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The Effect of Maternal Obesity on the Offspring

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Abstract

Maternal obesity is inextricably linked to adverse health outcomes for the mother and her children. The peripartum period is a critical period of risk. In this chapter, we examine the importance of maternal pre-pregnancy weight status, gestational weight gain, breastfeeding, and postpartum weight loss in relation to subsequent risk for maternal obesity and obesity in the offspring. Promoting optimal maternal weight during the preconception, pregnancy and postpartum periods will provide lifelong benefits for maternal health and the health of her progeny.

INTRODUCTION

The importance of the mother-infant dyad for obesity and its prevention

Focusing on pregnancy is a strategy to influence maternal, fetal, and infant health during pregnancy and beyond. Maternal weight and epigenetic influences, even from the prior generation, impart risk for the child.¹ The dyadic mother-infant relationship begins in the earliest stage of prenatal life and continues through infancy. The shared nature of the peripartum phase is especially salient for the development of obesity in the mother or the infant. Offspring of overweight and obese women are at increased risk to be born large-for-gestational age and become overweight or obese as children or adults.² Risk relates to maternal preconceptual weight, weight gain, and maternal glucose metabolism during pregnancy and breastfeeding. Thus, focusing on the mother and infant as an inseparable and reciprocal dyad allows an integral approach to promoting optimal weight in mothers and their offspring. Pregnancy is an amazing period of receptivity to behavior change as the mother focuses inward on the developing fetus, initially as an integral part of herself, and gradually as a separate individual. Therefore, it is a time of relative openness to improving health behaviors.

Obesity epidemic and the role of pregnancy and prenatal life

Dramatic changes in society over the past 40 years have led to an epidemic of obesity that threatens the overall health of the U.S. population.³ In 2012, about 36% of U.S. adults were obese (BMI >30) and an additional 30% were overweight (BMI > 25).³ Based on the latest estimates, women of childbearing age (20-39 years old) were 32% obese with an additional 24% who were overweight.⁴ Non-Hispanic black and Mexican American women had the highest rates.⁴ Overweight and obesity prevalences have continued to increase in minority women. With respect to parity, primiparous women tend to gain more weight during pregnancy and have higher rates of postpartum weight retention than multiparous women.⁵ For this reason, prioritizing optimal weight gain during the first pregnancy and return to prepregnancy weight afterwards has the potential to decrease the cycle of increasing obesity rates in women and their progeny. Perhaps because they have already experienced weight

gain during a prior pregnancy, multiparous women are less likely to have excessive gestational weight gain than primiparous women.⁵

Ongoing link between mother and child related to obesity risk

After the pregnancy, mothers continue to influence their infants' weight gain and weight status. Breastfeeding is one factor that promotes optimal weight gain in infants.⁶ Risk reduction is related to exclusivity and duration of breastfeeding. One postulated mechanism is the promotion of self-regulation of appetite in the infant. Another important factor is the timing of introduction of supplemental baby foods. Infants who receive first baby foods later in the first 6 months exhibit lower risk for obesity than those who receive baby foods early in that period. In addition, the family food and activity environment are important predictors of early weight gain. Weight gain in infancy is an important risk for later obesity.² In 2011 – 2012, an estimated 8.1% of infants under 2 years old were obese.³ This prevalence has not changed over the past decade. However, the obesity rate for 2- to 5-year-old children declined slightly over the last decade from 13.9% to 8.4%.³ During this period, there were important clinical efforts and public health interventions, some of which may be responsible for this change. Obstetric providers began to follow the 2009 Institute of Medicine Report "Weight Gain During Pregnancy: Reexamining the Guidelines".⁷ The USDA Special Supplemental Nutrition Program for Women, Infant, and Children (WIC) revised the food packages to increase fruits and vegetables and to decrease higher-calorie foods. In addition, pediatric providers were increasingly counseling families about the risks of excess weight gain in preschool-age children. The decline in obesity among 2 to 5 year olds is good news. However among black and Hispanic children, the rates are 30% higher than they are among white children.³ Similarly, low-income children are at increased risk for obesity. Furthermore, development of obesity as early as preschool imparts risk for later obesity, including biomarkers related to heart disease.¹ Because of these very critical periods related to the development of obesity, including fetal, early life and childhood, early prevention is essential.¹

Throughout the life cycle, there are multiple time points of risk for the development of obesity in both mother and offspring (Figure 1).¹ At the same time, these periods of risk present opportunities for intervention and the prevention of obesity. In this paper, we focus on pregnancy and the postpartum periods as, perhaps, the most influential times of risk and opportunity for interrupting the cycle of maternal and offspring obesity.

MATERNAL BODY MASS, FETAL WEIGHT GAIN AND INFANT BIRTHWEIGHT

For the newborn infant, the strongest predictor of later obesity is maternal preconceptional BMI.⁸ The mother's preconceptional weight status is a marker of both environmental and genetic risk for the child. Genetic traits from the family can influence obesity risk. Relatively common obesity susceptibility gene variants interact with diet in three possible ways: 1) increase saturated fat and refined carbohydrate consumption; 2) decrease energy expenditure; or 3) alter lipid metabolism regulation. It is highly likely that genetic determinants relate to eating behavior. Environments with readily available calorically-dense

foods and multiple sensory cues to prompt eating are considered particularly hazardous for those with genetic risk. Current high obesity rates suggest that such environments are risky for most.

Excess gestational weight gain is associated with risk for both the infant and the mother.^{9,10} In approximately two-thirds of U.S. pregnancies, weight gain exceeds Institute of Medicine guidelines.⁹ We first consider risk for the infant. Excess gestational weight gain is associated with fetal macrosomia and increased risk for developing childhood obesity.¹⁰ Macrosomic infants are at increased risk of obesity in childhood and adulthood compared to normal birthweight infants.⁸ Thus, more optimal gestational weight gain decreases risk for high birthweight. It is well documented that many women increase caloric intake and decrease physical activity during pregnancy. Based on knowledge gained from nutrition and physical activity interventions promoting behavior change techniques, limiting excess caloric intake and increasing exercise during pregnancy may reduce gestational weight gain.¹¹ Curbing excess gestational weight gain has been associated with lower risk of childhood overweight. This is true even when first and second trimester weight gain have exceeded the recommended guidelines.¹²

Low birthweight infants, whether they are premature or small-for-gestational age, are at increased risk for developing obesity largely based on rapid growth during infancy.⁸ It has been customary for pediatricians and neonatologists to encourage rapid growth for low birthweight infants. However, it is now understood that risk for obesity is an unintended consequence of rapid early growth. In addition, low birthweight infants are at increased risk for developing metabolic syndrome, high blood pressure, abnormal lipid profiles and cardiovascular diseases in adulthood compared to infants of normal birthweight.¹⁸

Infants' individual weight gain trajectories continue on a consistent path from prenatal into postnatal life. The effect of gestational weight gain on infant weight continues after birth, as fetal weight in the last trimester is associated with infant weight gain in the first months of life and subsequent risk for obesity.⁸

Excess gestational weight gain not only presents health risks for the mother during pregnancy, labor, and delivery, but also significant increased risk for postpartum weight retention.⁹ Furthermore, return to prepregnancy weight is important not only for the mother's health, but also the health of her future infants. The mother's postpartum weight often becomes her prepregnancy weight for the next pregnancy. For mothers, the risk for compounding weight gain and subsequent long-term obesity risk increases in women with short interpregnancy intervals. Weight retention varies greatly in the first year postpartum; however, it is estimated that between 15-25% of U.S. women retain 4 kg (~8.8 lbs.) or more in the first 6-18 months after birth.¹³ If women are already overweight or obese, retaining substantial postpartum weight, and then becoming pregnant again, puts both her and her offspring at greater risk for suboptimal outcomes related to excess weight. Women who have experienced an interpregnancy increase in BMI may be at higher risk for gestational diabetes mellitus in the next pregnancy.¹⁴ On the other hand, interpregnancy weight management may improve maternal health outcomes. Reducing postpartum weight retention lowers risk for obesity in subsequent pregnancies and improves the long-term health of the mother.¹⁵

Studies have shown mild to moderate interpregnancy weight loss in obese mothers may decrease the risk of subsequent large-for-gestational-age infants without necessarily increasing the risk for small-for-gestational-age infants.¹⁶ As such, the postpartum phase and the interpregnancy interval are crucial for promoting maternal weight loss, which may directly contribute to offspring weight outcomes. Hispanic, African American women, and women with lower education have increased prevalences of both short interpregnancy intervals and obesity. In addition, in women, obesity prevalence increases with age. Therefore, race/ethnicity, age, socioeconomic status and short interpregnancy intervals contribute to additive risk for high prepregnancy weight and excessive pregnancy weight gain in these populations.

BREASTFEEDING

Postnatally, the mother remains closely linked her infant through feeding. Breastfeeding offers some protection for the infant against early rapid weight gain and may promote return to prepregnancy weight in the mother.⁶¹⁷ Extended exclusive breastfeeding may also contribute to more optimal interpregnancy intervals, providing mothers more time to return to prepregnancy weight, or lose additional weight if the previous prepregnancy weight was in the overweight or obese range.

Breastfeeding has beneficial effects for maternal weight. In the mother, breastmilk production expends from 250 kilocalories per day at birth to up to 900 kilocalories per day between 6-12 months of age. This may facilitate return to prepregnancy weight. Additionally, breastfeeding may have other independent benefits for the mother. Breastfeeding has been associated with lower risk for type 2 diabetes mellitus, the metabolic syndrome, postpartum depression, and cardiovascular disease. Rates of premenopausal breast cancer and ovarian cancer are also lower in women who have breastfed a baby.

Breastfeeding decreases risk for later obesity in infants. Furthermore, maternal obesity and lack of breastfeeding interact to robustly increase risk for later obesity in the offspring (Figure 2).¹⁸ In the baby, breastfeeding promotes optimal feeding because infant demand is matched to milk production in the mother. This helps to avoid infant overfeeding. Formula-fed babies have been shown to have higher risks for obesity and type 2 diabetes mellitus. Furthermore, mothers influence infant weight gain through other feeding strategies based on their knowledge, beliefs and attitudes. Some of these may be confounded with the decision to breastfeed.

Obese women are less likely to initiate breastfeeding than their normal weight counterparts (Figure 3).¹⁹ Furthermore, they tend to breastfeed for shorter durations and introduce solid foods to their infants earlier than normal-weight women.¹⁸ There are, therefore, additive risks related to maternal obesity and lower likelihood of breastfeeding.

Obstetric providers may have the opportunity to promote and support breastfeeding for the benefit of both the mother and the infant. The decision about infant feeding usually begins prenatally, well before women have consulted a pediatrician. Review of maternal intentions to breastfeed and provision of materials about the benefits of breastfeeding for mother and

baby could have an impact. Breastfeeding initiation, determined in the first hours and days of life, is influenced by hospital policy and obstetric provider support. Labor and delivery units often provide mothers with education about the importance of breastfeeding. Breastfeeding can be presented as optimal infant nutrition and as beneficial to promote maternal postpartum weight loss, thus promoting optimal weight for the dyad. Because the first few hours and days are so crucial for breastfeeding initiation and establishing milk supply, education and identification of resources are ideally provided before delivery. Important resources include breastfeeding support groups, trained breastfeeding peer counselors, and lactation consultants. This information allows new mothers to prepare for breastfeeding and be aware of resources in case challenges arise.

PUBLIC HEALTH INTERVENTIONS AND IMPLICATIONS

Pregnancy is an optimal time to break the generational cycle of overweight and obesity (Figure 1).¹ Interventions addressing maternal obesity that consider offspring outcomes have been mainly designed to prevent excess gestational weight gain and gestational diabetes mellitus in overweight and obese pregnant women.¹¹ Observational studies have found that higher maternal prepregnancy weight increases risk of obesity among offspring, but interventions to prevent the “causal link” are rare.

Lifestyle interventions have included education and behavioral counseling related to diet and physical activity. Such interventions have shown positive outcomes in controlling gestational weight gain and gestational diabetes mellitus.²⁰ Behavioral interventions (including regular weight monitoring and social support) are modestly effective in both preventing excess gestational weight gain and promoting return to pre-pregnancy weight.¹¹ Focusing on exercise and breastfeeding in the postpartum phase could promote optimal maternal weight with lasting effects up to 10 years later.¹⁵ However, there have been few interventions focusing on long-term weight outcomes in both mother and infant. Furthermore, few culturally-tailored programs are available, even though postpartum weight retention is most prevalent among women from minority groups. To date, no published study has focused on high risk mother-infant dyads from Hispanic, Black, or Native American populations, all of whom have the highest rates of obesity among women of child-bearing age.⁴ A systematic review and meta-analysis on the effects of interventions in pregnancy on maternal weight and obstetric outcomes found that of the 44 randomized-controlled trials reviewed, many lacked information on characteristics of the sample such as ethnicity, socioeconomic status, and underlying medical conditions.²⁰ There is a need for more intervention studies focusing on these high-risk groups.

Breastfeeding promotion and support can also have public health effects. Education to support breastfeeding currently occurs during prenatal care and WIC appointments. Nonetheless, rates of exclusive breastfeeding and breastfeeding duration (to 6 months) remain low in the U.S.¹⁷ Pre and postnatal breastfeeding interventions, combined with trained peer counselors for breastfeeding support have been shown to improve breastfeeding initiation, duration, and exclusivity, especially in conjunction with prenatal breastfeeding classes.¹⁷

CONCLUSIONS AND PROVIDER RECOMMENDATIONS

Obstetric providers have the capacity to influence maternal weight outcomes during and after pregnancy (Table 1). These approaches will subsequently help decrease risk in the fetus and infant, as well as in the mother. Consequently, these decreased risks will be salient throughout that individual's life and continue into the next generations. The following strategies are recommended in order to positively affect mother-infant dyad weight outcomes:

- Counsel and guide women during the pre-conception and/or interpregnancy period about the benefits of starting pregnancy at the healthiest weight possible.
- Provide close monitoring of gestational weight gain by assisting women to plot their weights using simple, visual, color-coded tools at each prenatal visit (for example, green zone for appropriate weight gain, yellow zone for weight gain approaching excessive, red zone for excess weight gain). If gestational weight gain exceeds recommendations, at any time during the pregnancy, intervene with concrete suggestions for behavior and lifestyle changes (diet, self-monitoring of weight, exercise) to curb excess weight gain.
- Educate patients about the importance of postpartum weight loss and return to prepregnancy weight for the health of the mother-infant dyad in the next pregnancy.
- During the prenatal and immediate postpartum period, promote the decision to breastfeed.

Peripartum weight influences current and future pregnancies and the health of the mother. Appreciation of the importance of optimal rather than excessive weight gain for both mothers and infants could affect pregnancy and parenting practices. Focusing on this sensitive period is likely to add an important piece of the puzzle for solving the obesity epidemic.

References

1. Nader PR, Huang TT, Gahagan S, et al. Next steps in obesity prevention: Altering early life systems to support healthy parents, infants, and toddlers. *Child Obes.* 2012; 8(3):195–204. [PubMed: 22799545]
2. Taveras EM, Rifas-Shiman SL, Belfort MB, et al. Weight status in the first 6 months of life and obesity at 3 years of age. *Pediatrics.* 2009; 123(4):1177–1183. [PubMed: 19336378]
3. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of childhood and adult obesity in the United States, 2011–2012. *JAMA.* 2014; 311(8):806–814. [PubMed: 24570244]
4. Flegal KM, Carroll MD, Kit BK, et al. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999–2010. *JAMA.* 2012; 307(5):491–497. [PubMed: 22253363]
5. Lan-Pidhainy X, Nohr EA, Rasmussen KM. Comparison of gestational weight gain-related pregnancy outcomes in American primiparous and multiparous women. *Am J Clin Nutr.* 2013; 97(5):1100–1106. [PubMed: 23553161]
6. Owen CG, Martin RM, Whincup PH, et al. Effect of infant feeding on the risk of obesity across the life course: A quantitative review of published evidence. *Pediatrics.* 2005; 115(5):1367–1377. [PubMed: 15867049]
7. Rasmussen, KM.; Yaktine, AL. Weight gain during pregnancy: Reexamining the guidelines. Institute of Medicine; 2009.

8. Oken E, Gillman MW. Fetal origins of obesity. *Obes Res.* 2003; 11(4):496–506. [PubMed: 12690076]
9. Olson CM. Achieving a healthy weight gain during pregnancy. *Annu Rev Nutr.* 2008; 28:411–423. [PubMed: 18422452]
10. Oken E, Rifas-Shiman SL, Field AE, et al. Maternal gestational weight gain and offspring weight in adolescence. *Obstet Gynecol.* 2008; 112(5):999–1006. [PubMed: 18978098]
11. Skouteris H, Hartley-Clark L, McCabe M, et al. Preventing excessive gestational weight gain: A systematic review of interventions. *Obes Rev.* 2010; 11(11):757–768. [PubMed: 20880128]
12. von Kries R, Chmitorz A, Rasmussen KM, et al. Late pregnancy reversal from excessive gestational weight gain lowers risk of childhood overweight--a cohort study. *Obesity (Silver Spring).* 2013; 21(6):1232–1237. [PubMed: 23670829]
13. van der Pligt P, Willcox J, Hesketh KD, et al. Systematic review of lifestyle interventions to limit postpartum weight retention: Implications for future opportunities to prevent maternal overweight and obesity following childbirth. *Obes Rev.* 2013; 14(10):792–805. [PubMed: 23773448]
14. Ehrlich SF, Hedderson MM, Feng J, et al. Change in body mass index between pregnancies and the risk of gestational diabetes in a second pregnancy. *Obstet Gynecol.* 2011; 117(6):1323–1330. [PubMed: 21606742]
15. Rooney BL, Schauburger CW. Excess pregnancy weight gain and long-term obesity: One decade later. *Obstet Gynecol.* 2002; 100(2):245–252. [PubMed: 12151145]
16. Jain AP, Gavard JA, Rice JJ, et al. The impact of interpregnancy weight change on birthweight in obese women. *Am J Obstet Gynecol.* 2013; 208(3):205, e1–e7. [PubMed: 23246318]
17. Skouteris H, Nagle C, Fowler M, et al. Interventions designed to promote exclusive breastfeeding in high-income countries: A systematic review. *Breastfeed Med.* 2014 Epub ahead of print.
18. Li C, Kaur H, Choi WS, et al. Additive interactions of maternal prepregnancy BMI and breastfeeding on childhood overweight. *Obes Res.* 2005; 13(2):362–371. [PubMed: 15800295]
19. Thompson LA, Zhang S, Black E, et al. The association of maternal pre-pregnancy body mass index with breastfeeding initiation. *Matern Child Health J.* 2013; 17(10):1842–1851. [PubMed: 23247667]
20. Thangaratinam S, Rogozinska E, Jolly K, et al. Effects of interventions in pregnancy on maternal weight and obstetric outcomes: Meta-analysis of randomised evidence. *BMJ.* 2012; 344:e2088. [PubMed: 22596383]

Figure 1.

Developmental and intergenerational effects of obesity

Significant inter-stage events include: 1. Intrauterine Programming; 2. Breastfeeding, early food exposure, attachment stage; 3. Early childhood growth, child care, habit formation; 4. Brain maturation, self-management, puberty, health behavior change, increased salience of peer effects and school effects; 5. Independence, increasing life stress; 6. Pre-conceptual health, parental health status, prenatal care.

Reference: Nader PR, Huang TT, Gahagan S, et al. Next steps in obesity prevention: Altering early life systems to support healthy parents, infants, and toddlers. *Child Obes* 2012;8(3):195-204.

Figure 2.

Prevalence of childhood BMI ≥ 95th percentile by maternal prepregnancy BMI and breastfeeding

Reference: Li C, Kaur H, Choi WS, et al. Additive interactions of maternal prepregnancy BMI and breast-feeding on childhood overweight. *Obes Res* 2005;13(2):362-71.

Figure 3.

Breastfeeding initiation, 2004–2009 by pre-pregnancy BMI

Reference: Thompson L, Zhang S, Black E, et al. The association of maternal pre-pregnancy body mass index with breastfeeding initiation. *Matern Child Health J* 2013;17(10):1842-51.

Table 1**Key Points and ‘Take Home’ Messages**

- Mother-infant dyad is inextricably linked during entire peripartum period
- Maternal weight directly affects offspring during pregnancy, into childhood and later life
- Both maternal pre-pregnancy weight and gestational weight gain are important for offspring birthweight – curbing excess weight gain is most ideal early in pregnancy; however, it's never too late to start—even controlling 3rd trimester weight gain can help
- Special attention should be paid to women with overweight or obese prepregnancy BMI and those who have excess gestational weight gain – they are at higher risk for a number of factors affecting offspring weight, including: infant high birthweight, rapid infant growth in the 1st year, and lower rates of BF initiation and shorter duration
- Fetal growth trajectory is affected by maternal prepregnancy weight and gestational weight gain; this growth trajectory continues into the first months of life
- Breastfeeding is beneficial for maternal postpartum weight loss and optimal infant growth – women can begin discussing their feeding intentions prenatally with their obstetric providers
- Interpregnancy interval is a crucial time-period for mothers to return to prepregnancy weight (or lose additional weight if overweight or obese); the postpartum period for one baby is the preconception period for the next
- Effectively tailored public health and clinical interventions are needed to promote healthy maternal pre-pregnancy weight, gestational weight gain, breastfeeding, and postpartum weight loss and, thus, optimal offspring weight outcomes