Original/*Pediatría*

The association between pre-pregnancy obesity and weight gain in pregnancy, with growth deviations in newborns

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Abstract

Introduction: obesity in pregnancy has been associated with increased morbidity for the mother and fetus.

Objective: to quantify the association between obesity in pregnancy with growth deviations of their newborn infants.

Methods: a study of non-matched cases and controls was performed based on the Nuevo Civil Hospital of Guadalajara "Dr. Juan I Menchaca" 2012-2013. The dependent variables were the newborn being either large (LGA) or small for gestational age (SGA), and the independent variable was pre-pregnancy obesity. Gynecoobstetric and socioeconomic data were collected. The association between the dependent and independent variables was assessed with logistic regression.

Results: one-hundred and forty-three mother-child dyads were studied with growth deviations of their newborn infants, and 137 mother-child dyads without growth deviations were studied. The age of the patients was 24.7±6.3 *vs.* 24.0±6.0 years, and the gestational age was 38±1.2 *vs.* 38±1.5. Factors associated with growth deviations were pre-pregnancy obesity (OR 2.65, 95% CI 1.29- 5.44), elevated weight gain during pregnancy (OR 1.98, 95% CI 1.04-3.76) and disease during pregnancy (OR 2.62, 95% CI 1.05-6.76). A multivariate model with the dependent variable LGA and associated covariates showed that pre-pregnancy obesity and high gestational weight gain were predictors of LGA (OR 2.43, 95% CI 1.10-5.40) and (OR 3.31, 95% CI 1.83-5.96).

Conclusions: in a population of young women with scarce economic resources, pre-pregnancy obesity and high weight gain during pregnancy were predictors of LGA.

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LA ASOCIACIÓN ENTRE OBESIDAD PRE-GESTACIONAL Y GANANCIA DE PESO EN EL EMBARAZO, CON DESVIACIONES DEL CRECIMIENTO EN LOS RECIÉN NACIDOS

Resumen

Introducción: la obesidad en el embarazo se ha relacionado con mayor morbilidad para la madre y el feto.

Objetivo: cuantificar la asociación entre obesidad en el embarazo con desviaciones del crecimiento de sus recién nacidos.

Métodos: se realizó un estudio de casos y controles, no pareado, basado en el Nuevo Hospital Civil de Guadalajara "Dr. Juan I Menchaca" de 2012 a 2013. Las variables dependientes fueron recién nacido grande (GEG) y pequeño para edad gestacional (PEG), y la independiente obesidad pre-gestacional. Se recabaron datos socioeconómicos y ginecoobstétricos. La asociación entre las variables dependientes con las independientes, se evaluó con regresión logística.

Resultados: se estudiaron 143 díadas madre-hijo con desviaciones en el crecimiento de sus RN, y 137 díadas madre-hijo sin desviaciones. La edad de las embarazadas fue 24.7 ± 6.3 vs 24.0 ± 6.0 años, y la edad gestacional 38±1.2 vs 38±1.5. Los factores asociados con desviaciones en el crecimiento fueron: obesidad pre-gestacional (RM 2.65, IC95% 1.29-5.44), ganancia de peso durante el embarazo elevada (RM 1.98, IC95% 1.04-3.76) y enfermedades durante el embarazo (RM 2.62, IC95% 1.05-6.76). Un modelo multivariado, con la variable dependiente GEG, y las covariables asociadas, demostró que la obesidad pregestacional y ganancia de peso gestacional elevada fueron predictores de GEG (RM 2.43, IC95% 1.10-5.40) y (RM 3.31, IC95% 1.83-5.96).

Conclusiones: en una población de mujeres jóvenes de escasos recursos económicos, la obesidad pregestacional y la ganancia de peso durante el embarazo alta, fueron predictores de productos GEG.

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Palabras clave: *Obesidad pregestacional. Ganancia de peso gestacional. Peso al nacer.*

Abbreviations

LGA: large for gestational age.
SGA: small for gestational age.
AGA: weight with gestational age between 10th and 90th percentile.
LMP: last menstrual period.

Introduction

Overweight and obesity in pregnancy are risk factors for adverse pregnancy outcomes and have been associated with increased morbidity and mortality for the mother and infant in the short and long term[1]. The prevalence of obesity in pregnancy has been steadily increasing in some regions. In the UK, it increased from 9.9% to 16.0% between 1990 and 2004[1], and in the United States of America (USA), it increased from 24.8% to 28.3% from 1999 to 2008[2]. In Mexico, the prevalence of overweight and obesity in women of reproductive age (20-39 years) more than doubled in the last 30 years; at present, two-thirds of this population is overweight and obese[3]. It has been shown that pregnant overweight and obese women are at increased risk of hypertension induced by pregnancy, gestational diabetes, cesarean section and newborns that are large for gestational age (LGA)[1]. In addition, pregnant women with low body mass index (BMI) are at greater risk for having newborn infants that are small for gestational age (SGA)[4].

Obesity that occurs in pregnancy is related to the metabolism of glucose and lipids, changes that can affect fetal metabolism and other physiological processes. Although these changes may be similar in all mother-infants dyads, differences in the magnitude of adverse perinatal outcomes have been reported, which may relate to social, cultural, environmental, biological, and psychological factors[5]. The relationship between the nutritional status of pregnant women with fetuses can be influenced by educational, social, demographic, lifestyle and local dietetic practices, which could modify the association between obesity in pregnancy with the presence of growth deviations in their newborns. Therefore, the purpose of this research was to quantify the strength of the association between obesity during pregnancy with the frequency of growth deviations in newborns.

Methods

An unmatched case-control study based on hospital data was constructed[6]. The study population consisted of mothers and newborns born in the Nuevo Civil Hospital of Guadalajara to Dr. Juan I Menchaca between August 2012 and February 2013. This hospital provides health services to urban, open, low-income and low-education populations. The sample consisted of mothers with term pregnancies and newborn infants with growth deviations diagnosed within the first 24 hours of life (cases) and mothers with term newborn infants with no growth deviations (controls). The cases were consecutively included during the study period, and controls were randomly selected from all of the births that occurred the same day. Not included were mothers and newborn infants in which the mother was diagnosed with chronic disease before pregnancy and had multiple pregnancies as well as when the newborn had congenital malformations.

The dependent variable was defined by the deviation of growth in the newborn, and the independent variables were pre-pregnancy obesity and high weight gain during pregnancy. The presence and classification of growth deviations in the newborn infants was performed with the intrauterine growth curves of Lubchenko *et al*.[7], as follows: a) SGA was defined as when the weight of the newborn in relation to gestational age was below the 10th percentile; b) LGA was defined as when the weight of the newborn infant was above the 90th percentile of the gestational age; and c) AGA weight of an newborn was defined as being between the 10th and 90th percentile of the gestational age.

Anthropometry measurements

A researcher (DCB) was standardized to the Habitch method (WHO 1983)[8] for anthropometric measurements of newborns. **Weight**. The newborn was placed, naked and without a diaper, on an Acuweigh brand scale, model SB-240 (Acuweigh, Tainan, Taiwan), with a sensitivity of 10 g; the weight was obtained in duplicate for an average of two measurements, or measurements were repeated until two equal figures were obtained[8]. **Length.** A infantometer SECA, model 416 (Seca, Hamburg, Germany) was used; the infant was placed in a supine position with the body aligned in a straight position on the longitudinal axis of the infantometer so that the shoulders and hips had contact with the horizontal plane and the arms were on the sides of the trunk. The crown of the head touched the fixed base of infantometer and was placed and aligned perpendicular to the horizontal plane. Both the head and the base of infantometer were hold by a helper. With one hand, the investigator extended the newborn's legs, making sure that his knees did not flex, and with the other hand, the movable base of the infantometer was slid so that a slight pressure was exerted on the heels of the newborn so that the foot made a 90° angle. The measurement was approximated to the nearest 0.1 cm[9]. **Head circumference** was measured with a steel tape, Lufkin brand, model W606ME, 6 mm wide (Lufkin, Texas, USA). With the head free of any object, the tape was firmly applied around the head in the supraciliar region so that the tape ran down the most prominent part of the frontal area and occipital protuberance[9].

Obesity in pregnancy was defined as an excessive accumulation of fat determined through a BMI ≥ 30 kg/m[21,4,10]. The pre-pregnancy weight was obtained via the recording of the immediate weight in early pregnancy as reported in a previous study, where a high correlation was obtained between the prior self-reported weights with the measured weight in the first prenatal visit before pregnancy at 20 weeks of gestation[10]. Differences between the pre-pregnancy weight and weight prior to delivery or Cesarean section, which was taken from the clinical record weight, were obtained. Weight gain during pregnancy was evaluated according to the pre-pregnancy BMI as recommended by the IOM[11]. In underweight women (BMI <18.5), weight gain in pregnancy should fluctuate 12.5-18 kg; in normal weight women (BMI 18.5-24.9), weight gain should be 11.5-16.0 kg; in overweight women (BMI 25.0-29.9), weight gain in pregnancy should be 7.0-11.5 kg; and for pregnant obese women (BMI[3] 30), weight gain in pregnancy should be 5.0-9.0 kg. Based on these definitions, weight gain during pregnancy was categorized as less, normal or greater.

The same researcher collected information by directly interviewing the mothers in the first 24 hours after birth. An instrument developed for the collection of socio-economic, educational and gyneco-obstetric data was used. Information from medical records of pregnant women about the important prenatal data and diseases occurring during pregnancy and childbirth was collected.

The gestational age was calculated with the days elapsed from the first day of the last menstrual period (LMP), obtained by directly interviewing the mother. Additionally, all newborns were assessed for gestational age with the modified Capurro evaluation[12]. When there was a difference of more than two weeks between the gestational age calculated by LMP and measured by Capurro, or when the mother did not remember, the LMP was used to define the gestational age as obtained by Capurro.

The information was captured in a spreadsheet with Excel 2000. Quantitative variables were calculated as means and standard deviations, and qualitative variables were recorded as percentages and proportions. Quantitative variables were compared with Student's t test for two independent samples, and qualitative variables were compared with the x^2 and Fisher's exact tests. The association between pre-pregnancy obesity and high weight gain during pregnancy with growth deviations of newborns and the confounding effect were estimated by odds ratios with logistic regression. For all measurements, the confidence interval was of 95%. The calculations were made using the Statistical Package for Social Sciences (SPSS 17.0, SPSS Inc., Chicago, IL, USA).

The research was approved by the Research and Ethics Committees of the Hospital Civil of Guadalajara with registration from 1213/12, and written informed consent was obtained from the mothers studied.

Results

From August 2012 to February 2013, information from 314 mother-infant dyads was collected, of which 14 were excluded due to at least one chronic disease prior to pregnancy (hypertension, diabetes mellitus type 1, type 2 diabetes mellitus, hypothyroidism and asthma) or because it was not possible to collect the pre-pregnancy weight, gestational weight gain or height. Ultimately, the study sample consisted of 143 mother-infant dyads with growth deviations of the newborn infants (mother-infant dyads with newborn SGA + mother-infant dyads with newborn LGA) and 137 mother-infant dyads with no growth deviations of the newborn. The age of the pregnant mother-infant dyads with growth deviations of the newborn was 24.7±6.3 years and was 24.0±6.0 years in the mother-infant dyads without growth deviations (p = 0.305).

Of the newborns, gestational age was similar in the two study groups; however, the values of all of the anthropometric measurements in the group of the mother-infant dyads with newborns with growth deviations were higher (Table I). There was higher frequency of mothers who had incomplete primary education, an income that was less than two minimum wages, at least one disease during the pregnancy, pre-pregnancy obesity, and high weight gain during pregnancy in the group of the mother-infant dyads with newborns with growth deviations. The following variables were associated with higher frequency of growth deviations of newborns infants: pre-pregnancy obesity (OR 2.65, 95% CI 1.29-5.44; p = 0.003), elevated weight gain during pregnancy (OR 1.98, 95% CI 1.04-3.76; p = 0.017) and a history at least of one disease during pregnancy (OR 2.62, 95% CI 1.05-6.76; p = 0.023) (Table II).

In relation to diseases occurring during pregnancy, 20/143 of the mother-infant dyads had at least one disease (13.9%), 12 had preeclampsia, 6 had gestational diabetes, and two had gestational diabetes with preeclampsia. Moreover, in the control group, 8/137 mother-infant dyads had a history of illness during pregnancy (5.8%), of which four had gestational diabetes and four had pre-eclampsia. In connection with the growth deviations of newborns, of the 143 mother-infant dyads, 107/143 newborns were LGA (74.8%) and 36/143 were SGA (25.2%).

To assess the association between pre-pregnancy obesity and newborn LGA, after excluding the SGA newborns, pre-pregnancy obesity was documented in 26/107 mother-infant dyads (24.2%) in the case group and 12/137 mother-infant dyads (8.7%) in the controls (OR 3.34 95% CI 1.59-7.00; p <0.001). Moreover, to measure the association between pre-pregnancy obesity and the frequency of SGA infants, after excluding mother-infant dyads with LGA newborns, it was documented that 3/36 mothers with SGA babies exhibited pre-pregnancy obesity (8.3%), while 12/137 (8.7%) did in the control group (OR 0.95 95% CI 0.25-3.55; p = 0.467).

Table I
Anthropometry of mother-infants dyads in the study groups

Variable	With growth deviations n=143		Without growth deviations n=137		P*
	Mean	SD	Mean	SD	
Mothers					
Pre-pregnancy weight (kg)	65.5	16.3	60.9	12.3	0.009
Gestational weight gain (kg)	11.6	5.4	9.7	4.2	0.001
Pre-pregnancy BMI **	26.2	6.2	24.2	4.6	0.003
Gestational age (weeks)	38.9	1.2	38.9	1.2	0.684
Newborn infants					
Weight (g)	3523	786	3136	310	< 0.001
Length (cm)	49.5	2.9	48.7	1.6	< 0.001
Cephalic circumference (cm)	34.5	1.9	33.7	1.2	< 0.001
BMI	14.1	1.9	13.2	0.9	< 0.001

*P value to compare the means by Student's t test for two independent samples. **BMI: body mass index; SD: standard deviation.

A multivariate model with logistic regression was constructed by the method of forced entry, where the dependent variable consisted of all of the growth deviations (mother-infant dyads with SGA newborns + mother-infant dyads with LGA newborns), and the covariates were pre-pregnancy obesity, high gestational weight gain and a history of at least one disease that occurred during pregnancy. The model showed a decrease in the strength of the association between raw values resulting from the bivariate analysis, with the risk-adjusted values with the aforementioned covariates (Table III). Another multivariate logistic regression model was created by the method of forced entry, where the dependent variable was newborn LGA, after excluding mother/newborn dyads with SGA infants. The covariates were pre-pregnancy obesity, high gestational weight gain and disease during pregnancy. This model demonstrated the persistence of a significant association between pre-pregnancy obesity and high weight gain during pregnancy, with a high frequency of growth deviations in LGA infants (Table IV).

Discussion

The frequency distribution of gestational age, marital status, education, occupation, smoking, alcohol, illicit drugs, prenatal control and multiparity were similar in the two study groups, which dismissed its relation to changes in the frequency of growth deviations in newborns of the studied mother-infant dyads. Moreover, the bivariate analysis suggested that the increased frequency of diseases during pregnancy, pre-pregnancy obesity and high weight gain during pregnancy are associated with an increased frequency of growth deviations in the newborns of mother-infant dyads. However, when the association between pre-pregnancy

obesity with a high frequency of all growth deviations (mother-infant dyads with SGA newborns + mother-infant dyads with LGA newborns) was adjusted with the covariates high weight gain during pregnancy and diseases during pregnancy, the association disappeared (Table III).

Because growth deviations of newborns are different (mother-infant dyads with SGA newborns + mother-infant dyads with LGA newborns) and because there is evidence suggesting that obesity in pregnant women is associated with an increased frequency of LGA newborns (1,3), a multivariate model that included a LGA newborns a dependent variable was constructed prior to excluding the mother-infant dyads with SGA newborns, in which the independent variable was pre-pregnancy obesity and the covariates were high weight gain during pregnancy and disease during pregnancy. This model showed a significant association between pre-pregnancy obesity and high weight gain during pregnancy, most often with LGA newborns. The model also suggested that a history of pre-pregnancy obesity and high weight gain during pregnancy were predictors of an increased frequency of LGA newborns; the history of pre-pregnancy obesity doubled the frequency of LGA newborns (OR 2.24 95% CI 1.07-4.65; p = 0.031), and high weight gain during pregnancy tripled the frequency of LGA newborns (OR 3.21 95% 1.82-5.66; p <0.001) (Table IV).

Bove et al.[13] found similar results in a cohort of 23,832 pregnant women in Uruguay. The relative risk (RR) of LGA newborns in women with pre-gestational overweight was 1.68 (1.53, 1.85) and in women with obesity increased to 2.10 (1-86, 2-38). Likewise, the RR of LGE newborns was 1.57 (1.42, 1.74) in women with high weight gain during pregnancy; and, it increased to 2.33 (2.07, 2.62) when the weight gain during pregnancy was very high. Similarly, Ota et al.[4]

Table II
Socioeconomic and gyneco-obstetric factors in the study groups

Variables	Cases		Controls		OR (CI 95%)	P
	n/N	%	n/N	%		
Civil status[1]	22/143	15.4	24/137	21.2	0.86 (0.45-1.61)	0.630
Education[2]	20/143	13.9	11/137	8	1.86 (0.86-4.04	0.051
Occupation[3]	118/143	82.5	103/137	75.2	1.56 (0.87-2.78	0.066
Family income[4]	32/143	22.4	21/137	15.3	1.59 (0.86-2.92)	0.066
Smoking[5]	17/143	11.9	15/137	10.9	1.09 (0.52-2.29)	0.402
Alcohol[6]	11/143	7.7	9/137	6.6	1.18 (0.47-2.95)	0.357
Illicit drugs[7]	2/143	1.4	3/137	2.2	0.63 (0.07-4.74)	0.479
Prenatal control[8]	5/143	3.5	2/137	1.4	2.45 (0.41-18.53)	0.241
Multiple pregnancies vs. single pregnancy	109/143	76.2	109/137	79.6	0.82 (0.45-1.51)	0.501
Diseases in pregnancy	20/143	13.9	8/137	5.8	2.62 (1.05-6.76)	0.023
Pre-pregnancy Obesity (IMC)[9]	29/143	20.3	12/137	8.7	2.65 (1.31-5.44)	0.003
Weight gain during pregnancy[10]	52/95*	54.7	25/66*	37.9	1.98 (1.04-3.76)	0.017
Weight gain during pregnancy[11]	48/91**	52.7	71/112**	63.3	0.64 (0.37-1.32)	0.062
Type of delivery[12]	70/143	48.9	56/137	40.9	1.38 (0.86-2.25)	0.082

[1]Single, separated and divorced vs. married and cohabiting; [2]Incomplete primary vs. complete primary degree; [3]Home vs. other occupations; [4]≤2 vs. >2 minimum wage minimum wage; [5]> 1 cigarette vs. no smoking; [6]Alcohol Consumption yes vs. no; [7]illicit drugs yes vs. no; [8]adequate vs. inadequate; [9]Yes vs. No; [10]high vs. adequate; [11]low vs. adequate; [12]Cesarean vs. vaginal.
*Fifty mother-infant dyads were excluded with low weight gain during pregnancy in the case group, and 79 mother-child dyads with low weight gain during pregnancy were excluded in the control group; **55 mother-infant dyads were excluded with high weight gain during pregnancy in the case group, and 28 mother-child dyads with high weight gain during pregnancy were excluded in the control group. OR: odds ratio. CI: confidence interval. P: p value

Table III
Association between pre-pregnancy obesity with all of the deviations in growth (mother-infant dyads with SGA newborns + mother-infant dyads with LGA newborns), adjusted for high gestational weight gain and the presence of diseases during pregnancy

Covariates	OR*	(CI 95%)*	P**	OR**	(CI 95%)**	P**
Pre-pregnancy obesity	2.54	1.31-4.90	0.003	1.82	0.85-3.92	0.124
High weight gain during pregnancy	1.87	1.01-3.48	0.017	2.24	1.27-3.95	0.006
Disease during pregnancy	2.55	1.13-5.77	0.017	2.04	0.82-4.96	0.128

OR: odds ratio. CI: confidence interval. P: p value. *Crude odds ratio of each covariate; **Odds ratio adjusted for pre-pregnancy obesity and disease during pregnancy.

in Vietnam and Jolly et al.[14] in England documented an intensity of the strength of the association between pre-pregnancy obesity and more frequent LGA newborns (OR 2.04 95% CI 1.43-2.91 and OR 2.08 95% CI 1.99-21.7, respectively), similar to that found in this study. In China, Li et al.[15] showed a slightly greater force association (OR 2.56 95% CI 2.53-3.123). The similarity in the strength of the association between pre-pregnancy obesity with more frequent LGA newborns between the present study and commented investigations, even for such different regions, suggests that the strength of the relationship between pre-pregnancy obesity and more frequent LGA newborns is greater than the influence of the own local factors in each geographical region.

One explanation for the relationship between the history of pre-pregnancy obesity and high weight gain during pregnancy with more frequent LGA newborns may be that insulin resistance is often present in women with obesity. Insulin resistance causes metabolic disorders, resulting in the increased availability of nutrients to the fetus, which receives large amounts of glucose through the placenta, resulting in hyperinsulinemia and fetal growth acceleration. Individuals with insulin resistance have higher concentrations of triglycerides, which are fragmented into smaller molecules

Table IV

Association between pre-gestational obesity alone with LGA newborns, adjusted for gestational weight gain and a high presence of diseases during pregnancy

Covariates	OR*	(CI 95%)*	P**	OR**	(CI 95%)**	P**
Pre-pregnancy obesity	2.54	1.31-4.90	0.003	2.43	1.10-5.40	0.028
High weight gain during pregnancy	1.87	1.01-3.48	0.017	3.31	1.83-5.96	< 0.001
Disease during pregnancy	2.55	1.13-5.77	0.017	1.35	0.49-3.74	0.558

OR: odds ratio. CI: confidence interval. P: p value. *Crude odds ratio of each covariate. **Odds ratio adjusted for pre gestational obesity and disease during pregnancy.

by placental lipases and are transferred to the fetal circulation, resulting in greater energy input to the fetus. Additionally, insulin resistance increases the metabolism of leucine, resulting in the increased crossing of the amino acids to the fetus, and hyperinsulinemia with an increase in the speed of growth of the fetus[13].

Pre-pregnancy obesity and the total amount of weight gained during pregnancy are determined by multiple factors, including physiological, family, social and dietary factors, among others factors[3]. Therefore, we considered that although the findings of this study are similar to those reported in other regions, they are important because they provide information about the relationship between pre-pregnancy obesity and high pregnancy weight gain with deviations in the growth of the offspring in a less developed country, with different characteristics to those of other countries that have studied this phenomenon.

One limitation of this research was that the pre-pregnancy weight was obtained by a record of the weight in early pregnancy. In favor of this limitation, a previous study documented a high correlation between self-reported weights prior to the weight measured in the first prenatal visit before 20 weeks of gestation[10]. Another limitation was imposed by the design of the study, which ideally would have been a cohort study.

Conclusions

The present study demonstrated that pre-pregnancy obesity and high weight gain during pregnancy in a population of young pregnant women with low education and low income were predictors of an increased frequency of LGA newborns. These findings reinforce the importance of preventing obesity in women who eventually become pregnant, and when this happens, it is necessary to strictly monitor their weight through regular prenatal care with adequate information on food and nutrition.

Conflict of interest

The authors declare no conflict of interest.

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