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Higher Birthweight and Maternal Pre-pregnancy BMI Persist with Obesity Association at Age 9 in High Risk Latino Children

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Abstract

Background—Childhood obesity is increasing especially in Latinos and early intervention is essential to prevent later obesity complications.

Methods—Latino children (n=201) recruited at two San Francisco hospitals were assessed at birth including infant anthropometrics and feeding practices and followed to age 9 with annual anthropometric assessments. We evaluated the relationship between perinatal risk factors and obesity at age 9 and chronic obesity (obesity at both 5 and 9 years).

Results—Higher birthweight (odds ratio (OR) 2.48, 95% confidence interval (CI) 1.06-5.81) and maternal pre-pregnancy body mass index (BMI) (OR 1.09, 95%CI 1.00-1.18) were associated with increased risk for obesity at 9 years. Higher maternal pre-pregnancy BMI (OR 1.10, 95%CI 1.01-1.20) was associated with chronic obesity. Additionally, prenatal depression symptoms were protective (OR 0.33, 95%CI 0.11-0.94) against chronic obesity. We found no association between maternal age and education, exclusive breastfeeding at 4-6 weeks, rapid infant weight gain, and obesity or chronic obesity.

Discussion—Perinatal risk factors for obesity including higher birthweight and maternal pre-pregnancy BMI persisted until age 9, whereas, other variables significant at age 5 in our cohort

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and other populations including exclusive breastfeeding and rapid infant weight gain were no longer associated with increased risk.

Keywords

childhood obesity; Latinos; perinatal infant risk factors; perinatal maternal risk factors

Background

Obesity

Obesity has increased from 13.9% to 17.2% in US children aged 2-19 years over the last 25 years [1]. Severe childhood obesity (body mass index (BMI) >99% percentile) has tripled over the same period. Mexican Americans are the largest group of Latino children in the US [2] and have higher rates of obesity (21.9%) compared to non-Latino white children (14.7%) [1].

Early intervention for obesity in high-risk groups is necessary as obesity persists from childhood to adulthood. Latinos have a higher risk for overall obesity and higher risk for co-morbidities associated with obesity such as diabetes and non-alcoholic fatty liver disease than non-Latino whites, emphasizing the need to predict and prevent obesity and associated health, social and economic costs.

Perinatal risk factors and obesity

Perinatal risk factors including limited or no breastfeeding, high birthweight and rapid infant weight gain have been shown to have an important impact on childhood obesity up to age 5 in Latinos [3, 4]. However, there are limited studies to address whether the effect of these perinatal risk factors extend into middle childhood [5]. Studies in non-Latino white populations have suggested that some early exposures may persist until middle childhood including limited breastfeeding, rapid infant weight gain and high birthweight, however the impact of these early exposures may weaken over time [6–9]

Maternal factors including excessive gestational weight gain, high pre-pregnancy BMI and maternal perinatal depression are also associated with childhood obesity in some studies in predominantly white populations, but again it is not clear if these risk factors extend to middle childhood [10–12].

The consequences of childhood obesity in Latino children are higher prevalence of hypertension in adolescence [13], non-alcoholic liver disease, and diabetes mellitus than seen in non-Latino white children and not obese Latino children. This suggests that there is a need to understand the impact of perinatal risk factors for obesity in middle childhood to prevent child obesity development by early prediction and intervention. This study aims to identify perinatal infant and maternal risk factors as predictors for obesity in high-risk, low-income Latino children persisting until middle childhood.

Method

Participants and Procedures

Latina women (n=201) pregnant in the second and third trimester were recruited between May 2006 and May 2007 at the prenatal clinics of University of California, San Francisco Medical Center and San Francisco General Hospital. The recruitment process and procedures have been described in previously published papers [2–4] with women with pre-existing diabetes mellitus, insulin treated gestational diabetes and any contraindication for breastfeeding excluded from the study. Of the women who qualified approximately 95% agreed to participate in the study. At 9 years 29% (58/201) were lost to follow-up. Mothers were interviewed during the prenatal period, and mothers and children dyads were followed at birth, 4-6 weeks, 6 months and 12 months post-partum and then yearly thereafter. At each time point, mothers were interviewed and anthropometrics were taken on both mother and child as described in detail below. All interviews were conducted in English and Spanish as per study participant's request.

The study protocol was approved by the Committee on Human Research at University of California, San Francisco and the Institutional Review Board at San Francisco General Hospital. The women gave written consent for themselves and their children.

Child characteristics—Anthropometric measurements of the child including weight to nearest 0.1 kg (0.005 kg at birth) and length to nearest 0.1 cm were taken at each time point using standard digital scales for weight (standard digital infant scales at birth) and tape measures for length. Rapid infant weight gain was defined as an increase in weight-for-age Z-score of ≥ 0.67 standard deviation or more (and alternatively 1 standard deviation or more) between birth and 6 months. Breastfeeding behaviors were assessed with a dietary information questionnaire administered by a trained research assistant, and exclusive breastfeeding was defined using WHO's definition including only breast milk with the exception of oral rehydration solution, medicines, minerals, and vitamins, but no other liquids or solids, not even water [14].

Maternal characteristics—Maternal BMI was assessed at each time of follow-up and categorized using the National Heart, Lung and Blood Institute (NHLBI) definition [15] with underweight as having a BMI <18.5, normal weight with a BMI ≥18.5 to <25, overweight with a BMI ≥25 to <30, and obesity having a BMI ≥30. Pre-pregnancy BMI was based on self-report as was language use, immigration status and ethnicity. Gestational weight gain was measured in kilograms and was evaluated continuously, dichotomously as either gaining more than 18.1 kg (40 lbs.) versus 18.1 kg and less, and dichotomously as above versus equal or below Institute of Medicine (IOM) recommendations based on pre-pregnancy BMI [16]. Maternal age at delivery was also assessed as a continuous variable. Immigration was assessed dichotomously as being born outside the US versus inside the US. Maternal ethnicity was defined as originating from Mexico or Central America based on self-report. Maternal education level was categorized as completion of less than a high school degree or a high school degree or more.

Maternal depression—As described in a previous published paper [2], the mothers were screened for current depressive symptoms using the Edinburgh Postpartum Depression Scale (EPDS) [17] and the Center for Epidemiologic Studies Depression Scale (CES-D) [18] during the prenatal period, 4-6 weeks, 6 months, and yearly until age 5. Depressive symptoms were defined if EPDS≥16 or CES-D ≥ 13. The Mini International Neuropsychiatric Interview (M.I.N.I, version 5.0) [19] was administered to assess current major depressive episodes.

Outcome – obesity at 9 years and chronic obesity—Childhood BMI was categorized using the CDC growth curves [20]. Obesity was defined as having a BMI ≥95th percentile, whereas overweight was defined as having a BMI ≥85th percentile and <95th percentile and underweight as BMI ≤5th percentile. Chronic childhood obesity was defined as being obese at both 5 and 9 year time points and not being chronically obese was defined as not being obese at either time point.

Statistical analysis

Dichotomous variables—Bivariate analyses were performed using chi-squared test and Fischer's exact test to evaluate the relationship between predictors and two outcomes: child obesity at 9 years and chronic obesity. Predictors included exclusive breastfeeding or any breastfeeding (yes/no), rapid weight gain from birth to 6 months using the two definitions (yes/no), maternal ethnicity (Mexican vs. Central American), immigrant status (born inside or outside the US), English skills (any English yes/no), education (<high school diploma vs. ≥high school diploma, excessive gestational weight gain (above 18.1kg yes/no and above IOM recommendation yes/no), and maternal obesity (BMI ≥ 30).

Maternal depressive symptoms and clinical depression were also evaluated as predictors. Maternal depression symptoms were defined as having one of the following: 1) CESD ≥ 16 or 2) EPDS ≥ 13; or 3) having a major depressive episode or dysthymia as per the MINI. Clinical depression was defined as per the MINI [19]. Chronic depression was defined as having depressive symptoms at both time points measured (prenatal and 6 months; 3 years and 5 years) (including a possible diagnosis of clinical depression as per the MINI).

Continuous variables—Student t-test was used for bivariate analyses of the relationship between outcomes; child obesity at 9 years or chronic obesity and the continuous predictors including maternal and child characteristics such as birthweight (kg), maternal age (years), maternal BMI (kg/m^2), and gestational weight gain (kg).

Multivariable logistic regression—Multivariable logistic regression models were used to evaluate the association between predictors and child obesity at 9 years or chronic obesity, one set of models was calculated for each outcome. Variables with a $p<0.10$ in bivariate analysis or those that were identified a priori: exclusive breastfeeding at 4-6 weeks and maternal age or for biological reasons such as gender were included in the multivariable logistic regression model. For all results we defined statistical significance to be $p<0.05$. Exclusive breastfeeding and breastfeeding were not included in the same models due to collinearity. To avoid collinearity for variables measured at different time points only

measurements at one time point were included in the model for the variables maternal depressive symptoms, maternal BMI, and obesity. All analyses were conducted using Stata 12.0 (Stata Corporation, TX, USA).

Results

Of the 201 children included n=143 (71%) of the children were followed up at age 9. Of these children 37% (n=53) were obese. There were no differences between those lost to follow-up and those maintained in the cohort in regards to birthweight (p=0.17), maternal pre-pregnancy BMI (p=0.41), maternal age (p=0.48), gestational weight gain (p=0.88), maternal education (p=0.31), gender (p=0.87), exclusive breastfeeding at 4-6 weeks (p=0.21), and maternal depression symptoms prenatal (p=0.99). There were n=118 children followed-up at both age 5 and 9 years and of these 33% (n=39) were chronically obese.

Child characteristics

Obesity at 9 years—Birthweight differed between children who were obese at 9 years compared with those not obese at 9 years with those who were obese heavier at birth (mean ±SD 3.46±0.45 kg vs 3.27±0.49, p=0.02). (Table 1) The risk of obesity at 9 years did not differ by gender, rapid weight gain between birth and 6 months, or exclusive breastfeeding and breastfeeding at any time point. (Table 1)

Chronic obesity—There was a difference in birthweight in those chronically obese versus those not chronically obese with those who were chronically obese heavier at birth (mean ±SD 3.44±0.41 vs. 3.26±0.48 kg, p=0.04). Exclusive breastfeeding at 4-6 weeks (26% versus 45%, p=0.06) and breastfeeding at 4-6 weeks (84% versus 95%, p=0.06) approached association with child chronic obesity. (Table 1). Child chronic obesity was not associated with gender, rapid weight gain from birth to 6 months, or exclusive breastfeeding and breastfeeding at other time points. (Table 1)

Maternal characteristics

Obesity at 9 years—We found no difference in child obesity by maternal ethnicity, maternal birthplace, use of English language, gestational weight gain, and maternal age at birth. For maternal education ((≥ high school diploma vs <high school diploma) mothers with obese children were less likely to have a high school diploma compared to children not obese at 9 years of age although the results were not statistically significant (p=0.09). Maternal BMI pre-pregnancy (mean±SD 27.1±6.6 vs. 24.8±4.4 kg/m^2, p=0.01), maternal BMI at 4 years postpartum (31.8±6.0 versus 27.3±5.0 kg/m^2, p<0.001) and maternal BMI at 5 years postpartum (31.1±6.2 versus 27.5±5.0 kg/m^2, p<0.001) differed significantly between children who were obese at 9 years versus children not obese at 9 years, with heavier mothers having heavier children. Similarly maternal pre-pregnancy obesity (in obese vs. not obese 32% vs 11%, p=0.002), maternal obesity at 3 years post-partum (52% versus 29% p=0.01), maternal obesity at 4 years post-partum (59% versus 27% p=0.001), and maternal obesity at 5 years post-partum (48% versus 28% p=0.03) were associated with child obesity at 9 years. (Table 2)

Chronic obesity—Maternal pre-pregnancy BMI (27.2±7.1 versus. 24.7±4.3 kg/m^2, p=0.02), maternal BMI at 4 years (31.6±6.2 versus 27.3±5.1 kg/m^2, p<0.001), and maternal BMI at 5 years (31.5±6.7 vs. 27.5±5.1 kg/m^2, p=0.001) were higher in children who were chronically obese compared with those not chronically obese. Maternal pre-pregnancy obesity (34% vs 11%, p=0.003), maternal obesity at 3, 4 and 5 years post-partum (54% vs 29%, p=0.01; 61% vs 29%, p=0.002; 49% vs 29%, p=0.048, respectively) were higher in children with chronic obesity versus those children who were not chronically obese. Maternal age at birth (25.2±5.7 versus 27.2±5.1 years, p=0.06) were lower for children who were chronically obese compared to the children who were not. Maternal ethnicity, being foreign born, using English language, gestational weight gain, and education were not associated with child chronic obesity. (Table 2)

Maternal depression

Obesity at 9 years—Maternal clinical depression and maternal depressive symptoms in early childhood did not differ by child obesity status at 9 years. Maternal chronic depression spanning the prenatal period to 6 months of age and from 3 to 5 years also was not associated with child obesity at 9 years. (Table 3)

Chronic obesity—Not having maternal depressive symptoms during the prenatal period (18% vs 37%, p=0.045) and at 6 months postpartum (6% vs 22%, p=0.051), and maternal depressive symptoms at 5 years postpartum (27% vs 12%, p=0.04) were associated with increased risk for child chronic obesity. This difference was not seen at other time points. There also was no difference between groups for maternal clinical depression measured at all time points including chronic maternal depression measured from the prenatal period to 6 months and from 3 to 5 years. (Table 3)

Multivariable predictors of obesity at 9 years

We conducted a multivariable analysis of obesity at 9 years, which included birthweight, gender, exclusive breastfeeding at 4-6 weeks, maternal pre-pregnancy BMI, maternal age, and education. Higher birthweight (odds ratio (OR) 2.48, 95% confidence interval (CI) 1.06-5.81, p=0.04) and higher maternal pre-pregnancy BMI (OR 1.09, 95% CI 1.00-1.20, p=0.04) were associated with obesity at 9 years. Also, lower maternal education (OR 0.36 95% CI 0.12-1.09, p=0.07) trended towards statistically significance with obesity at age 9, but gender (p=0.53), exclusive breastfeeding (p=0.13), and maternal age (p=0.43) were not associated with childhood obesity at 9 years. (Table 4)

Multivariable predictors of chronic obesity

For chronic obesity, the multivariable logistic regression model included birthweight, gender, exclusive breastfeeding at 4-6 weeks, maternal pre-pregnancy BMI, maternal age and prenatal maternal depression symptoms. We found that higher maternal pre-pregnancy BMI (OR 1.10, 95% CI 1.01-1.20, p=0.03) and not having prenatal maternal depression symptoms (OR 0.33, 95% CI 0.11-0.94, p=0.04) were associated with chronic obesity. Younger maternal age (OR 0.92, 95% CI 0.84-1.01, p=0.08) and higher birthweight (OR 2.69, 95% CI 0.90-8.05, p=0.08) trended towards statistical significance for chronic obesity,

but gender (p=0.37) and exclusive breastfeeding (p=0.12) were not associated with chronic childhood obesity. (Table 5)

Discussion

Significant in this study

Our study is the first study to look at perinatal and maternal risk factors for long-term obesity in Latino children to pre-pubescence. We found that many of the risk factors (rapid infant weight gain, breastfeeding, maternal education level, and maternal age) associated with early childhood obesity in other populations and at age 4 and 5 in our cohort [3, 4] were not associated with obesity at age 9. Meanwhile, however, some perinatal factors such as higher maternal pre-pregnancy BMI and birthweight persisted in their association with obesity up until age 9 in our cohort.

Perinatal risk factors

We previously found that infant rapid weight gain had a strong association with childhood obesity at age 5 [4], but this effect did not persist to age 9, suggesting that by middle childhood the impact of early childhood gain is attenuated. Other studies have found that rapid Infant weight gain increased risk for childhood obesity at 9-14 years in a primarily white population [10, 11]. In our cohort, higher birthweight incrementally increased childhood obesity risk (OR 2.48, 95% CI 1.06-5.81). Other studies found that birthweight consistently increased the risk for childhood obesity, but primarily focused on the role of macrosomia in increasing risk [8, 21], in predominantly white populations. Our previous study assessing birthweight and obesity at age 5 found that increasing birthweight (weight-for-age z-score) was a strong risk factor for obesity (OR 3.15-3.85) [4]. It is possible that the impact of birthweight on obesity risk attenuates over time in childhood. Additionally, we did not see any relationship between breastfeeding and obesity at age 9. In other studies the effects of exclusive breastfeeding at 6 months [6] and any breastfeeding for longer than 6 months [7] were shown to persist to middle childhood, but weaken over time [9]. In our cohort, we previously found that any breastfeeding at 1 year was associated with protection against obesity at age 4 [3] and exclusive breastfeeding at 4-6 weeks and any breastfeeding at 6 months protected against obesity at age 5, but the impact of child feeding is attenuated by age 9 [4].

This lack of protective association in middle childhood may be because other nutritional factors at age 9 overrule the role of breastfeeding or because of the weakened effect of breastfeeding over time; this study might not have power to find the association.

Maternal risk factors

We found no association between maternal education level and obesity in our pre-pubescent population. Lower maternal education levels have been shown to be associated with childhood obesity in both cross-sectional and longitudinal studies in mostly European populations [10, 22, 23]. Two longitudinal studies found no association between childhood overweight and maternal education in a combined estimate [21] and a cross-sectional study found that childhood obesity at 6 years, but not at 12 years was associated with lower

maternal education levels [24] in a predominantly white population. In contrast to our population, which was relatively low-income and without post-secondary education (only 21% had some college education) these other studies were conducted in higher income populations with higher levels of education [10, 23].

Our study also found that pre-pregnancy BMI was significant for later childhood obesity at 9 years, a finding universally seen in other studies [10, 11, 21]. Maternal pre-pregnancy BMI is likely a proxy for the important role of genetics to determine risk for childhood obesity; it is not clear if reducing maternal BMI before conception could serve as an intervention to reduce childhood obesity. We found no association between gestational weight gain and child obesity at 9 years and chronic obesity. This differs from other studies conducted in predominantly white and multiethnic populations where excessive gestational weight gain was associated with childhood obesity between age 5-18 [10, 11, 25]. The meta-analysis reported the mean gestational weight gain to be 9.5-14.3 kg in the included studies [25], whereas our study had a mean gestational weight gain of 15.2 kg, an overall high gain. Some of the studies showed that there was only an association for excessive weight gain in women with a normal pre-pregnancy BMI (mean 22.6 kg/m^2 and 23.7 kg/m^2) [26, 27] which could account for disparate findings as the mean pre-pregnancy BMI in our cohort was 25.6 (SD 5.5) kg/m^2. It is possible that excessive weight gain in pregnancy has a more significant impact for fetal development in normal weight women, but is less significant if women are already overweight or obese.

Maternal depression

We found a protective association between childhood chronic obesity and prenatal maternal depression symptoms. Previous studies in both multi-ethnic cohorts and white populations have found that maternal depression in early childhood increased the risk of obesity in preschoolers [12] and middle childhood [28]. A prospective study in Latino children found that chronic maternal depression from age 1 to 7 years was associated with overweight and obesity at 7 years [28], however a meta-analysis looking at perinatal maternal depression and the association with later childhood obesity in a multi-ethnic population was found to be inconclusive [29]. Previous studies in our cohort found that chronic maternal depression during the perinatal period was associated with underweight and reduced weight gain from birth to age 2 [2]. Other studies have also found an association between exposure to maternal depression measured between 1 month and 1 year and failure to thrive in children defined as a weight below the 2^{rd}-5^{th} centile [30, 31]. It is possible that as exposure to maternal depression is associated with failure to thrive and reduced weight gain, and that by middle and late childhood this translates into reduced risk for obesity. Meanwhile, however, it is not clear why our results differ from previous studies, particularly those conducted in other Latino populations.

Most of the findings in this study differs from findings in other studies. The other studies are predominantly conducted in white or multiethnic cohorts indicating that there is an ethnic reason underlying the differences in the results and those perinatal risk factors varies in different ethnic groups. This suggests that prediction and prevention might differ in different populations.

Limitations and further directions

A strength of our study design is the nine years of follow-up, longer than many prospective studies. Another strength is that our population is relatively homogenous in terms of socio-economic status and origin, which reduced some heterogeneity in our cohort even with the limited sample size (n=143). Future studies should be conducted in larger, multi-ethnic, and socio-demographically heterogeneous cohorts to determine whether our findings are comparable with other population groups. Furthermore, as we restricted our cohort to women without pre-existing diabetes mellitus or insulin treated gestational diabetes, perinatal risk factors may differ in higher risk population groups. We also did not assess the potential role of later nutrition and exercise and possible interactions between perinatal risk factors and future exposures in risk for obesity at age 9.

Conclusion

Perinatal risk factors for obesity such as higher birthweight and maternal pre-pregnancy BMI persisted at age 9. Meanwhile, however, other variables that were significant at age 5 in our cohort and other populations including exclusive breastfeeding and rapid infant weight gain were no longer associated with obesity at age 9. Focusing on the perinatal period may have long-term impacts for the prevention of childhood obesity in high-risk populations.

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Abbreviations

OR	odds ratio
CI	confidence interval
BMI	body mass index
UCSF	University of California San Francisco
SFGH	San Francisco General Hospital
WHO	World Health Organization
CDC	Centers for Disease Control and Prevention
IOM	Institute of Medicine
EPDS	Edinburgh Postpartum Depression Scale
CES-D	Center for Epidemiologic Studies Depression Scale
MINI	Mini International Neuropsychiatric Interview
SD	standard deviation

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Table 1

Child characteristics and the risk of obesity at 9 years (n=143) and chronic obesity (n=118)

	Obese at 9 years (mean ± SD or N/total [%])	Not obese at 9 years (mean ± SD or N/total [%])	P-value	Chronically obese[1] (mean ± SD or N/total [%])	Not chronically obese (mean ± SD or N/total [%])	P-value
Sex						
Male	29/53 [55]	43/90 [48]	0.42	18/38 [53]	38/79 [48]	0.94
Female	24/53 [45]	47/90 [52]		20/38 [47]	41/79 [52]	
Breastfeeding						
Exclusive breastfeeding at 4-6 weeks	17/53 [32]	39/87 [45]	0.14	10/38 [26]	34/76 [45]	0.06
Breastfeeding at 4-6 weeks	46/53 [87]	84/89 [95]	0.12	32/38 [84]	74/78 [95]	0.06
Exclusive breastfeeding at 6 months	12/43 [28]	28/81 [35]	0.45	9/35 [26]	25/73 [34]	0.37
Breastfeeding at 6 months	30/49 [61]	59/86 [69]	0.38	20/36 [56]	52/76 [68]	0.18
Breastfeeding at 12 months	18/47 [38]	35/83 [42]	0.67	10/34 [29]	34/75 [45]	0.12
Weight status						
Birthweight (kg)	3.46 ± 0.45	3.27 ± 0.49	0.02	3.44 ± 0.41	3.26 ± 0.48	0.04
Rapid weight gain wfa 0.67 SD	24/47 [51]	40/83 [48]	0.75	19/35 [54]	33/73 [45]	0.38
Rapid weight gain wfa 1 SD	17/47 [36]	33/83 [40]	0.69	15/35 [43]	29/73 [40]	0.76

[1]Chronic obesity is defined as obesity at both age 5 and 9 years and no chronic obesity is defined as not being obese at either

Table 2

Maternal characteristics and the risk of obesity at 9 years (n=143) and chronic obesity (n=118)

	Obese at 9 years (mean ± SD or N/total [%])	Not obese at 9 years (mean ± SD or N/total [%])	P-value	Chronically obese[1] (mean ± SD or N/total [%])	Not chronically obese (mean ± SD or N/total [%])	P-value
Demographics						
Ethnicity						
Mexican	29/53 [55]	54/90 [60]	0.54	24/38 [63]	47/79 [59]	0.70
Central American	24/53 [43]	36/90 [40]		14/38 [37]	32/79 [41]	
Immigrant (born outside the US)	51/53 [96]	83/90 [92]	0.49[2]	37/39 [95]	75/79 [95]	1.00[2]
Any English language skills	11/53 [21]	26/90 [29]	0.28	11/39 [28]	23/79 [29]	0.92
Mothers age at birth (years)	25.6 ± 5.4	27.0 ± 5.2	0.13	25.2 ± 5.7	27.2 ± 5.1	0.06
Education (≥ high school diploma)						
Yes	7/53 [13]	22/88 [25]	0.09	6/38 [16]	17/77 [22]	0.43
No	46/53 [87]	66/88 [75]		32/38 [84]	60/77 [78]	
Weight						
BMI pre pregnancy (kg/m^2)	27.1 ± 6.6	24.8 ± 4.4	0.01	27.2 ± 7.1	24.7 ± 4.3	0.02
Obese pre pregnancy	17/53 [32]	10/90 [11]	0.002	13/38 [34]	9/79 [11]	0.003
Obesity 3 years	25/48 [52]	24/82 [29]	0.01	20/37 [54]	22/75 [29]	0.01
BMI 4 years (kg/m^2)	31.8 ± 6.0	27.3 ± 5.0	<0.001	31.6 ± 6.2	27.3 ± 5.1	<0.001
Obesity 4 years	24/41 [59]	20/74 [27]	0.001	19/31 [61]	20/70 [29]	0.002
BMI 5 years (kg/m^2)	31.1 ± 6.2	27.5 ± 5.0	0.001	31.5 ± 6.7	27.5 ± 5.1	0.001
Obesity 5 years	21/44 [48]	19/69 [28]	0.03	17/35 [49]	19/66 [29]	0.048
Gestational weight gain (kg)	14.8 ± 9.7	15.4 ± 7.3	0.72	15.0 ± 9.6	15.6 ± 7.5	0.86
Gestational weight gain >18.1 kg (40lbs)	9/35 [26]	17/62 [27]	0.86	7/26 [27]	15/55 [27]	0.97
Gestational weight gain above IOM recommendation	19/35 [54]	30/62 [48]	0.58	15/26 [58]	27/55 [49]	0.47

[1]Chronic obesity is defined as obesity at both age 5 and 9 years and no chronic obesity is defined as not being obese at either

[2]Fischer's exact test

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Table 3

Maternal depression and the risk of obesity at 9 years (n=143) and chronic obesity (n=118)

	Obese at 9 years (mean ± SD or N/total [%])	Not obese at 9 years (mean ± SD or N/total [%])	P-value	Chronically obese[1] (mean ± SD or N/total [%])	Not chronically obese (mean ± SD or N/total [%])	P-value
Depression						
Clinical depression prenatal	3/53 [5.7]	7/90 [7.8]	0.75[2]	2/38 [5.3]	5/79 [6.3]	1.00[2]
Depression symptoms prenatal	15/53 [28]	32/90 [36]	0.37	7/29 [18]	29/79 [37]	0.045
Clinical depression 4-6 weeks	4/53 [7.6]	2/89 [2.3]	0.20[2]	3/38 [7.9]	2/78 [2.6]	0.33[2]
Depression symptoms 4-6 weeks	8/53 [15]	16/89 [18]	0.66	4/38 [11]	15/78 [19]	0.23[2]
Clinical depression 6 months	3/43 [7.0]	9/79 [11]	0.54[2]	1/35 [2.9]	8/71 [0.3]	0.27[2]
Depression symptoms 6 months	7/43 [16]	17/81 [21]	0.53	2/35 [5.7]	16/73 [22]	0.051[2]
Chronic depression from perinatal to 6 months	5/53 [9.4]	2/90 [2.2]	0.10[2]	2/38 [5.3]	2/79 [2.5]	0.60[2]
Clinical depression 1 year	5/47 [11]	6/83 [7.2]	0.50	3/35 [8.6]	5/75 [6.7]	0.72[2]
Depression symptoms 1 year	6/47 [13]	12/83 [14]	0.79	3/35 [8.6]	9/75 [12]	0.59[2]
Clinical depression 3 years	5/49 [10]	5/85 [5.9]	0.36	5/38 [13]	5/76 [6.6]	0.24
Depression symptoms 3 years	10/48 [21]	17/86 [20]	0.88	8/37 [22]	16/77 [21]	0.92
Clinical depression 4 years	5/51 [9.8]	3/81 [3.7]	0.26[2]	3/38 [7.9]	3/74 [4.1]	0.41[2]
Depression symptoms 4 years	8/50 [16]	12/79 [15]	0.90	5/37 [14]	12/72 [17]	0.67
Clinical depression 5 years	6/48 [13]	4/82 [4.9]	0.17[2]	5/37 [14]	4/76 [5.3]	0.13[2]
Depression symptoms 5 years	11/48 [23]	11/81 [14]	0.17	10/37 [27]	9/76 [12]	0.04
Chronic depression symptoms from 3 to 5 years	5/50 [10]	4/87 [4.6]	0.29[2]	4/38 [11]	4/78 [5.1]	0.28[2]

[1]Chronic obesity is defined as obesity at both age 5 and 9 years and no chronic obesity is defined as not being obese at either

[2]Fischer's exact test

Table 4

Multivariable predictors of obesity at 9 years

Variable	Odds ratio	95% confidence interval	P-value
Birthweight (kg)	**2.48**	**1.06 – 5.81**	**0.04**
Gender (male)	1.28	0.59 - 2.76	0.53
Exclusive breastfeeding at 4-6 weeks	0.54	0.25 - 1.20	0.13
Maternal pre pregnancy BMI (kg/m^2)	**1.09**	**1.00 - 1.18**	**0.04**
Maternal age (years)	0.97	0.90 - 1.05	0.43
Education (≥high school diploma)	0.36	0.12 - 1.09	0.07

Table 5

Multivariable predictors of chronic obesity

Variable	Odds ratio	95% confidence interval	P-value
Birthweight (kg)	2.69	0.90 – 8.05	0.08
Gender (male)	0.66	0.27 – 1.64	0.37
Exclusive breastfeeding at 4–6 weeks	0.47	0.18 – 1.21	0.12
Maternal pre pregnancy BMI (kg/m^2)	**1.10**	**1.01 – 1.20**	**0.03**
Maternal age (years)	0.92	0.84 – 1.01	0.08
Maternal depression symptoms prenatal	**0.33**	**0.11 – 0.94**	**0.04**