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EDITORIAL

Maternal weight before and during pregnancy in women with gestational diabetes: one step forward, one step back☆

Roslyn Mainland [a], **Ravi Retnakaran** [a,b,c,*]

[a] *Mount Sinai Hospital, Leadership Sinai Centre for Diabetes, Toronto, Canada*
[b] *University of Toronto, Division of Endocrinology, Toronto, Canada*
[c] *Mount Sinai Hospital, Lunenfeld-Tanenbaum Research Institute, Toronto, Canada*

Maternal weight before and during pregnancy has implications for both mother and child. Indeed, elevated preconception body mass index (BMI) and excessive gestational weight gain (GWG) are each associated with adverse infant outcomes. In addition, excess GWG can contribute to maternal complications during pregnancy, such as gestational diabetes mellitus (GDM), and is often retained for months to years after delivery. With rising global rates of obesity in recent decades coupled with growing clinical recognition thereof, the impact of these societal changes on pre-pregnancy BMI and GWG warrants consideration, particularly given the implications for transgenerational health affecting both mother and child.

Progress in controlling gestational weight gain

GWG refers to the weight that a mother gains between the time of conception and the onset of labor. Variability in the measurement of total GWG has historically made it challenging to compare research studies and develop appropriate weight gain guidelines. Women often present in the first trimester of pregnancy, making it difficult to accurately capture pre-pregnancy weight. As a result, healthcare teams must often utilize self-reported pre-pregnancy weight (which is commonly underreported),[1] weight at the first prenatal appointment, or a previously charted measurement to serve as pre-pregnancy weight. Similarly, final gestational weight is often based on that which was measured at the last prenatal appointment in the third trimester, rather than weight immediately before delivery.

Despite the challenges of obtaining accurate measurements, both inadequate and excessive GWG have been linked to adverse infant outcomes; therefore, specific guidelines for weight gain during pregnancy have been proposed. In 1990, the Institute of Medicine (IOM) developed its first guidelines for optimal GWG targets. These guidelines were updated in 2009 to reflect changes in population demographics — namely, higher rates of women who were overweight or obese prior to conception.[2] The revised IOM guidelines suggest a recommended weight gain range according to pre-pregnancy BMI category (underweight, normal weight, overweight, obese), thereby acknowledging that appropriate GWG varies in relation to pre-pregnancy weight.

GWG outside of these guidelines — whether excessive or inadequate — has been linked to both adverse infant outcomes and maternal complications. In a systematic review and meta-analysis of over 1.3 million women, Goldstein et al. reported that GWG below current recommendations was associated with a higher risk of small-for-gestational-age (SGA) infants and preterm delivery, while GWG above recommendations was associated with higher rates of large-

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* Corresponding author.
E-mail: ravi.retnakaran@sinaihealthsystem.ca (R. Retnakaran).

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for-gestational-age (LGA) infants and Caesarean delivery.[3] Similarly, women with GDM who gain above IOM guidelines are at higher risk of LGA, preterm delivery, and Caesarean delivery, while those who gain below recommendations are more likely to delivery an SGA infant.[4] GWG also has implications for maternal health. Excessive GWG, particularly in the first trimester, has been associated with maternal complications such as an increased risk of developing GDM.[5] Moreover, the propensity for excess GWG to be retained and carried into subsequent pregnancies is high, leading to a cycle of increasing BMI and adverse health outcomes.[2]

In this background, in the current issue of the Journal, Silveira et al. report a comparison of two cohorts of Brazilian women with GDM to evaluate trends in total GWG and pre-pregnancy BMI over multiple decades.[6] The researchers compared a cohort of women with GDM that was formed from 1991 to 1995 to a cohort of women with GDM recruited over 20 years later, from 2014 to 2017. They observed that although the proportion of women gaining excessive GWG increased, the mean total GWG was lower in the more recent GDM cohort (9.2 ± 7.6 kg in 2014–2017 *vs.* 11.3 ± 6.1 kg in 1991–1995).

This reassuring downward trend in total GWG is likely accounted for by a combination of increased awareness of associated risks and more effective management of GDM. As the relationships between total GWG and adverse infant outcomes have become better understood, specific guidelines on healthy GWG in the context of GDM have been developed and implemented. Current guidelines for the clinical management of GDM recommend a combination of medical nutritional therapy, appropriate GWG targets, exercise, glucose monitoring, and pharmacologic therapy, and thus generally aim for lower total GWG than historically reported.

Furthermore, there is increasing awareness of the effects of untreated maternal metabolic dysfunction on the offspring, which has led to more comprehensive management of maternal health during pregnancy. Indeed, Langer et al. observed a two- to four-fold higher risk of metabolic complications and delivery of an LGA infant among women with untreated GDM, as compared to those with treated GDM or those without a diagnosis of GDM.[7] In the Australian Carbohydrate Intolerance Study in Pregnant Women (ACHOIS) trial, as compared to routine care, treatment of GDM with dietary advice, glucose monitoring, and insulin therapy resulted in significantly lower rates of serious perinatal outcomes (infant death, shoulder dystocia, bone fracture, or nerve palsy).[8] Thus, treatment of maternal glycemia has emerged as an effective approach for mitigating adverse infant outcomes among women with GDM.

Evolving diagnostic criteria for GDM may also contribute to the apparent decreasing trend in total GWG over the past few decades. Notably, the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study provided robust evidence that maternal hyperglycemia, even below the traditional diagnostic thresholds for GDM, is associated with fetal overgrowth.[9] In response to the HAPO trial, the International Association of the Diabetes and Pregnancy Study Groups recommended lower glycemic thresholds for the diagnostic criteria of GDM.[10] Thus, women with milder degrees of glycemia are now included in calculations of mean GWG among women with GDM.

Taken together, there have been many changes in maternal care over the past few decades. More specific guidelines on weight gain during pregnancy, increasing awareness of the adverse effects of GWG outside of these guidelines, and a concerted effort to treat maternal metabolic conditions during pregnancy have likely all contributed to the apparent downward trend in total GWG among patients with GDM reported by Silveira et al.[6]

The challenge of optimizing pre-pregnancy BMI

Despite a reassuring downward trend in average total GWG, pre-pregnancy BMI has steadily increased over the past few decades, reflecting increasing global rates of obesity. The prevalence of overweight and obesity has continued to increase since 1980 among men and women in both developing and developed countries.[11] Rates of pre-pregnancy overweight and obesity are now estimated to be 42%, 30%, and 10% in the United States, Europe, and Asia, respectively.[12] This trend of increasing pre-pregnancy BMI is also reflected among women with GDM. Silveira et al. found that, in 2014–2017, women with GDM presented with higher pre-pregnancy BMI (30.3 ± 6.5 *vs.* 24.6 ± 4.4 kg/m^2) and were more frequently obese at the time of conception (46.4 *vs.* 11.1%) than women in 1991–1995.[6]

Elevated pre-pregnancy BMI is associated with adverse infant and maternal outcomes, independent of the magnitude of weight gained during pregnancy. Mothers who are overweight or obese at the time of conception have an increased risk of preeclampsia, delivery of an LGA infant, and intrauterine death, as well as increased risk of GDM, postpartum hemorrhage, and genital tract infections.[13] Maternal obesity has also been associated with metabolic conditions that persist into childhood. Indeed, Boney et al. observed that the children of obese mothers were two times more likely to have metabolic syndrome by age 11 than the children of mothers who had normal pre-pregnancy BMI.[14]

Both excessive GWG and elevated pre-pregnancy BMI are associated with adverse outcomes. However, there is increasing evidence to suggest that clinical interventions that target pre-pregnancy BMI, rather than GWG, may more effectively mitigate the risks of adverse maternal and infant outcomes. Indeed, in a meta-analysis of 25 cohort studies, Voerman et al. found that pre-pregnancy BMI and the magnitude of GWG were independently associated with adverse obstetrical outcomes (preeclampsia, gestational hypertension, GDM, Caesarean delivery, preterm birth, SGA, or LGA).[15] However, GWG ranges had limited predictive value for these outcomes, while the associations between pre-pregnancy BMI and adverse pregnancy outcomes were more robust. In a recent prospective, preconception cohort study, weight gained from preconception to 18 weeks of gestation was associated with infant birthweight, but maternal weight gained after 18 weeks of gestation was not.[16] These results indicate maternal weight before conception and in early gestation, rather than total weight gained across the span of pregnancy, as most influential on fetal outcomes. Furthermore, patterns of GWG appear to be similar globally, despite significant differences in healthcare and culture between countries. A study of women from eight geographically diverse urban regions (Brazil, China, India, Italy, Kenya, Oman, United Kingdom, and United States) reported that GWG was relatively conserved across all populations studied, despite genetic and lifestyle variations between cultures.[17] This conserved nature highlights the difficulty of altering GWG, of which a certain amount is physiologically necessary and inevitable.

Furthermore, little success has resulted from attempts to improve maternal and infant outcomes through lifestyle interventions that restrict GWG. For example, the Lifestyle in Pregnancy (LiP) group randomized 360 obese pregnant women to either lifestyle intervention —which included dietary guidance, free gym memberships, physical training, and personal coaching — or to a control group.[18] Although the lifestyle intervention resulted in significantly lower GWG (7.0 *vs*. 8.46 kg, $p = 0.01$), there was no difference in obstetrical outcomes between the groups. Numerous meta-analyses of trials evaluating the effects of lifestyle interventions during pregnancy have been published in the past few years. In particular, a meta-analysis of 44 randomized controlled trials reported that any lifestyle intervention decreased GWG by 1.42 kg overall, with dietary interventions resulting in the greatest GWG reduction.[19] However, lifestyle interventions initiated during pregnancy had no effect on infant birthweight or rates of LGA or SGA infants.

The importance of targeting pre-pregnancy BMI, rather than GWG, may be explained in part by the developmental origins of adult health and disease (DOHaD). The DOHaD paradigm is based on the postulate that the intrauterine environment programs changes in fetal developmental pathways, thereby influencing the individual's health and vulnerability to disease later in life. Current understanding suggests that maternal obesity is likely one of the foremost factors. Though the intrauterine consequences of maternal obesity are not fully understood, maternal endothelial dysfunction, elevated inflammatory mediators, insulin resistance, and placental insufficiency have been proposed as mechanistic links between maternal obesity and altered fetal programming that leads to adverse infant outcomes.[20]

Conclusion

Excess GWG and elevated pre-pregnancy BMI have implications for both mother and child and require increasing attention as obesity rates continue to rise. Though both GWG and pre-pregnancy BMI are independently associated with adverse obstetrical outcomes, increasing evidence suggests that preconception weight may be a more effective target for mitigating adverse maternal and infant outcomes. Further work is required to better understand the mechanistic links between maternal obesity and the intrauterine environment, and to implement effective interventions that can optimize short- and long-term outcomes for both mother and child.

Conflicts of interest

The authors declare no conflicts of interest.

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