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Pregnancy and post-delivery maternal weight changes and overweight in preschool children

Camille A. Robinson [a,b], Alison K. Cohen [b], David H. Rehkopf [c], Julianna Deardorff [d], Lorrene Ritchie [e], Ruvani T. Jayaweera [b], Jeremy R. Coyle [f], Barbara Abrams [b,d,*]

[a] University of California —San Francisco, School of Medicine, San Francisco, CA, USA
[b] University of California —Berkeley, School of Public Health, Division of Epidemiology, Berkeley, CA, USA
[c] Stanford University School of Medicine, Division of General Medical Disciplines, Stanford, CA, USA
[d] University of California —Berkeley, School of Public Health, Division of Community Health and Human Development, Berkeley, CA, USA
[e] University of California —Berkeley, Atkins Center for Weight and Health, Berkeley, CA, USA
[f] University of California —Berkeley, School of Public Health, Division of Biostatistics, Berkeley, CA, USA

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ABSTRACT

Objectives. High maternal weight before and during pregnancy contributes to child obesity. To assess the additional role of weight change after delivery, we examined associations between pre- and post-pregnancy weight changes and preschooler overweight.

Methods. Sample: 4359 children from the Children and Young Adults of the 1979 National Longitudinal Survey of Youth (NLSY) born to 2816 NLSY mothers between 1979 and 2006 and followed to age 4–5 years old. Exposures: gestational weight gain (GWG) and post-delivery maternal weight change (PDWC). Outcome: child overweight (body mass index (BMI) ≥85th percentile).

Results. Adjusted models suggested that both increased GWG (OR: 1.08 per 5 kg GWG, 95% CI: 1.01, 1.16) and excessive GWG (OR: 1.29 versus adequate GWG, 95% CI: 1.06, 1.56) were associated with preschooler overweight. Maternal weight change after delivery was also independently associated with child overweight (OR: 1.12 per 5 kg PDWC, 95% CI: 1.04, 1.21). Associations were stronger among children with overweight or obese mothers.

Conclusions. Increased maternal weight gain both during and after pregnancy predicted overweight in preschool children. Our results suggest that healthy post-pregnancy weight may join normal pre-pregnancy BMI and adequate GWG as a potentially modifiable risk factor for child overweight.

Introduction

More than one in four U.S. children age 2–5 are overweight or obese (Ogden et al., 2012), and the prevalence of overweight and obesity among 4 year-olds in European Union countries ranges from 12 to 32% (Cattaneo et al., 2010). Indeed, child obesity is considered a global epidemic (Wang and Lobstein, 2006). Child obesity is associated with poor lifelong health; understanding early life determinants as part of the environmental, social, and genetic multifactorial pathways to child overweight (Butland et al., 2007) is essential for primary prevention (Biro and Wien, 2010; IOM et al., 2011).

Several mechanisms have been proposed to explain how pregnancy-related maternal weight changes may contribute to child obesity (Oken and Gillman, 2003; Tarry-Adkins and Ozanne, 2011). Prepregnancy obesity as well as prenatal maternal diet, excessive or inadequate gestational weight gain, or gestational diabetes may contribute to offspring adiposity through developmental programming via the thrifty obesity or fetal over nutrition pathways (Dabelea and Crume, 2011; Drake and Reynolds, 2010; Poston et al., 2011). After birth, maternal obesity, diet and diabetes may also program neural development of the neonatal hypothalamus, influencing long-term appetite (Armitage et al., 2008). Both maternal and paternal BMI are associated with child's BMI (Durmuş et al., 2013), suggesting that genetics as well as shared environments, and post-birth behaviors, including breastfeeding and physical activity, are linked to both maternal and infant weights (Chu et al., 2012).

Postpartum weight retention and interpregnancy weight gain are growing concerns: for example, 50% of low income U.S. women retain 10 lb and 25% retain more than 20 lb after pregnancy (IOM, 2009). Weight retention after pregnancy is a risk factor for both permanent maternal obesity (Gore et al., 2003; Linee et al., 2004; Rooney and Schauberger, 2002) and adverse outcomes in subsequent pregnancies (Ehrlich et al., 2011; Jain et al., 2013; Villamor and Cnattingius, 2006). While there is growing evidence that high prepregnancy body mass index (BMI) and excessive gestational weight gain (GWG) are each associated with child obesity (independent of pregnancy-related

* Corresponding author at: University of California —Berkeley, School of Public Health, Division of Epidemiology, 103 Haviland Hall, Berkeley, CA, 94720, USA.
E-mail address: babrams@berkeley.edu (B. Abrams).

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characteristics such as smoking or length of gestation, post-pregnancy characteristics such as breastfeeding, and child characteristics such as birthweight) (de Hoog et al., 2011; Fraser et al., 2010; Hinkle et al., 2012a; Margerison Zilko et al., 2010; Nehring et al., 2013; Oken et al., 2007; Olson et al., 2009). However, the contribution of maternal weight changes after delivery to child obesity has not been explored.

We investigated how excessive GWG and post-delivery maternal weight change are associated with preschooler (age 4–5 years old) overweight, and how these associations vary by maternal prepregnancy weight in a nationally representative cohort. We hypothesized that overweight preschool children would have higher odds of having a mother with less weight loss between delivery and three years postpartum.

Methods

Sample

This secondary data analysis utilized the 1979 National Longitudinal Survey of Youth (NLSY79), a nationally representative cohort study of U.S. youth aged 14–22 in 1979, and the Children and Young Adults of the 1979 National Longitudinal Survey of Youth (NLSY79-CYA), a cohort of all children born to NLSY79 mothers starting in 1986. Detailed information on sampling design, data collection, and response rates is reported elsewhere (CHRR, 2008, 2010). The Office for the Protection of Human Subjects at the University of California, Berkeley did not require formal review because these data are deidentified and publicly available.

The analytic data set included all singleton births born to each NLSY79 mother between 1979 and 2010 with at least one follow-up survey when the child was 4–5 years old ($n = 7613$) and a reported maternal weight at 3–36 months postpartum, and excluded births with a gestational age of <22 or >44 weeks ($n = 19$) or births with implausible birthweight–gestational age combinations ($n = 25$) (Alexander et al., 1996). The sample was further restricted to cases with complete data for all variables of interest described below (Table 1), yielding a final analytic sample of 4359 children born to 2816 mothers, which represented about 58% of NLSY participants. Similar retention rates are common among secondary analyses of cohort studies (Mei et al., 2004; Wake et al., 2007).

Measures

Maternal pregnancy-related weight

In the first survey after each pregnancy, NLSY79 mothers recalled their prepregnancy weight and weight before delivery. Height was reported in 1985. Maternal BMI was calculated as weight (in kilograms) divided by height (in meters) squared (kg/m^2). We calculated observed GWG as the difference (kilograms) between prepregnancy weight and delivery weight (Fig. 1) and then categorized GWG as inadequate, adequate, or excessive based on adequacy for gestational age and BMI using the Institute of Medicine (IOM) recommendations (IOM, 2009) as described in detail elsewhere (Bodnar et al., 2010; Deardorff et al., 2013).

Postpartum weight

Mothers reported their current weight, which was regression-calibrated to account for potential self-reporting bias (Strauss and Thomas, 1996; Thomas and Frankenberg, 2002). We created a post-delivery weight change variable (PDWC), defined as the difference (kilograms) between the current weight within 3–36 months after delivery (mean 13.4 months, SD 7.6 months) and delivery weight (Fig. 1). If a mother became pregnant again before completing her first postpartum survey for the index child (13%), we used the prepregnancy weight for the next child as the postpartum weight for the previous child.

The PDWC variable was created to decompose the prepregnancy through postpartum weight into GWG and PDWC (Fig. 1). Traditionally, the difference between postpartum weight and prepregnancy weight has been defined as postpartum weight retention (IOM, 2009). However, because new weight gain postpartum can be misclassified as retained GWG, others suggest using "postpartum weight difference" (PPWD) (Lipsky et al., 2012) to describe weights obtained after 1 year. For purposes of comparison to previous studies (i.e., Kac et al., 2004; Nehring et al., 2011; Olson et al., 2003; Rode et al., 2012; Walker et al., 2004), we also calculated PPWD (kilograms) as the difference between the first postpartum weight and prepregnancy weight (Fig. 1).

Child overweight

The outcome of interest was child overweight (BMI ≥85th percentile which includes both overweight: BMI ≥85th and <95th percentiles, and obese: BMI ≥95th percentile) (Ogden and Flegal, 2010) at age 4–5 years old. Children's weights and heights were either measured at the in-home interview (by a trained interviewer using a tape measurement for height and a portable scale for weight) or reported by the mother; 74% of weights and 82% of heights were measured. Others have found no bias resulting from mother report of child weight and height (Weden et al., 2012), but we nevertheless regression-calibrated the mother-reported weights and heights to reduce potential bias (Strauss and Thomas, 1996; Thomas and Frankenberg, 2002). We calculated sex-specific BMI-for-age percentiles using the SAS Program for the Centers for Disease Control and Prevention (CDC) Growth Charts (CDC, 2007). This age range (4 to 5 years old) was chosen to capture the time before the potential critical period in the development of obesity known as the adiposity rebound (Dietz, 1994) at 5–7 years of age, when body fatness reaches a nadir before increasing into adolescence and adulthood (Boonpleng et al., 2012; Dietz, 1994; Whitaker et al., 1998).

Potential confounders were selected based on previous studies of both pregnancy-related weight exposures of interest and child overweight (Fraser et al., 2010; Hinkle et al., 2012a; Lawlor et al., 2011; Oken et al., 2007; Olson et al., 2009). Demographic confounders (defined in Table 1) were measured in the child's birth year and included race/ethnicity, maternal educational attainment, maternal employment status, maternal marital status, and equivalized household income (continuous variable in year 2000 U.S. dollars that accounts for household size; Rehkopf et al., 2010). Pregnancy-related confounders were: smoking during pregnancy, prepregnancy BMI (continuous), maternal age at child's birth, maternal prepregnancy height (meters), and length of gestation (weeks). Maternal birth year, child's birth order, and year in which the child was 4–5 years old were also included in the model as survey characteristics to account for any potential birth cohort effects. The models for PDWC and PPWD additionally adjusted for GWG (kilograms), child's birthweight (grams), and child's age (months) when maternal postpartum weight was obtained. All continuous covariates were median-centered.

Data analysis

Separate models were used to examine how maternal weight changes pre- and post-delivery (expressed as per 5 kg weight change) were associated with child overweight, adjusting for potentially confounding demographic and pregnancy variables. Given the wide time range of reported postpartum weights, we also conducted subgroup analyses to compare results for mothers reporting within the first 12 months of delivery versus more than 1 year post-delivery. To determine if prepregnancy BMI category (BMI <25, BMI ≥25) modified the association between maternal pre- or post-pregnancy weight, we also ran models with interaction terms, using an a priori cutoff of 0.10.

All models used generalized estimating equations (GEE) in Stata 12.1 (Stata Corporation, 2011) to: a) account for the clustering of births by mothers, since about 90% of children had at least one sibling, and b) make a population average estimate, which is more clinically relevant than random effects (Hubbard et al., 2010). These GEE models allow us to report odds ratios that are adjusted for covariates in the model. We used custom sampling weights to make the sample nationally representative to account for oversampling and loss to follow-up, and robust standard errors were calculated.

Results

Almost one-fourth of the 4359 children in the analytic sample were overweight at age 4–5 (Table 1). A similar proportion of mothers were overweight or obese before pregnancy. Mean maternal GWG was 14.4 kg (SD 6.0 kg) and almost half of all the mothers in our analytic sample had excessive GWG. On average, at 13.4 months postpartum, mothers had lost 12.3 kg (SD 6.7 kg) from their delivery weight (PDWC) and gained 2.1 kg (SD 5.4 kg) over their prepregnancy weight (PPWD). Comparing the analytic sample to those excluded, a larger proportion of included mothers who were included were non-Black non-Hispanic, out of the labor force or unemployed, and married; a larger proportion of mothers excluded due to incomplete data had less than a high school education, were obese before pregnancy, and had inadequate GWG. The prevalence of child overweight was the same