines have not done.

Cedergren¹⁶ recommended optimal GWG recommendations based on a large Swedish population-based cohort registry of nearly 300,000 women, almost all of Caucasian origin (►Table 2). Interestingly, selection of outcome variables directly related to maternal GWG and BMI was not the purpose of the study. Rather, the aim was to 'estimate weight gain limits that were associated with significantly decreased risk of the most clinically dangerous situations for the mother and the infant'. Analysis included SGA, LGA, preeclampsia and several short-term maternal and infant complications. Recommendations emerging from this work have a narrower limit for GWG than IOM, across all BMI categories. Of note, the outcomes were not weighted for severity and a number are

rare, perhaps limiting usefulness. Moreover, weight gain information was only available in <40% of women.

The 1990 IOM and Cedergren recommendations have been directly compared using the New Jersey Pregnancy Risk Assessment Monitoring System (PRAMS) database of over 9000 women.⁵⁴ Using the Cedergren guidelines, the incidence of macrosomia and caesarean delivery was lower, however low birth weight, preterm deliveries and neonatal intensive care admissions occurred more frequently. Ideal GWG was assessed to be between both these sets of recommendations.

The IOM guidelines have also been evaluated in large observational datasets. A German study based on more than 170,000 deliveries (►Table 2) created a model for joint predicted risks of SGA and LGA in relation to GWG and found much wider optimal GWG ranges across the BMI range.⁵⁵ More recently, the Norwegian Mother and Child Cohort

Table 2 Key guidelines for GWG

Author	Rasmussen (IOM)	Cedergren	Beyerlein	Ee
Year	2009	2007	2009	2014
Country of origin	US	Sweden	Germany	Singapore
Guideline development based on	Systematic review, commissioned reports	Population based cohort study	population based cohort study	population based cohort study
Maternal outcomes assessed	Caesarean section	Preeclampsia, eclampsia	N/A	Caesarean section
	Post partum weight retention	Postpartum hemorrhage		Vaginal delivery
		Venous complications		
		Shoulder dystocia		
		Complications of anesthesia		
		Stillbirth after 28 weeks		
Infant outcomes assessed	SGA	SGA	SGA	SGA
	LGA	LGA	LGA	LGA
	Preterm birth	Birth trauma		AGA (appropriate for
	Childhood obesity	Respiratory disorders		Gestational age)
		Bacterial sepsis		
		Haemorrhagic disorders		
		Convulsions		
		perinatal death		
		Apgar score < 7 at 5 minute		
Proposed optimal GWG	Weight in kg			
BMI categories (kg/m ²)				
Underweight < 18.5	12.5–18	4 - 10*	8- 25	19.5 (12.9 to 23.9)***
Normal weight 18.5–24.9	11.5–16	2- 10*	2–18	13.7 (7.7 to 18.8)**
Overweight 24.9–29.9	7–11.5	< 9	-7 to 12	7.9 (2.6 to 14.0)**
Obese ≥30	5–9.0	< 6	-15 to 2	1.8 (-5.0 to 7.0)**

* BMI cutoff of 20.

** BMI cutoff of 18.5 to < 23 for normal weight; 23 to <27.5 for overweight; ≥ 27.5 for obese.

***numbers in parenthesis represent the lower and upper markings of the GWG range for which aggregated risk of composite adverse outcome does not exceed a 5% increase from the lowest aggregated risk.

Study⁴² evaluated the risk of several maternal and infant outcomes with a GWG outside of the guidelines in data on more than 50,000 women. There was an increased risk of macrosomia, preeclampsia and emergency caesarean section in the normal weight and overweight groups who exceeded GWG recommendation. Excess GWG across all weight gain groups resulted in postpartum weight retention of >2kg at 18 months.

The IOM guidelines have been criticized for their lack of global utility, given that they are based on mostly observational studies from developed Western countries. Their use of WHO BMI cut points are not specific for Asian women. With this in mind, Ee⁵⁶ et al used the WHO BMI cut points for Asian women and created new optimal GWG recommendations in their multiethnic Singapore cohort (► **Table 2**). Of interest, optimal GWG in underweight and obese women was outside the IOM range.

While IOM recommendations currently guide practice in many countries, a recent study has shown significant variation in practice internationally in terms of policies on GWG.⁵⁷ To clearly define healthy GWG, the 2009 IOM guidelines need to be validated in the current setting of higher maternal BMI's and greater rates of GWG. Systematic review, meta-analysis and further research is needed addressing adverse outcomes across diverse multi-ethnic populations.

Lifestyle Interventions and the Need for More Research

Prevention of obesity is important for all lifelong. In this context, targeting pregnant women in prevention of weight gain is important as i) there are significant reproductive implications of obesity ii) many women now exceed international GWG recommendations^{11,13,58,59} and ~2–5kg are retained per pregnancy^{13,60} iii) pregnancy offers a defined life stage for women captured in our existing health system with enablers for lifestyle change iv) healthy lifestyle change in pregnancy improves outcomes v) weight gain during pregnancy contributes significantly to maternal obesity with potential for long term health benefits vi) women influence family lifestyle with maternal lifestyle changes having broader implications for families and communities.

Lifestyle interventions in pregnancy focusing on improving dietary intake and physical activity has been shown in a comprehensive systematic review of 7278 women to prevent excess GWG gain. Overall, there was 1.42 kg less weight gained (95% confidence interval 0.95 to 1.89 kg) and lifestyle intervention reduced preeclampsia (OR 0.39 - 0.74) and shoulder dystocia (OR 0.39), with a trend to reduced GDM (OR 0.78, CI 0.57–1.08).²¹ Lifestyle intervention do not appear to impact on birth weight, or have safety concerns.²¹ Monitoring maternal weight alone is ineffective, but improves efficacy when used in combination with interventions.⁶¹

There are many effective lifestyle interventions in pregnancy. The Healthy Lifestyle Program for women (HeLP-her) is one example of an effective intervention.²¹ The HeLP-her program is an evidence-based self-management weight gain prevention intervention initially targeting reproductive aged

non pregnant women and published in the BMJ.⁶² Now trialled across different urban and metropolitan settings and populations, it has demonstrated efficacy in over 1000 women including women in pregnancy.^{10,63,64} HeLP-her has significant evidence of efficacy for weight gain prevention and is designed for implementation as a low cost pragmatic simple intervention that leverages off self-management and is integrated into routine antenatal care.⁶ It involves simple dietary and activity messages, self-management, behavioral strategies such as goal setting, problem solving, relapse prevention, self-monitoring, phone coaching and SMS reminder messages⁶⁵ shown to support small lifestyle behavior changes and effective weight gain prevention.^{66,67} Diet messages follow national guidelines and include increased unprocessed grains, fruits and vegetables.^{10,21,64} HeLP-her has now been adapted to target limiting excess GWG, promoting postpartum weight loss and preventing type II diabetes in women with a history of GDM. This intervention is being trialled in large scale implementation research across low-mid socioeconomic, multiethnic countries in an internationally funded RCT of 1600 women in resource poor settings.

The UPBEAT study focused solely on obese women ($n = 1555$, mean BMI 36.3kg/m²), with the primary outcomes of maternal diagnosis of GDM and reduction of LGA. The intervention was relatively intensive with 8, mainly group sessions combining behavioral components, dietary and physical activity advice. GWG and skinfold thickness were lower in the intervention group, although results were modest with 0.55kg (95%CI -1.08 to -0.02) less GWG in the intervention group, and no maternal or neonatal benefits demonstrated.^{68,69}

The LIMIT study in Australia again had primary outcomes focused on reduction in neonatal complications, with the primary endpoint being reduction in LGA, rather than prevention of weight gain alone. Here, 2212 overweight and obese women were randomized to standard care with or without an additional lifestyle intervention. The intervention was delivered by a dietitian and was not integrated with routine antenatal care.⁷⁰ This study did not show differences in the primary endpoint, but did show a reduction in babies born over 4000 gms.⁷⁰ These results are consistent with the majority of the literature in this area, which shows a failure to impact significantly on birth weight.²¹

Overall, antenatal lifestyle interventions, prevent excess GWG and offer important obesity prevention opportunities at a vital life stage, when women are engaged with the health system,⁶ yet they do not significantly alter birth weights and appear to have limited impact on neonatal outcomes.

Although systematic reviews had identified beneficial effects of mainly diet based, physical activity based and mixed interventions,²¹ findings are limited by the variation in the characteristics of the population, intervention and outcomes. The effects of lifestyle interventions on various groups of women based on BMI category, age, ethnicity, parity and risk status in pregnancy is not known. These questions cannot be answered from published aggregate data, as patient-level information is not available and subgroup effects ('treatment-covariate interactions') are usually not reported in

sufficient detail. However, these gaps in evidence can be addressed by meta-analysis of individual participant data IPD, where the raw patient-level data are obtained and synthesized across trials.

The International Weight Management in Pregnancy (i-WIP) individual patient data (IPD) collaborative network is funded by the UK National Institute for Health Research (NIHR) to assess differential weight management interventions in pregnancy by BMI, age, ethnicity, parity and underlying medical conditions on a) maternal weight and b) composite pregnancy outcome of maternal and fetal complications.³⁰ The Network also aims to quantify the relationship between the amount of weight gained in pregnancy and the risk of adverse maternal and fetal outcomes for normal weight, overweight and obese women. The i-WIP Network comprises 36 principal investigators from 17 countries, and comprises of obstetricians, physicians, nutritionists, physiotherapists, researchers, dieticians, exercise physiologists, midwives, nurses and consumers involved in the evaluation of diet and physical activity on GWG and other complications in pregnancy.

The findings of the i-WIP initiative will soon enable us to clearly define the efficacy of lifestyle interventions in pregnancy to prevent excess GWG and obesity. It will also provide clarity on maternal (e.g., GDM, preeclampsia) benefits. Remaining clinical and research gaps which should be addressed in the i-WIP work, include the most effective components of lifestyle interventions, optimal delivery modes and a cost benefit analyses.³⁰ This important information will inform implementation (the next vital step) and scale up of healthy lifestyle interventions to target the broader population of pregnant women outside those in randomized controlled trials.

In considering implementation of lifestyle interventions into routine antenatal care, barriers need to be addressed. Misperceptions around healthy weight among health professionals and women need to be redressed. For example, it is estimated that less than 16% of obese pregnant women identify as obese.⁷¹ Inadequate weight monitoring in routine care and disparities in medically advised GWG targets also needs to be rectified.⁷² Only 4% of obstetricians and midwives accurately identified IOM GWG recommendations,²⁶ only 25–30% suggested weight targets; only 1% base targets on IOM guidelines and ~70% reported inadequate training in lifestyle behavior change methods.²⁶ In a midwifery survey, provision of lifestyle advice by midwives was limited and interventions to assist women and staff in developing skills to aid this intervention provision were lacking.⁷³

Alongside identified barriers, implementation gaps in prior interventions include failure to partner to establish problems, engage stakeholders, address barriers and enablers, use implementation informed study design; expand beyond single institutions, as well as inconsistent designs, poor or unreported recruitment. There has been a lack of focus on normal and overweight women at highest risk of additional weight retention postpartum, failure to use theoretical frameworks, apply evidence based components, integrate into routine antenatal care and to provide

implementation resources for health services and for health professionals. Finally there has also been limited postpartum extension⁷⁴ and lack of evaluation. Implementation research is now needed to address these barriers and gaps. We need to know how best to address health system and health professional factors including how to engage, train and support health professionals in lifestyle change. Ideally this will include integrating key lifestyle message prompts, weighing reminders and triggers when GWG is exceeded, into routine maternity care workflows, as this approach is known to increase application of clinical guidelines by 20-fold compared with provision of guidelines alone.⁷⁵

Conclusion

Overweight and obesity present a major and neglected public health burden. Reproductive aged women are a recognized high risk target group for weight gain and related complications. Excess GWG is a significant contributor to obesity in women which carries independent increased risks of adverse maternal and infant outcomes, including and not limited to caesarean section, increased birth weight, LGA and long term maternal and childhood obesity. Further research is required to assist in refining and optimizing GWG recommendations across different BMI categories and ethnic groups. Individually targeted antenatal lifestyle interventions effectively limit excess GWG, contributing to prevention of obesity in reproductive aged women. Specific maternal and neonatal pregnancy benefits of these interventions still require clarification. Optimal components of antenatal lifestyle interventions as well as the cost effectiveness of these interventions are currently being researched through an international individual patient data meta-analysis of lifestyle interventions in pregnancy that will guide practice and policy in this area. We then require pragmatic implementation strategies to scale up healthy lifestyle into routine antenatal care.

Ultimately, antenatal interventions need integration with prevention efforts across the life stages including in childhood and adolescence and preconception to prevent maternal weight related pregnancy complications. While ultimately healthy lifestyle is a matter of individual behavior change, individual interventions must extend beyond individual targeted initiatives to address societal and environmental factors and enable children, adolescents and women to have a healthier lifestyle and to prevent obesity and related complications.

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