# Effect of Obesity on Gestational and Perinatal Outcomes

## *Efeito da obesidade sobre os resultados gestacionais e perinatais*

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## Abstract

**Purpose** To assess the impact of pre-pregnancy obesity (body mass index [BMI] $\geq$ 30 kg/m$^2$) on the gestational and perinatal outcomes.
**Methods** Retrospective cohort study of 731 pregnant women with a BMI $\geq$ 30 kg/m$^2$ at the first prenatal care visit, comparing them with 3,161 women with a BMI between 18.5 kg/m$^2$ and 24.9 kg/m$^2$. Maternal and neonatal variables were assessed. Statistical analyses reporting the demographic features of the pregnant women (obese and normal) were performed with descriptive statistics followed by two-sided independent Student's *t* tests for the continuous variables, and the chi-squared ($\chi^2$) test, or Fisher's exact test, for the categorical variables. We performed a multiple linear regression analysis of newborn body weight based on the mother's BMI, adjusted by maternal age, hyperglycemic disorders, hypertensive disorders, and cesarean deliveries to analyze the relationships among these variables. All analyses were performed with the R (R Foundation for Statistical Computing, Vienna, Austria) for Windows software, version 3.1.0. A value of $p < 0.05$ was considered statistically significant.
**Results** Obesity was associated with older age [OR 9.8 (7.8–12.2); $p < 0.01$], hyperglycemic disorders [OR 6.5 (4.8–8.9); $p < 0.01$], hypertensive disorders [OR 7.6 (6.1–9.5); $p < 0.01$], caesarean deliveries [OR 2.5 (2.1–3.0); $p < 0.01$], fetal macrosomia [OR 2.9 (2.3–3.6); $p < 0.01$] and umbilical cord pH [OR 2.1 (1.4–2.9); $p < 0.01$). Conversely, no association was observed with the duration of labor, bleeding during labor, Apgar scores at 1 and 5 minutes after birth, gestational age, stillbirth and early neonatal mortality, congenital malformations, and maternal and fetal injury.

**Keywords**
► obesity
► body mass index
► pregnancy outcomes
► neonatal outcomes

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**Conclusion** We observed that pre-pregnancy obesity was associated with maternal age, hyperglycemic disorders, hypertension syndrome, cesarean deliveries, fetal macrosomia, and fetal acidosis.

## Resumo

**Objetivo** Avaliar o impacto da obesidade pré-gestacional (índice de massa corpórea [IMC] $\geq$ 30 kg/m$^2$) sobre os resultados gestacionais e perinatais.

**Métodos** Estudo transversal retrospectivo, com 731 gestantes que apresentaram IMC $\geq$ 30 kg/m$^2$ na primeira consulta de pré-natal, comparando-as a 3.161 gestantes com IMC entre 18,5 kg/m$^2$ e 24,9 kg/m$^2$. Foram avaliadas variáveis maternas e neonatais. A análise estatística baseou-se nas características demográficas das gestantes (obesas e com peso normal), e foi realizada com estatísticas descritivas seguidas de testes t de Student independentes bicaudais para variáveis contínuas, e teste de qui-quadrado ($\chi^2$) ou exato de Fisher para as variáveis categóricas. Foi realizada uma regressão linear múltipla do peso do recém-nascido sobre o IMC materno, ajustado por idade materna, síndromes hiperglicêmicas, síndromes hipertensivas hipertensivas e operações cesarianas, a fim de analisar a relação entre essas variáveis. Todas as análises foram realizadas com o uso de R (R Foundation for Statistical Computing, Viena, Áustria) para Windows, versão 3.1.0. Um valor de $p < 0{,}05$ foi considerado estatisticamente significante.

**Resultados** A obesidade associou-se à idade materna [OR 9,8 (7,8–12,2); $p < 0{,}01$], distúrbios hiperglicêmicos [OR 6.5 (4,8–8,9); $p < 0{,}01$], distúrbios hipertensivos (RP: 7,6 [6,1–9,5]; $p < 0{,}01$), maior taxa de operação cesariana [OR 2,5 (2,1–3,0); $p < 0{,}01$], macrossomia fetal [OR 2,9 (2,3–3,6); $p < 0{,}01$] e baixo pH na artéria umbilical [OR 2,1 (1,4–2,9); $p < 0{,}01$]. Não foi observada associação com tempo de trabalho de parto, sangramento durante o trabalho de parto, índice de Apgar no 1° e 5° minutos, idade gestacional, natimortalidade e mortalidade neonatal precoce, malformações congênitas e tocotraumatismo materno e fetal.

**Conclusões** O estudo mostrou que a obesidade pré-gestacional associou-se com idade materna mais elevada, distúrbios hiperglicêmicos e hipertensivos, taxas mais altas de operação cesariana, macrossomia e acidose fetal.

**Palavras-chave**
- obesidade
- índice de massa corpórea
- desfechos gestacionais
- desfechos neonatais

## Introduction

Obesity is considered one of the largest global health problems of the 21st century. The World Health Organization (WHO) estimated that in 2008, ~ 205 million men and 297 million women over the age of 20 were obese – a total of more than half a billion adults worldwide.[1] In the WHO Regions of the Americas, ~ 62% of the population over the age of 20 were overweight (body mass index [BMI] $\geq$ 25 kg/m$^2$), and 26% were obese (BMI $\geq$ 30 kg/m$^2$).[1,2] We should highlight that, in the WHO Region for Europe, the Eastern Mediterranean and the Americas, over 50% of women were overweight and, of these, about half of overweight women were obese (23%, 24% and 29% respectively).[1,2] In Brazil, we have little data on the nutritional status of women of reproductive age. Nucci et al[3] analyzed the pre-pregnancy nutritional status of women aged 20 to 48 years old between 1991 and 1995. Their study found pre-obesity (BMI between 25 kg/m$^2$ and 30 kg/m$^2$) and obesity (BMI $\geq$ 30 kg/m$^2$) rates of 19.2% and 5.5% respectively.[3] Epidemiological data about disease from the Surveillance of Risk and Protective Factors for Chronic Diseases by Telephone Survey (VIGITEL, in the Portuguese acronym), which is provided by the Brazilian Institute of Geography and Statistics, showed an increased rate of BMI > 25 kg/m$^2$ in women aged between 18–24, 25–34, and 35–44 years old (24.4, 38%, and 50.9% respectively).[4] Such a scenario suggests that obstetricians are dealing more frequently with pregnant women who are overweight and obese and, therefore, have increased risks of poor maternal and child health outcomes. Tennant et al[5] found an increased risk of fetal and infant death in a cohort of women who were obese at the beginning of pregnancy compared with women who had the recommended weight, and preeclampsia commonly caused fetal deaths among obese women. Additionally, Aune et al,[6] in a systematic review and meta-analysis, showed that high a BMI during pregnancy was associated with fetal death, stillbirth, and neonatal, perinatal, and infant death. Nohr et al[7] reported an association between high pre-pregnancy BMI and excessive maternal weight gain with an increased risk of cesarean delivery (CD), and infants large for their gestational age or with a low Apgar score.[7] Even in developed countries, obese women tend to have a higher likelihood of urinary tract and lower genital tract infections; induced deliveries; CD;[8,9] severe bleeding in the puerperium period; puerperal infections;[8] birth defects; fetal death; fetal macrosomia; and maternal death during pregnancy or at childbirth.[10–15] The present study was performed to evaluate the association of maternal pre-pregnancy obesity with gestational and perinatal outcomes in a population of pregnant women and newborns.

## Methods

This retrospective cohort study was performed by reviewing the medical charts at the Department of Gynecology and Obstetrics from March 1998 to June 2010. According to their BMIs in early pregnancy, the pregnant women were categorized as: underweight (BMI $< 18.5$ kg/m$^2$); normal weight (BMI between 18.5 kg/m$^2$ and 24.9 kg/m$^2$); overweight (BMI between 25 kg/m$^2$ and 29.9 kg/m$^2$); grade 1 obesity (BMI between 30 kg/m$^2$ and 39.9 kg/m$^2$); and grade 2 and grade 3 obesity (BMI $\geq$ 40kg/m$^2$).[1] All pregnant women with BMI $\geq$ 30kg/m$^2$ and their respective newborns were included in the obese group (OG). And all pregnant women in the normal weight category were included in the normal group (NG).

Obesity at the first prenatal visit was considered a predictor variable. The outcome variables were fetal weight and hyperglycemic and hypertensive disorders. Other maternal information included education (literate or not); gestational age according to the first day of the last menstrual period, and confirmed by early ultrasonography and/or Capurro index; parity; CD rate; the duration of labor (in minutes); bleeding during labor; and BMI obtained according to the WHO criteria, and calculated as the ratio between the weight and the height squared.[1]

Hyperglycemic disorders included gestational diabetes mellitus (GDM), and type 1 and 2 diabetes mellitus (DM1 and DM2), according to the Brazilian Diabetes Society.[16]

Hypertensive disorders included chronic hypertension, mild and severe preeclampsia, and pre-existing hypertension plus superimposed gestational hypertension, according to the Report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Pregnancy.[17]

Neonatal variables included fetal breech presentation diagnosed by delayed ultrasonography or during delivery; birth weight in grams; fetal macrosomia (fetal weight $\geq$ 4,000 g);[18] large for gestational age (LGA) newborns; fetal birth trauma; requiring admission to the neonatal intensive care unit (NICU); stillbirth and early neonatal mortality rates; malformations identified by ultrasound examination during pregnancy and confirmed in the postnatal period; and pH and base excess in the umbilical cord. Blood samples to perform the blood gas analysis were obtained from the umbilical cord immediately after birth, and were analyzed within 30 minutes using AVL OMNI Modular System equipment (Roche Diagnostics, Graz, Austria). The pH rates $\geq$ 7.10 and $<$ 7.3 were considered normal, and pH rates $<$ 7.10 were associated with acidotic fetuses.[19] The Apgar scores at 1 minute and 5 minutes[20,21] were assessed during the first attendance in the delivery room.

The research project was approved by the Research Ethics Committee of our institution under number 142/2010.

### Statistical Analysis

The demographic characteristics of the pregnant women (obese and normal) were analyzed using descriptive statistics followed by two-sided independent Student's $t$ tests for the continuous variables, and the chi-squared ($\chi^2$) test or Fisher's exact test for the categorical variables. The relative risk was estimated as the ratio between the probability of developing an adverse outcome (that is, hyperglycemic or hypertensive disorders, macrosomia, stillbirth) in the obese group and the probability of the event occurring in the non-obese group. The data were presented as mean and standard deviation, unless otherwise indicated. We performed a multiple linear regression to investigate the effects of obesity in the newborns' body weight, adjusted by maternal age, hyperglycemic disorders and hypertensive disorders. All analyses were performed using the R (R Foundation for Statistical Computing, Vienna, Austria) for Windows software, version 3.1.0. A value of $p < 0.05$ was considered statistically significant.

## Results

Out of the 15,495 deliveries performed at the Department of Gynecology and Obstetrics from March 1998 to June 2010, 10,111 did not have data in the medical charts about weight or height in early pregnancy, and they were excluded. Thus, 5,384 medical charts were selected. According to the BMI in early pregnancy, 295 (5.5%) pregnant women were categorized as underweight; 3,161 (58.7%) as normal weight; 1,197 (22.3%) as overweight; 662 (12.3%) as having grade 1 obesity; and 69 (1.3%) as having grades 2 and 3 obesity.

All pregnant women with BMIs $\geq$ 30 kg/m$^2$ ($n = 731$; 18.8%) and their respective newborns were included in the OG. All pregnant women with BMIs between 18.5 kg/m$^2$ and 24.9 kg/m$^2$ ($n = 3{,}161$; 81.2%) and their respective newborns were included in the NG. Thus, 3,892 pregnant women were included in this study (►**Table 1**, ►**Fig. 1**).

The women were older in the OG than in the NG (28.8 $\pm$ 6.9 versus 24.3 $\pm$ 8.6; $p < 0.01$), and there were 6.7 times more pregnant women older than 35 years of age in the OG than in the NG (35.6% versus 5.3%; $p < 0.01$) (►**Table 1**).

Hyperglycemic disorders (14.5% versus 2.5%; $p < 0.01$) and hypertensive disorders (33.5% versus 6.2%, $p < 0.01$) were more incident in the OG than in the NG. The incidence of CD in the OG was 2.5 higher than in the NG (51.2% versus 29.4%; $p < 0.01$). The variables education, duration of labor, and hemorrhage during labor and delivery were similar in both groups (►**Table 1**).

Regarding the neonatal variables in both groups (►**Table 2**), the highest rate of fetal acidosis (6.6 versus 3.3%; $p < 0.01$) and macrosomic neonates (22.7% versus 9.2%; $p < 0.01$) occurred in the OG (►**Table 2**). The multiple linear regression analysis shows newborn weight was on average 295.3 g higher in the obese group, adjusted by maternal age, hyperglycemic and hypertensive disorders. Even though the relationship was

**Table 1** Distribution of maternal and obstetric variables in the sample ($n = 3{,}892$) from our institution, 1998–2010

| Maternal and obstetric variables | Obese Group ($n = 731$) | Normal Group ($n = 3{,}161$) | $p$ | OR (95%CI) |
|---|---|---|---|---|
| Age (mean ± SD) | 28.8 ± 6.9 | 24.3 ± 8.6 | < 0.01[d] | – |
| Age ≥ 35[a] | 260 (35.6%) | 169 (5.3%) | < 0.01[b] | 9.8 (7.8–12.2) |
| Education[a] | | | | |
| Illiterate[a] | 9 (1.2%) | 27 (0.9%) | NS[c] | 1.44 (0.68–3.05) |
| Literate[a] | 714 (97.7%) | 3,076 (97.3%) | NS[b] | 1.00 (0.99–1.01) |
| Parity (mean) | 1.8 ± 0.5 | 1.2 ± 0.4 | NS[d] | |
| Hyperglycemic disorders[a] | 106 (14.5%) | 80 (2.5%) | < 0.01[b] | 6.5 (4.8–8.9) |
| Hypertensive disorders[a] | 245 (33.5%) | 196 (6.2%) | < 0.01[b] | 7.6 (6.1–9.5) |
| Cesarean delivery[a] | 374 (51.2%) | 929 (29.4%) | < 0.01[b] | 2.5 (2.1–3.0) |
| Duration of labor[a] | | | | |
| ≤ 360 minutes[a] | 79 (10.8%) | 390 (12.3%) | NS[b] | 0.87 (0.69–1.10) |
| > 360minutes[a] | 367 (50.2%) | 2,057 (65.1%) | NS[b] | 0.77 (0.71–0.83) |
| Bleeding during labor[a] | 6 (0.8%) | 22 (0.7%) | NS[c] | 1.14 (0.56–2.32) |

Abbreviations: CI, confidence interval;; n, sample size; NS, not statistically significant; OR, odds ratio; SD, standard deviation.
Notes: Obese group: composed of pregnant women with BMIs ≥ 30 kg/m$^2$); normal group: composed of pregnant women with BMIs between 18.5 kg/m$^2$ and 24.9 kg/m$^2$.
Hyperglycemic disorders: gestational diabetes mellitus, and types 1 and 2 diabetes mellitus; hypertensive disorders: chronic hypertension, mild and severe preeclampsia, and pre-existing hypertension plus superimposed gestational hypertension.
[a]Results expressed in absolute number and percentage;
[b]chi-squared test;
[c]Fisher's exact test;
[d]two-sided independent Student's $t$ test.

statistically different between the groups ($p < 0.01$), only 1.5% of the variability in newborn weight can be explained by the model. The neonatal variables defined as base excess, gestational age, Apgar score, breech presentation, stillbirth, NICU, early neonatal mortality, birth defects, and fetal birth trauma were not different between the two study groups.

## Discussion

Our institution is responsible for ~ 50% of births in the Public Health System for the municipality and surrounding municipalities; therefore, it provides a large population sample. This study strengthens the evidence that demonstrates the

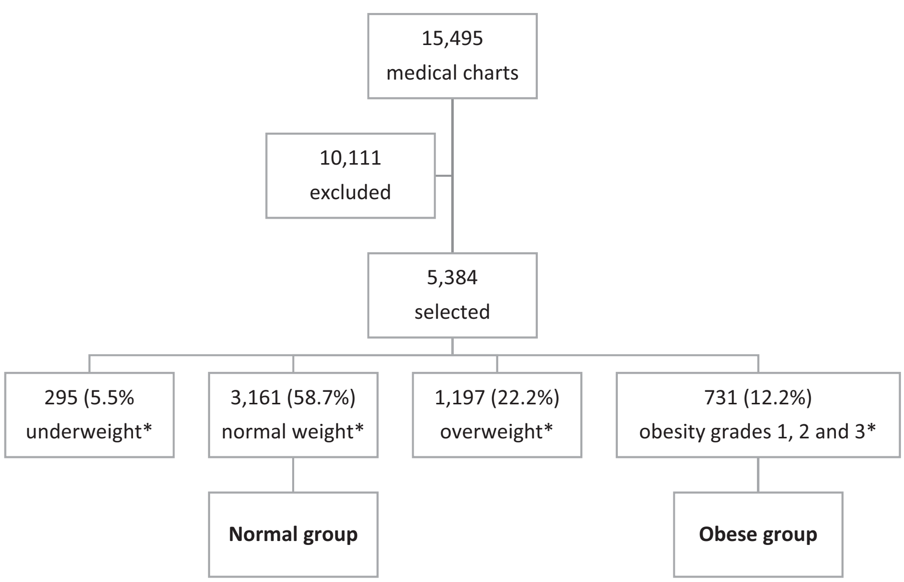


**Fig. 1** The flow of the selected population through the study. Notes:*Underweight: BMI < 18.5 kg/m$^2$; normal weight: BMI between 18.5 kg/m$^2$ and 24.9 kg/m$^2$; overweight: BMI between 25 kg/m$^2$ and 29.9 kg/m$^2$; obesity grades 1, 2, and 3: BMI ≥ 30 kg/m$^2$.

**Table 2** Distribution of neonatal variables in the sample ($n = 3,892$) from our institution, 1998–2010

| Neonatal variables | Obese Group n = 731 | Normal Group n = 3,161 | $p$ | OR (95%CI) |
|---|---|---|---|---|
| Apgar score | | | | |
| 1 minute [median IQR] | [8 7–9] | [8 7–9] | NS[d] | |
| 5 minute [median IQR] | [9 9–9] | [9 9–10] | NS[d] | |
| Umbilical cord pH | $7.23 \pm 0.10$ | $7.24 \pm 0.42$ | NS[g] | |
| $\leq 7.1$[a] | 48 (6.6%) | 105 (3.3%) | $< 0.01$[e] | 2.1 (1.4–2.9) |
| Base excess | $-6.53 \pm 3.85$ | $-6.23 \pm 3.66$ | NS[g] | |
| Birth weight (kg) | $3,206.5 \pm 708.8$ | $2,989.5 \pm 578.4$ | $< 0.01$[g] | |
| GA (weeks) (mean $\pm$ SD)[b] | $38.4 \pm 2.9$ | $38.2 \pm 3.4$ | NS[g] | |
| $< 30$ (%) | 0.8 | 1.2 | NS[f] | 0.68 (0.29–1.60) |
| 30 to 34 (%) | 4.5 | 5.4 | NS[e] | 0.83 (0.58–1.20) |
| 35 to 36 (%) | 6.7 | 8.2 | NS[e] | 0.84 (0.64–1.09) |
| $\geq 37$ (%) | 88.0 | 85.2 | NS[e] | 1.03 (0.99–1.06) |
| Breech presentation[a] | 40 (5.5%) | 150 (4.8%) | NS[e] | 1.15 (0.82–1.61) |
| Stillbirth[a] | 11 (1.5%) | 54 (1.7%) | NS[e] | 0.88 (0.46–1.67) |
| Need for treatment in NICU[a] | 125 (17.1%) | 503 (15.9%) | NS[e] | 1.07 (0.89–1.28) |
| Early neonatal mortality[a] | 11 (1.5%) | 58 (1.8%) | NS[e] | 0.82 (0.43–1.55) |
| Fetal macrosomia[c] | 166 (22.7%) | 292 (9.2%) | $< 0.01$[e] | 2.9 (2.3–3.6)<br>1.82 (1.44–2.32)[h] |
| Birth defects[a] | 4 (0.6%) | 44 (1.4%) | NS[f] | 0.39 (0.14–1.09) |
| Fetal birth trauma[a] | 11 (1.5%) | 38 (1.2%) | NS[e] | 1.25 (0.64–2.44) |

Abbreviations: CI, confidence interval; GA, gestational age; IQR, interquartile range; NICU, Neonatal Intensive Care Unit; NS, not statistically significant; OR, odds ratio; SD, standard deviation.
Notes: Early neonatal mortality: less than 7 days;
[a]results expressed in absolute numbers and percentages;
[b]results expressed as mean $\pm$ standard deviation;
[c]Fetal macrosomia, fetal weight $\geq 4,000$ g;
[d]Mann Whitney Wilcoxon test;
[e]chi-squared test;
[f]Fisher's exact test;
[g]two-sided independent Student's $t$ test;
[h]adjusted by hyperglycemic disorder.

direct association of obesity assessed by BMI with disorders during pregnancy, as well as a greater number of obstetric interventions. The data show that women older than 35 years of age were 2.5 times more likely to be obese than younger women. This observation is consistent with the studies by Pleis et al[22] and Gross et al,[23] who also reported that older pregnant women among obese pregnant women had higher parity compared with the control group. On the other hand, Stepan et al[13] observed no significant difference between maternal age and gestational age in the comparison between groups with and without obesity. Studies have reported a higher risk of complications in women who start their pregnancies with a BMI above normal.[7,23,24] Furthermore, obesity was related to an increased risk of preeclampsia and GDM, CD, hemorrhage, puerperal infections, birth defects, fetal death, fetal macrosomia, and maternal death during pregnancy and childbirth.[8,10,13]

Torloni et al[25] observed that GDM was present in 24.5% of the cases of morbid obesity, and in 14.2% of pregnant women with BMI $\geq 35$ kg/m$^2$.[25] Our data show that obese women have a 6 times greater risk of developing hyperglycemic disorders (14.4% versus 2.5%), and such results are consistent with those of other authors.[9,23,26]

We found that obesity in early pregnancy was associated with an increased risk of hypertensive disorders (33.5% versus 6.2%). These data are corroborated by the literature.[9,24,26] We also found a higher CD rate in the OG (51% versus 29.4%). This fact can be explained by the increased number of elective and iterative CDs, and fetopelvic disproportion, which is commonly related to fetal macrosomia. In this study, the risk of CD was 1.7 times higher in the OG. These results are in agreement with previously published studies.[9,27,28] This rate can be explained by the maternal and fetal risks, in addition to the ethical and legal aspects regarding vaginal birth after cesarean.

The results pertaining to the newborns showed a significant increase in acidosis (pH of the umbilical cord blood $\leq$ 7.10) in newborns from obese mothers.[29] Conner et al[30] also found that an increase in BMI was associated with a statistically significant increased risk of arterial cord blood pH $<$ 7.20 and base excess $< -8$.

Stepan et al[13] observed a greater need for intubation procedures and cardiac resuscitation in infants from obese mothers. Our study did not assess the need for intubation procedures or cardiac resuscitation; however, the analysis of the variables requiring treatment at a NICU and early neonatal mortality did not differ between the groups. This suggests that adequate perinatal care might have reduced the risk of complications.

The correlation of the Apgar score with neonatal health and survival is widely established.[12,30,31] This parameter was assessed in our study and showed no significant difference between the groups. In a similar study, Stepan et al[13] showed low Apgar scores at minute 1 along with the improvement at minutes 5 and 10. On the other hand, in a retrospective cohort study, Abenhaim et al[31] observed the higher risk of an Apgar score $\leq$ 3 at 5 minutes among obese women compared with women with normal BMIs.[30]

Fetal birth weight was statistically higher in the newborns of obese mothers (3,200 g $\pm$ 708 g) compared with non-obese mothers (2,989 g $\pm$ 578 g). Similarly, Bautista-Castaño et al[32] reported that newborn weight was directly related to maternal baseline BMI. In relation to intrauterine growth restriction, our data indicate that fetal growth restriction was not influenced by BMI; however, Perlow et al[33] suggested an increased risk in massive obesity.

The current study did not identify a relationship between preterm deliveries and obesity. The reports about preterm delivery and obesity have been contradictory. Kumari et al[34] observed a decreased risk of preterm deliveries in obese women with BMIs $>$ 40 kg/m$^2$ compared with women with normal BMIs (0.5 versus 5.3%; $p < 0.01$), which is contrary to the observations of Baeten et al.[35]

Although many studies have demonstrated that maternal obesity is an independent risk of occurrence of fetal neural tube defects, cardiac malformations, and orofacial clefts,[35–38] our study did not find this.

A potential limitation of our study is its retrospective design. Additionally, this study did not assess the effect of gestational weight gain among the obese and control groups. It is known that women who gain weight excessively or inadequately during pregnancy are at increased risks of poor maternal and child health outcomes.[39–42]

In summary, our study shows that the obese women were older than the controls, and that obesity in early pregnancy increased the risk of hyperglycemic disorders, hypertensive disorders, cesarean delivery, fetal macrosomia, and fetal acidosis.

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