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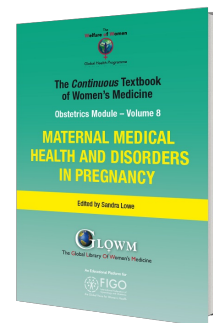
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Chapter

Gestational Weight Gain

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INTRODUCTION

Women invariably gain weight in pregnancy due to fat deposition, fluid retention, weight attributed by the growing fetus, uterus and breasts. Gestational weight gain (GWG) can influence the pregnancy outcomes as well as the long-term health of both the mother and child. It is well known that excessive GWG increases the risk of macrosomia, while inadequate GWG will increase the risk low birth weight (LBW).¹ Recent studies also demonstrate that GWG impacts on mothers' postpartum weight retention, future obesity and its related disease² and children's cardiometabolic risk.³ It is reported that nearly 50% of the mothers worldwide gain excessive weight in pregnancy, and more concerns are among those overweight/obese women.^{4,5}

THE COMPOSITION OF GESTATIONAL WEIGHT GAIN

Physiological GWG is attributed primarily by the fetal weight, maternal fat and water deposition. On average, total maternal weight gain at term is contributed by the following:

1. Fetus – 7–8 lb (3.2–3.6 kg);
2. Fat deposition – 6–8 lb (2.7–3.6 kg);
3. Extra blood volume – 3–4 lb (1.4–1.8 kg);
4. Increased extravascular fluid volume – 2–3 lb (0.9–1.4 kg);
5. Amniotic fluid – 2 lb (0.9 kg);
6. Breast enlargement – 1–3 lb (0.45–1.4 kg);
7. Uterus – 2 lb (0.9 kg);
8. Placenta – 1.1–1.5 lb (0.5–0.7 kg).

OPTIMAL GESTATIONAL WEIGHT GAIN

Recommendation from the National Academy of Medicine

The National Academy of Medicine, formerly called the Institute of Medicine (IOM) of the United States (US), developed the first guidelines on GWG in 1990 on the basis of a 1980 National Natality Survey of a largely white population, aiming to reduce low birth weight. It was updated in 2009, incorporating World Health Organization (WHO) categories of maternal body mass index (BMI) (Table 1). The 2009 guidelines which were endorsed by the American College of Obstetricians and Gynecologists (ACOG) considered the risk of potential pregnancy outcomes in association with GWG, namely small for gestational age (SGA)/large for gestational age (LGA), preterm birth, cesarean delivery, postpartum weight retention and childhood obesity. However, the recommended weight gains were designated for the Caucasian population and hence cannot be extrapolated to other ethnic groups.⁶ Moreover, the BMI ranges used to define underweight and overweight/obesity specific for the Caucasians in the IOM recommendation are also not applicable to other populations. For example, Asians are expected to have lower BMI cut-off points in defining overweight and obesity.^{1,7,8,9,10,11,12}

Table 1 Institute of Medicine (IOM) 2009 recommendations for gestational weight gain.⁶

Prepregnancy BMI	Total weight gain		Rates of weight gain from the 2nd trimester*	
	Range in kg	Range in lbs	Mean (range) in kg/week	Mean (range) in lbs/week
Underweight (<18.5 kg/m ²)	12.5–18	28–40	0.51 (0.44–0.58)	1 (1–1.3)
Normal weight (18.5–24.9 kg/m ²)	11.5–16	25–35	0.42 (0.35–0.50)	1 (0.8–1)
Overweight (25.0–29.9 kg/m ²)	7–11.5	15–25	0.28 (0.23–0.33)	0.6 (0.5–0.7)
Obese (≥30.0 kg/m ²)	5–9	11–20	0.22 (0.17–0.27)	0.5 (0.4–0.6)

* With the assumption that weight gain in the first trimester is 0.5–2 kg (1.1–4.4 lbs).

Furthermore, IOM only offers a provisional guideline to mothers carrying a twin pregnancy (Table 2). Meanwhile, there is insufficient information to recommend a reference for underweight women carrying twins.

Table 2 Institute of Medicine (IOM) 2009 recommendations for gestational weight gain for women with twins.⁶

Prepregnancy BMI	Total weight gain	
	Range in kg	Range in lbs
Underweight (<18.5 kg/m ²)	Insufficient information	
Normal weight (18.5–24.9 kg/m ²)	17–25	37–54
Overweight (25.0–29.9 kg/m ²)	14–23	31–50
Obese (≥30.0 kg/m ²)	11–19	25–42

Recommendations from other countries

Contrary to in the US, there is no recommendation on optimal weight gain from the United Kingdom (UK). Both the National Institute for Health and Care Excellence (NICE) guidelines on the pregnancy weight management and the National Collaborating Centre for Women's and Children's Health on routine antenatal care concluded that there was

insufficient evidence to determine the optimal weight gain for their population.^{13,14} Meanwhile, using the same argument of a lack of consensus on optimal GWG in pregnancy, the Royal College of Obstetricians and Gynaecologists (RCOG) suggested that focus should be placed on healthy diet rather than prescribed weight gain targets for obese mothers at risk of weight management.¹⁵

In 2016, the Japanese Ministry for Health, Labor, and Welfare (JMHLW) and the Japanese Society for the Study of Obesity (JSSO) jointly updated the guideline on GWG for Japanese (Table 3).⁹

Table 3 Recommendations on gestational weight gain for Japanese women.⁹

Prepregnancy BMI	Total weight gain range (kg)
Underweight (<18.5 kg/m ²)	9–12
Normal weight (18.5–24.9 kg/m ²)	7–12
Overweight (25.0–29.9 kg/m ²)	≤7
Obese (≥30.0 kg/m ²)	≤5

In 2018, the National Health Commission of the People's Republic of China provisionally proposed a recommendation for Chinese (unpublished data in Chinese) (Table 4). The BMI ranges used to define underweight and overweight/obesity are based on those recommended by the Working Group on Obesity in China and National Health and Family Planning Commission in 2013.^{16,17,18,19} The BMI cut-off points for overweight and obesity are lower than those proposed by the World Health Organization (WHO).

Table 4 Provisional recommendations on GWG by the National Health Commission of the People's Republic of China.

Pre-pregnancy BMI*	Total weight gain range (kg)	Total weight gain in the 1st trimester (kg)	Rates of weight gain-2nd and 3rd trimester (kg/week)
Underweight (<18.5 kg/m ²)	11–16	<2	0.46 (0.37–0.56)
Normal weight (18.5–24.0 kg/m ²)	8–14	<2	0.37 (0.26–0.48)
Overweight (24.0–28 kg/m ²)	7–11	<2	0.3 (0.22–0.37)
Obese (≥28.0 kg/m ²)	<9	<2	<0.3

* The pre-pregnant BMI category according to the 'adult BMI classification standards' in China.

IMPACT OF GESTATIONAL WEIGHT GAIN ON PREGNANCY OUTCOMES

A meta-analysis in 2017 of over 1 million women from 23 cohort studies showed that, across all BMI categories, GWG below the guideline levels was associated with higher risk of small for gestational age (SGA) (OR 1.53, 95% CI 1.44–1.64) and preterm birth (OR 1.70, 95% CI 1.32–2.20) than GWG within the guidelines. These associations were greatest with lower BMI for both SGA (underweight: OR 1.89, 95% CI 1.67–2.14; normal weight: OR 1.63, 95% CI 1.54–1.71; overweight: OR 1.34, 95% CI 1.24–1.44) and obese: OR 1.24, 95% CI 1.06–1.45; and preterm birth (underweight: OR 2.41, 95% CI 1.01–5.73; normal weight: OR 1.96, 95% CI 1.17–3.29; overweight: OR 1.55, 95% CI 1.10–2.19) and obese: OR 1.20, 95% CI 1.03–1.40; respectively. Likewise, GWG above the guidelines was associated with higher risk of large for gestational age (LGA) (OR 1.85, 95% CI 1.76–1.95), macrosomia (OR 1.95, 95% CI 1.79–2.11), and cesarean delivery (OR 1.30, 1.25–1.35).⁴ Among those classified into obesity classes (class 1, BMI of 30–34.9; class 2, BMI of 35–39.9; and class 3, BMI of 40 or higher),

both weight loss and GWG below guidelines were associated with lower risk of CD (weight loss: OR 0.78, 95% CI 0.72–0.85; GWG below guidelines: OR 0.87, 95% CI 0.82–0.93).⁴

In 2019, another meta-analysis of pooled individual participant data from 25 cohorts, included nearly 20,000 women, predominantly from western cohorts from Europe, North America, and Oceania derived optimal GWG according to various pre-pregnancy BMI categories (Table 5). The magnitude of GWG was only weakly associated with adverse pregnancy outcomes, namely LGA, SGA, gestational hypertensive, gestational diabetes, CD and preterm birth.²⁰

Table 5 Optimal gestational weight gain (GWG) ranges proposed by LifeCycle Project-Maternal Obesity and Childhood Outcomes Study Group.²⁰

Pre-pregnancy BMI	Optimal GWG in kg
Underweight (<18.5 kg/m ²)	14.0–16.0
Normal weight (18.5–24.9 kg/m ²)	10.0–18.0
Overweight (25.0–29.9 kg/m ²)	2.0–16.0
Obese class 1 (30.0–34.9 kg/m ²)	2.0–6.0
Obese class 2 (35.0–39.9 kg/m ²)	0–4.0
Obese class 3 (≥40.0 kg/m ²)	0–6.0

Among women categorized as obese, the highest absolute risks were 63.7% for GWG of 28.0 kg or greater in obesity class 1, 67.7% for GWG of 16.0 kg or greater in class 2 and 78.8% for GWG of 16.0 kg or greater in class 3.

IMPACT OF GESTATIONAL WEIGHT GAIN ON MOTHERS' LONG-TERM OUTCOMES

Pregnancy is regarded as a potential risk factor for the development of obesity in women at their reproductive age.²¹ Therefore, excessive GWG may contribute to the rising trend of obesity and obesity-related diseases, such as diabetes mellitus, hypertension and cerebrovascular disease, through postpartum weight retention.

In a meta-analysis of 65,000 women from nine observational studies, GWG above the recommended level was found to result in an average of 3 and 4.7 kg more in weight retention after 3 and 15 years postpartum, respectively.²²

IMPACT OF GESTATIONAL WEIGHT GAIN ON CHILDREN'S LONG-TERM OUTCOMES

Apart from its effect on the pregnancy outcomes, GWG also influence children's risk of metabolic disorders. The majority of studies have been on the association of excessive maternal weight gain with children's obesity and adiposity fat deposition.^{3,23,24,25,26} Furthermore, excessive GWG was also found to be associated with higher blood pressures,^{3,27,28,29,30,31} higher levels of inflammatory markers such as C-reactive protein and interleukin-6, and lower high-density lipoprotein cholesterol and apolipoprotein A1 levels.^{3,27,29} These risks could be found in the offspring at various stage of life course from childhood to adulthood.

Nonetheless, the impact of inadequate GWG remains controversial. The Southampton Women's Survey reported that inadequate GWG was associated with childhood adiposity at 6 years of age,²⁶ while most other studies included in the meta-analysis did not find any association between inadequate maternal weight gain and childhood obesity or adiposity.^{23,24,25} However, a study in the Chinese population showed a quadratic association between maternal weight gain and children's blood pressure, insulin sensitivity and secretion, suggesting the inadequate GWG also might have adverse cardiometabolic risk to the offspring.³

INTERVENTIONS TARGETING WEIGHT GAIN WITHIN RECOMMENDATIONS DURING PREGNANCY

Maternal weight gain can be influenced by multiple factors. Whilst maternal appetite, nausea and vomiting related to pregnancy, smoking habits, maternal diseases in particular those associated with malabsorption, psychological conditions such as eating disorders, and food insecurity could result in inadequate weight gain, the majority of mothers gain excess weight due to overeating and inadequate exercise. Moreover, mothers who are already overweight or obese are most vulnerable to excessive weight gain and its impact to the pregnancy and long-term outcomes.

Nevertheless, studies also reported a higher risk of SGA, lower lean body and fat mass at birth in infants of obese women having GWG below that recommended by IOM.^{32,33} It is, therefore, important to advise obese mothers against gestational weight loss.³⁴ On the contrary, studies also suggested that the recommended weight gain by IOM might not be applicable to super obese women with BMI >50 kg and type 2 diabetes mellitus mothers, provided the fetus is growing normally.^{35,36}

In several large randomized controlled trials, such as RADIEL, DALI and UPBEAT, and a meta-analysis, aiming to reduce adverse pregnancy outcomes among obese women, antenatal dietary and life-style advice was found to achieve a modest reduction in excessive maternal weight gain.^{37,38,39,40} Although the LIMIT randomized trial did not show any prevention of excessive weight gain,⁴¹ offering antenatal dietary and lifestyle advice to women who are overweight or obese can reduce macrosomia (defined as birth weight >4.5 kg) and respiratory distress syndrome compared to standard care group.⁴² The ROLO study,⁴³ which specifically examined the role of low glycemic index diet in pregnancy, also showed beneficial effect of reducing excessive gestational weight gain and lowering maternal glucose intolerance, but was not shown to reduce the incidence of LGA infants.

Given the experience that pregnant women with gestational diabetes treated with metformin have lower GWG compared to those treated with insulin,^{44,45} studies also investigated the role of metformin in the prevention of pregnancy complications among overweight/obese mothers. In the MOP trial, administering a daily dose of 3000 mg of metformin was found to reduce GWG in nondiabetic women with BMI >35 kg/m².⁴⁶ However, two other studies, namely GRoW and EMPOWaR, using a daily dose of at most 2000 mg and 2500 mg respectively, did not show any effect on the GWG in nondiabetic obese women.^{47,48} A Cochrane systematic review also concluded that there was still insufficient evidence to support the use of metformin for obese women in improving maternal and infant outcomes.⁴⁹

SUMMARY

In general, both inadequate and excessive weight gain in pregnancy are associated with adverse pregnancy outcomes. GWG also impacts on both mothers' and children's long-term health especially excessive weight gain among the obese and overweight mothers. Recommended maternal weight gain varies slightly among different ethnic populations with different pre-pregnant BMI categories. It is also important to note that the recommendation of optimal GWG is a useful reference at pre-conception and upon pregnancy, but not a target to be prescribed and that all women must be met. Appropriate dietary and lifestyle advice could be useful in preventing excessive weight gain in obese women, but care should be taken to avoid inducing weight loss, which could be potentially harmful to the unborn fetus.

PRACTICE RECOMMENDATIONS

- **Optimal gestational weight gain (GWG) is a useful reference for a woman at pre-conception and upon pregnancy, but not a target to be prescribed, or that must be fulfilled.**
- **There is no universally accepted recommendation in optimal GWG based on different BMI categories. Each region or ethnic population should consider its own local adaptation when considering a reference for**

optimal GWG.

- **Appropriate dietary and lifestyle advice provided to obese women can be helpful to prevent excessive weight gain, but caution should be taken to avoid inducing weight loss, which could be potentially harmful to the pregnancy.**

CONFLICTS OF INTEREST

The authors of this chapter declare that they have no interests that conflict with the contents of the chapter.

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