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ARTICLE

Clinical Research

The relationship between maternal body mass index and pregnancy outcomes in twin compared with singleton pregnancies

Maya Ram[1,2] · Howard Berger[3] · Hayley Lipworth[1] · Michael Geary[4] · Sarah D. McDonald[5] · Beth Murray-Davis[6] · Catherine Riddell[7] · Haroon Hasan[7] · Jon Barrett[1] · Nir Melamed[1] · for the DOH-Net (Diabetes, Obesity and Hypertension in Pregnancy Research Network) and SOON (Southern Ontario Obstetrical Network) Investigators

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Abstract

Objective Women with twins have an a priori increased risk for many of the complications associated with maternal obesity. Thus, the impact of maternal obesity in twins may differ from that reported in singletons. In addition, given the increased metabolic demands in twin pregnancies, the impact of maternal underweight may be greater in twin compared with singleton gestations. Our objective was to test the hypothesis that the relationship between maternal pre-pregnancy body mass index (BMI) and adverse pregnancy outcomes differ between twin and singleton gestations.

Methods This was a retrospective population-based study of all women who had a singleton or twin hospital birth in Ontario, Canada, between April 2012 and March 2016. Data were obtained from the Better Outcomes Registry & Network (BORN) Ontario. The relationship between maternal BMI category and pregnancy complications was assessed separately in twin and singleton gestations. The primary outcome was a composite variable that included any of the following complications: preeclampsia, gestational diabetes, or preterm birth before $32^{0/7}$ weeks. Relative risk (aRR) and 95% confidence intervals (CI) for adverse outcomes for each BMI category as defined by WHO (using normal weight category as reference) were generated using modified Poisson regression, adjusting for maternal age, nulliparity, smoking, previous preterm birth, and fetal sex.

Results A total of 487,870 women with singleton ($n = 480{,}010$) and twin ($n = 7860$) pregnancies met the inclusion criteria. The risk of the composite primary outcome, preeclampsia, gestational diabetes, and cesarean delivery increased with high maternal BMI in both singleton and twin gestations, but these associations were weaker in twin compared with singleton gestations (association of BMI ≥ 40.0 kg/m^2 with primary outcome: aRR = 3.10, 95%-CI 2.96–3.24 in singletons compared with aRR = 1.74, 95%-CI 1.37–2.20 in twins). In singleton pregnancies the risk of preterm birth at < $32^{0/7}$ weeks increased with maternal BMI, mainly due to an increased risk of provider-initiated preterm birth. In twin gestations, however, underweight (but not overweight or obesity) was associated with the greatest risk of preterm birth at < 32 weeks (aRR 1.67, 95%-CI 1.17–2.37), mainly due to an increased risk of spontaneous preterm birth (aRR 2.10, 95%-CI 1.44–3.08).

Conclusion In healthy women with twin pregnancies, underweight is associated with the greatest risk for preterm birth, while the association of maternal obesity with adverse pregnancy outcomes is weaker than that observed in singletons.

Introduction

Maternal obesity has become a major public health issue with ~40% of pregnant women in the United States being overweight or obese [1–3]. Maternal obesity has been recognized as a major risk factor for maternal and perinatal morbidity and mortality, including hypertensive disorders of pregnancy, gestational diabetes mellitus, preterm birth, cesarean delivery, stillbirth, macrosomia, and birth trauma [1, 4–25].

The current study was presented at the meeting of the Society of Maternal Fetal Medicine in Dallas, Tx (January 2018) and the Canadian National Perinatal Research Meeting in Banff, AB (February 2018).

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✉ Maya Ram
maya3000@gmail.com

Extended author information available on the last page of the article

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Women with twins are at an a priori increased risk for many of the complications associated with maternal obesity described above [26–42]. It thus may be hypothesized that in twin pregnancies the adverse effects of maternal obesity would be partially masked by the higher baseline risk of these complications. In addition, given the increased metabolic demands [43–45] and the increased risk of fetal growth restriction in twin pregnancies, the effect of maternal underweight may be greater in twin compared with singleton gestations.

However, most of the data regarding the association of each of maternal obesity and maternal underweight with adverse pregnancy outcomes are derived from singleton pregnancies, while data on these associations in twin pregnancies are relatively limited and conflicting [46–58]. Possible reasons for the conflicting data include small sample size [46, 48, 50, 52, 55–58], lack of a comparison group of singleton pregnancies [46, 49, 51–53, 55, 57, 58] and lack of adjustment for potential confounding variables such as assisted reproductive technology [47, 48, 52–54, 56], smoking [46, 47, 54, 56], race [47, 48, 52, 54, 56, 57], and parity [53, 54].

Our aim was to test the hypothesis that the relationship between maternal BMI and adverse pregnancy outcomes differs between twin and singleton gestations using a large provincial cohort and while adjusting for potential confounding variables.

Methods

Study population

We conducted a retrospective population-based study of all women who had a singleton or twin hospital birth in Ontario, Canada, between April 2012 and March 2016. Data were obtained from the Better Outcomes Registry & Network (BORN) Ontario (https://www.bornontario.ca/en/about-born/). BORN Ontario is a registry of all births in the province of Ontario, Canada. For each hospital birth, data are collected by healthcare providers and hospital staff from charts, clinical forms, and patient interview, and then entered into the BORN Information System (either directly or by electronic upload from a hospital's EMR system). The BORN Information System contains maternal demographics, health behaviors and reproductive history, as well as clinical information related to pregnancy, labor, birth, and fetal and neonatal outcomes. An ongoing program of data verifications, quality checks, and formal training sessions for individuals collecting and entering data assures a high level of data quality is maintained. Maternal race was obtained through linkage with the Prenatal Screening Ontario (PSO) database which contains data for ~70% of pregnancies in Ontario.

Exclusion criteria included birth before $24^{0/7}$ weeks of gestation, maternal pre-existing medical conditions (including chronic hypertension, pre-gestational diabetes mellitus, renal disease, and autoimmune disorders), monochorionic twins complicated by twin-to-twin transfusion syndrome (TTTS), monoamniotic twins, higher order multifetal pregnancies, reduction/termination of one or both fetuses, missing pre-pregnancy BMI, or pregnancies complicated by genetic or structural fetal anomalies. The current study was approved by Sunnybrook Health Sciences Centre's Research Ethics Board.

Exposure and outcomes

Women were classified into six groups based on pre-pregnancy BMI as defined by the National Institutes of Health and the World Health Organization [4, 5]: (1) underweight (BMI < 18.5 kg/m^2); (2) normal weight (BMI 18.5–24.9 kg/m^2); (3) overweight (BMI 25.0–29.9 kg/m^2); (4) obesity class I (BMI 30.0–34.9 kg/m^2); (5) obesity class II (BMI 35.0–39.9 kg/m^2); and (6) obesity class III (BMI ≥ 40.0 kg/m^2). Missing BMI values were ascertained by estimating pre-pregnancy BMI for those women with 1st trimester weight and height available by subtracting the average weight gain during the 1st trimester of 2 kg from the 1st trimester weight [5]. Of those remaining, multiple imputation via a chained equation approach, using a subset of women with available pre-pregnancy weight, was performed [59]. Pregnancy outcomes were compared between women in the different BMI groups.

The primary exposure of interest was pre-pregnancy BMI category stratified by singletons and twins. The primary outcome was a composite variable that included any of the following complications: preeclampsia, GDM or preterm birth before 32 weeks. Secondary maternal outcomes included the individual components of the primary outcome, preterm birth at less than 34 and 28 weeks, cesarean delivery, placental abruption, shoulder dystocia, 3rd or 4th degree anal sphincter injury, postpartum hemorrhage, and abdominal wound complications.

The neonatal composite outcome was a composite variable that included the presence of any of the following: perinatal mortality, 5-min Apgar score < 7, umbilical artery pH < 7.1, admission to the neonatal intensive care unit (NICU), birth trauma or neonatal respiratory morbidity. Secondary neonatal outcomes included the individual components of the neonatal composite outcome, stillbirth, neonatal mortality, and small for gestational age (SGA, defined as birth weight below the 10th percentile for gestational age) or large for gestational age (LGA, defined as birth weight above the 90th percentile for gestational age) according to sex-specific singleton-based Canadian birth weight reference [60]. Neonatal respiratory morbidity was defined as any of the following: need for respiratory support in the form of continuous positive airway pressure (CPAP) or mechanical ventilation, a diagnosis of transient tachypnea of the newborn (TTN) or respiratory distress syndrome (RDS). Birth trauma was defined as long-bone fracture, nerve injury at 72 h of age or at discharge, or intracerebral hemorrhage. Neonatal mortality defined as death within 28 days of birth.

Definitions

Preterm birth was defined as a live birth with a gestational age at delivery $<37^{0/7}$ weeks. Provider-initiated ('iatrogenic') preterm birth was defined as preterm birth following labor induction or cesarean delivery without ruptured membranes or conditions indicating prior onset of labor. All other preterm births were defined as spontaneous preterm births.

Fertility treatments included the use of assisted reproductive technology: in-vitro fertilization, ovulation induction, intracervical, and intrauterine insemination. Smoking referred to smoking at admission for birth or first prenatal visit.

Data analysis

The baseline characteristics of the cohort as well as the primary and secondary maternal and neonatal outcomes were compared between the different BMI groups. Separate comparisons were performed for singleton and twin pregnancies. The Man–Whitney U-test was used for continuous variables and the Chi-squared or Fisher's exact tests were used for categorical variables, as appropriate.

Multivariable modified Poisson regression analysis was used to assess the association between maternal BMI category and the maternal and neonatal outcomes. The results were expressed as adjusted relative risks (aRRs) and 95% confidence intervals (CIs) using the normal weight category as reference. Models were adjusted for the following variables: maternal age, nulliparity, smoking, and previous preterm birth. Neonatal outcomes were adjusted for fetal sex as well. For neonatal outcomes of the twin group, these models were fitted with generalized estimating equations (GEE) to account for correlation within a pair of twins from the same mother.

The analysis described above was performed separately for twins and singletons, and the associations for each BMI category (expressed as aRR) were compared between the singleton and twin groups using relative risk ratios as per the methodology described by Altman and Bland (2003) [61] to identify differential association with BMI in twins compared with singleton gestations. Relative risk ratio <1 indicates lower association in twins compared with singletons while a relative risk ratio >1 indicates higher association in twins compared with singletons.

Data were analyzed using the SAS statistical software Version 9.4. Significance was set at a two-sided $P\text{-value} < 0.05$.

Results

Characteristics of the study groups

Of a total of 542,870 women identified during the study period, 487,870 met the inclusion criteria including 480,010 (98.4%) with a singleton and 7860 (1.6%) with a twin pregnancy (Fig. 1). The characteristics of the study group are presented in Table 1. Overall, women in the underweight group were younger and were more likely to be nulliparous and of Asian race. Overweight and obese women were less likely to be nulliparous and were more likely to have a history of preterm birth and cesarean delivery.

Maternal BMI and pregnancy outcomes—unadjusted analysis

The relationship between the unadjusted rates of the key outcomes and maternal BMI is compared between the twin and singleton groups in Fig. 2, while the full results are provided in Supplementary Tables S1 (singletons) and S2 (twins).

The unadjusted rate of the following outcomes increased with maternal BMI in both singleton and twin gestations: primary outcome, preeclampsia, gestational diabetes, cesarean delivery, neonatal respiratory morbidity, and birth weight > 90th percentile (Fig. 2, Tables S1 and S2). The rate of birth weight < 10th percentile was inversely related to maternal BMI among both twins and singletons. Although the absolute rates of most of these outcomes were higher in twins than in singletons, the relationship between BMI and the rate of these outcomes was similar between singleton and twin pregnancies (Fig. 2).

The main differences between twins and singletons were observed with regard to the rate of preterm birth, neonatal composite outcome, and NICU admission. In singletons, the rate of these outcomes increased with maternal BMI, while in twins these outcomes were most frequent in underweight women (Fig. 2b).

The relationship between preterm birth and maternal BMI was further stratified by onset of preterm birth: provider-initiated vs. spontaneous preterm birth (Fig. 3). In singletons,

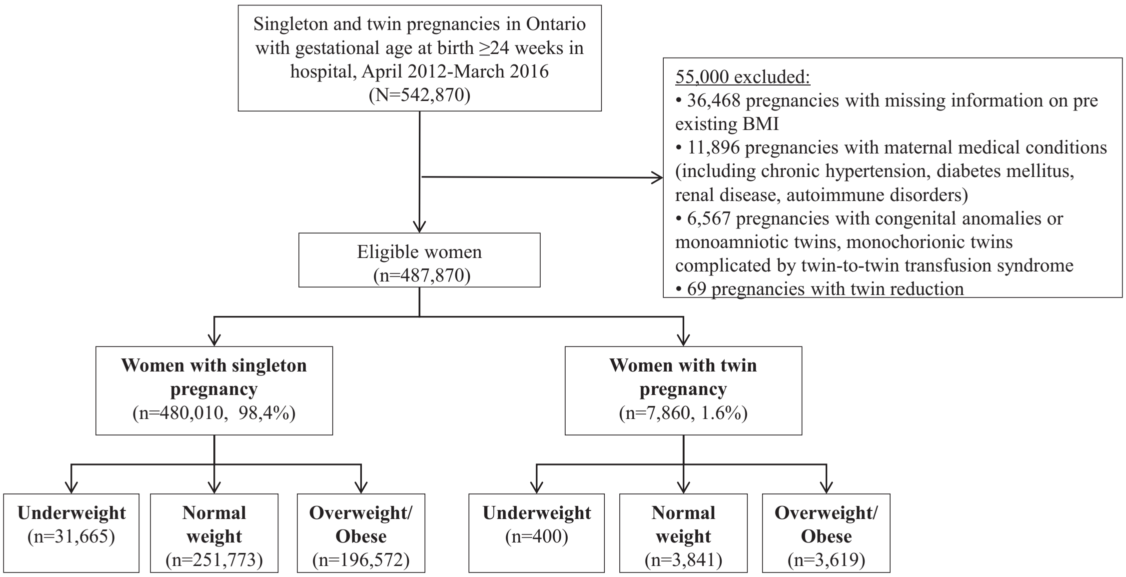

Fig. 1 Selection of the study groups. BMI, body mass index

the rate of provider-initiated preterm birth increased with maternal BMI, while the rate of spontaneous preterm birth was higher in both underweight and high BMI women (Fig. 3a). In twins, the main finding was an increased rate of spontaneous preterm birth in underweight women, while elevated BMI was not associated with the rate of spontaneous or provider-initiated preterm birth (Fig. 3b).

The rate of outcomes such as placental abruption, shoulder dystocia, anal sphincter injuries, maternal wound infection, perinatal mortality, and birth trauma in the twins group could not be interpreted due to low event rate (Table S2).

Maternal BMI and pregnancy outcomes—adjusted analysis

To account for the differences in baseline characteristics between women of different BMI categories, we assessed the association between maternal BMI (using normal weight group as reference) and adverse pregnancy outcomes while adjusting for maternal age, nulliparity, smoking, previous preterm birth, and fetal sex. The results for the key outcomes are presented in Fig. 4, while the full results are provided in Supplementary Tables S3 (singletons) and S4 (twins).

The risk of the primary outcome, preeclampsia, gestational diabetes and cesarean delivery increased with maternal BMI category among both singleton and twin pregnancies, but the association of maternal BMI with these outcomes in twins was weaker compared with singletons (Fig. 4a). For example, while in singletons the risk of preeclampsia was significantly increased in women with overweight or any level of obesity, the risk of preeclampsia in twins was increased only in women with class III obesity but not among women with lower degree of obesity. Underweight was associated with a protective effect for these outcomes in singleton but not in twin pregnancies (Fig. 4a).

With regard to preterm birth at <32 weeks, in singleton pregnancies the risk was elevated in both obese and underweight women, while twin gestations, only underweight (but not high BMI) was associated with an increased risk of preterm birth (Fig. 4b). Unlike in the case of singletons, the risk of provider-initiated PTB in twins was not related to maternal BMI (Fig. 4b and Table S4). The risk of composite neonatal outcome followed a similar pattern to that observed for preterm birth (Fig. 4b).

The risk of birth weight > 90th percentile increased with maternal BMI in both singletons and twins, but the effect was greater among twins (Fig. 4b). In contrast, the risk of birth weight < 10th percentile was increased in underweight women, while high BMI had a protective effect in both singletons and twins (Fig. 4b).

In singletons, the risk of low Apgar score, low pH, NICU admission, and respiratory morbidity increased with high maternal BMI (Table S4), while such a relationship was not observed among twins (Tables S4).

Discussion

Principal findings of the study

Our aim was to test the hypothesis that the relationship between maternal BMI and adverse pregnancy outcomes differ between twin and singleton gestations after adjusting for confounders. We found that although the absolute rate of adverse outcomes is higher in twin pregnancies

Table 1 Characteristics of the singleton and twin groups by maternal BMI

Characteristic	Singletons				Twins			
	Underweight (BMI < 18.5 kg/m^2) (N = 31,665)	Normal weight (BMI 18.5–24.9 kg/m^2) (N = 251,773)	Overweight/obese (BMI ≥ 25.0 kg/m^2) (N = 196,572)	p-value	Underweight (BMI < 18.5 kg/m^2) (N = 400)	Normal weight (BMI 18.5–24.9 kg/m^2) (N = 3841)	Overweight/obese (BMI ≥ 25.0 kg/m^2) (N = 3619)	p-value
Maternal age (years)	29.0 ± 5.6	30.4 ± 5.3	30.7 ± 5.3	**< 0.0001**	31.1 ± 5.4	32.2 ± 5.2	31.9 ± 5.3	**0.0003**
Age > 35 years	3719 (11.7)	41,163 (16.3)	35,975 (18.3)	**<0.0001**	79 (19.8)	952 (24.8)	864 (23.9)	0.0734
Nulliparity	16,342 (51.6)	117,068 (46.5)	75,666 (38.5)	**< 0.0001**	204 (51.0)	1870 (48.7)	1501 (41.5)	**< 0.0001**
Maternal ethnic group								
Caucasian	10,291 (32.5)	101,737 (40.4)	82,956 (42.2)	**< 0.0001**	139 (34.8)	1624 (42.3)	1547 (42.7)	**0.0085**
Asian	10,330 (32.6)	51,615 (20.5)	23,243 (11.8)	**< 0.0001**	122 (30.5)	615 (16.0)	342 (9.5)	**< 0.0001**
Black	977 (3.1)	8424 (3.3)	11,579 (5.9)	**< 0.0001**	6 (1.5)	125 (3.3)	235 (6.5)	**< 0.0001**
Other	1053 (3.3)	8747 (3.5)	7716 (3.9)	**< 0.0001**	13 (3.3)	148 (3.9)	132 (3.6)	0.7836
Missing	9014 (28.5)	81,250 (32.3)	71,078 (36.2)	**< 0.0001**	120 (30.0)	1329 (34.6)	1363 (37.7)	**0.001**
Pre-pregnancy BMI (kg/m^2)	17.3 ± 1.2	21.9 ± 1.8	30.7 ± 5.6	**< 0.0001**	17.3 ± 1.3	22 ± 1.7	31.1 ± 6.1	**< 0.0001**
25.0–29.9 kg/m^2	N/A	N/A	113,983 (58)	N/A	N/A	N/A	2003 (55.3)	N/A
30.0–34.9 kg/m^2	N/A	N/A	49,291 (25.1)	N/A	N/A	N/A	924 (25.5)	N/A
35.0–39.9 kg/m^2	N/A	N/A	20,179 (10.3)	N/A	N/A	N/A	414 (11.4)	N/A
≥ 40.0 kg/m^2	N/A	N/A	13,119 (6.7)	N/A	N/A	N/A	278 (7.7)	N/A
Maternal height (cm)	165.4 ± 8.3	163.7 ± 7.0	163.2 ± 7.6	**< 0.0001**	166.8 ± 7.9	164.7 ± 7.1	163.9 ± 7.6	**< 0.0001**
Pre-pregnancy weight (kg)	47.3 ± 5.1	58.6 ± 6.7	81.8 ± 16.6	**< 0.0001**	48.1 ± 5.2	59.8 ± 6.7	83.6 ± 17.8	**< 0.0001**
Smoking	4000 (12.6)	22,319 (8.9)	21,810 (11.1)	**< 0.0001**	40 (10.0)	255 (6.6)	343 (9.5)	**< 0.0001**
Prior preterm birth	1415 (4.5)	11,157 (4.4)	11,159 (5.7)	**< 0.0001**	17 (4.3)	198 (5.2)	231 (6.4)	**0.0326**
Prior Caesarean section	2812 (8.9)	30,267 (12)	36,420 (18.5)	**< 0.0001**	43 (10.8)	449 (11.7)	610 (16.9)	**< 0.0001**
Fertility treatments	633 (2.0)	7056 (2.8)	6627 (3.4)	**< 0.0001**	95 (23.8)	1096 (28.5)	971 (26.8)	0.0580

BMI body mass index, *N/A* non-applicable

Data are presented as mean ± standard deviation or n (%)

Significant p-values are emphasized in bold font

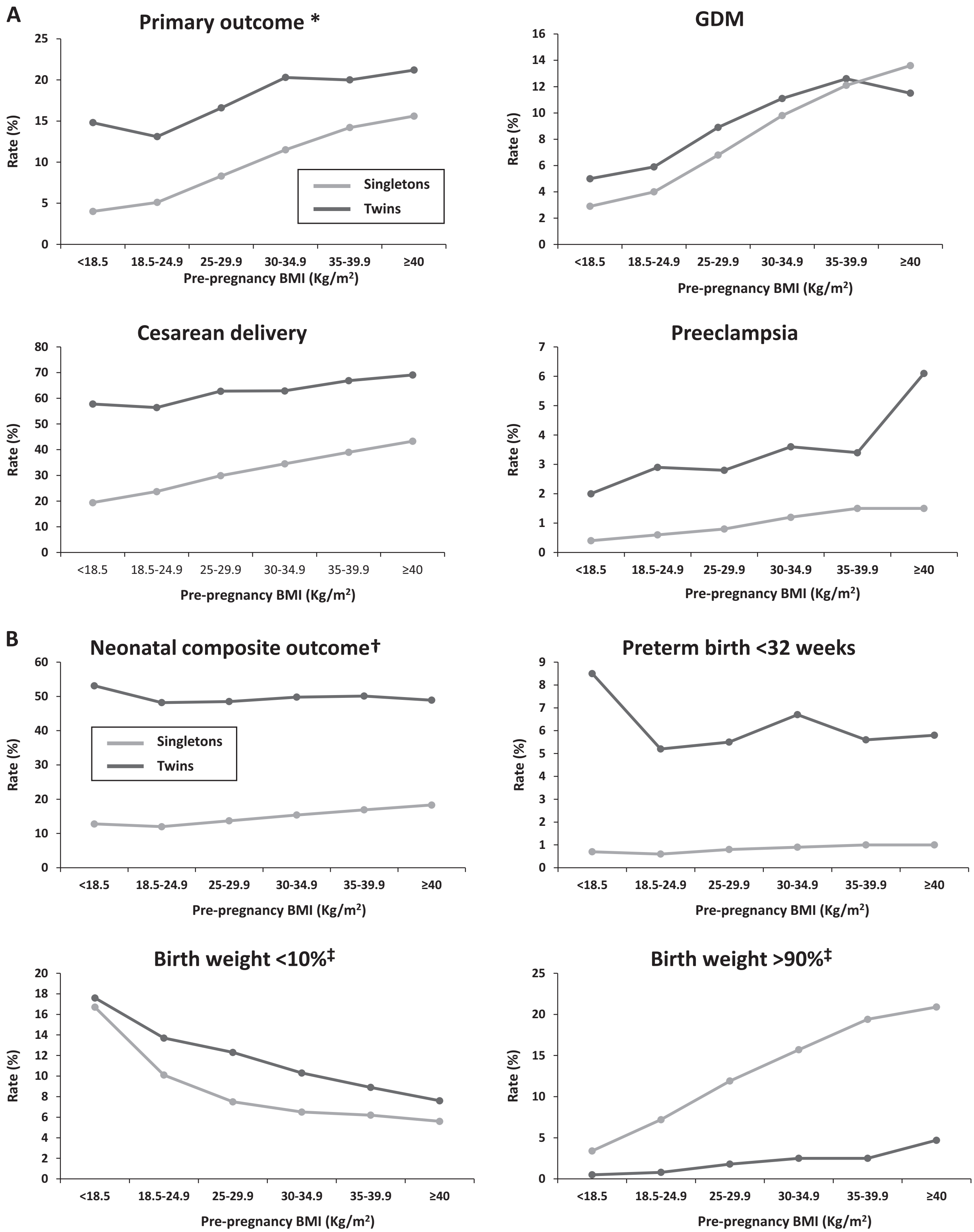

Fig. 2 Rate of adverse outcomes by BMI category in singleton and twin pregnancies. BMI body mass index, GDM gestational diabetes mellitus. The relationship between the rate of maternal (**a**) and neonatal (**b**) adverse outcomes with maternal BMI is presented for twin (red line) and singleton (blue line) pregnancies. *Defined as preeclampsia, gestational diabetes or preterm birth before 32 weeks. †Defined as any of the following: perinatal mortality, 5-min Apgar score < 7, Umbilical Artery pH < 7.1, admission to NICU, birth trauma, or neonatal respiratory. ‡Based on Canadian birth weight reference [60]

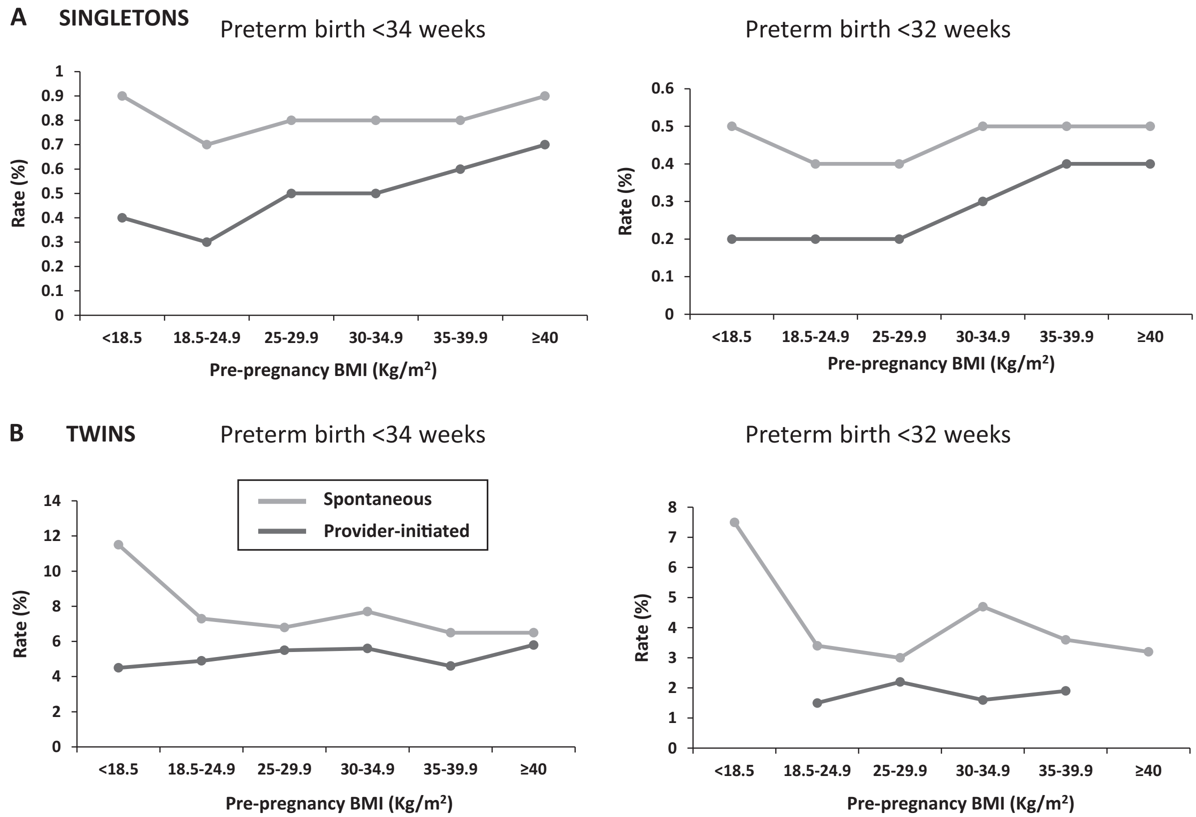

Fig. 3 Rate of spontaneous vs. provider-initiated preterm birth by BMI category in singleton and twin pregnancies. BMI body mass index. The relationship between the rate of preterm birth at < 34 weeks and < 32 weeks with maternal BMI in singleton (**a**) and twin (**b**) gestations is stratified by spontaneous (blue line) vs. provider-initiated (red line) preterm birth. Provider-initiated preterm birth was defined as live preterm birth following labor induction or cesarean delivery without ruptured membranes or conditions indicating prior onset of labor. All other preterm births are defined as spontaneous preterm births

(regardless of maternal BMI), the association between these complications and maternal BMI differs considerably between twin and singleton pregnancies: (1) the association between high maternal BMI and GDM, preeclampsia and cesarean delivery is weaker in twin compared with singletons pregnancies; (2) the risk of preterm birth in singleton pregnancies increases with maternal BMI, mainly due to an increase in provider-initiated preterm births; in contrast, in twin pregnancies, underweight women are at the highest risk of preterm birth due to an increased risk of spontaneous preterm birth, while high BMI is not associated with an increased risk of preterm birth; (3) the relationship between maternal BMI and a deviation in normal fetal growth is overall similar between singletons and twins, although elevated maternal BMI has a greater effect on the risk of birth weight > 90th percentile in twin compared with singleton pregnancies. Thus, overall, it seems that in twin pregnancies the impact of high BMI is lower than in singleton pregnancies and that being underweight has a greater negative impact in twin compared with singleton pregnancies.

Results of the study in the context of other observations

The weaker association between high maternal BMI and GDM, preeclampsia and cesarean delivery may be explained by the fact that the effects of maternal obesity in twins are partially masked by the higher a priori risk of these complications in twins [26–42]. This finding is in agreement with previous smaller studies [48, 54, 56].

The most notable finding identified in the current study relates to the relationship between maternal BMI and the risk of preterm birth. We found that it is not only the relationship but also the mechanism underlying the association between BMI and preterm birth that seems to differ between twins and singletons. In singletons, high maternal BMI was associated with an increased risk of preterm birth mainly due to a higher rate of provider-initiated preterm birth, as has been previously demonstrated by others [62–66]. This relationship however was not observed in twins where the risk of preterm birth was mainly increased in underweight women, due to a higher rate of spontaneous preterm birth. The mechanisms underlying the association between maternal obesity and preterm birth are not entirely clear. It has been suggested that obesity predisposes to both provider-initiated preterm birth due to increased risk of maternal or fetal complications and spontaneous preterm birth due to the association between obesity and inflammation [20]. At the same time, maternal underweight has also been associated with preterm birth in both singletons and twins [45, 67–69]. Maternal underweight may be a proxy for poor maternal nutritional status which has been associated with a reduction in placental weight and surface area as well as iron deficiency anemia, both of which have been linked with preterm birth [67, 70–75]. We speculate that this association may be stronger in twin pregnancies given the greater metabolic and nutritional demands in the presence of multifetal gestation.

Data regarding the association between maternal BMI and preterm birth in twin pregnancies are limited and

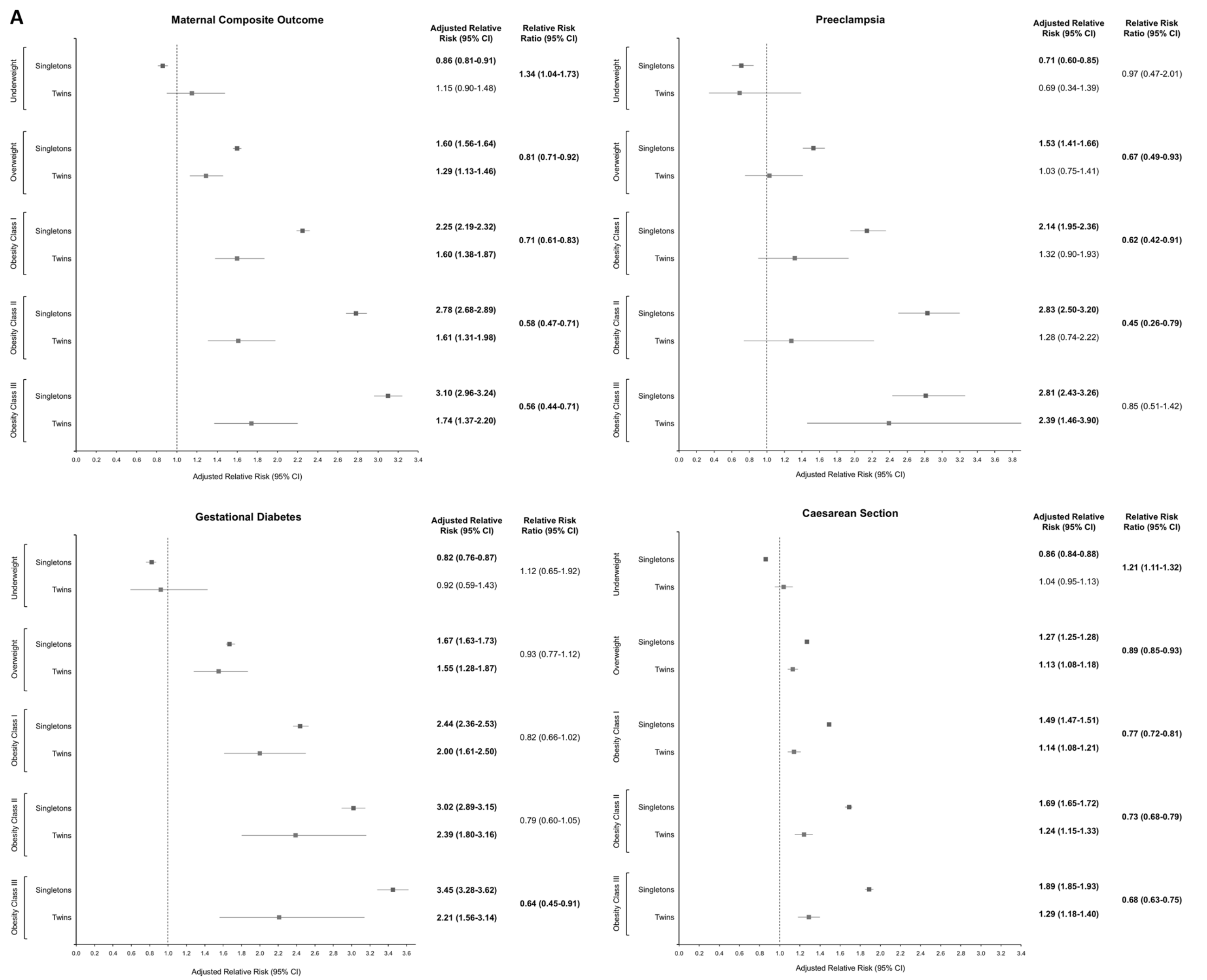

Fig. 4 Risk of adverse outcomes by BMI category in singleton and twin pregnancies. BMI body mass index. The relationship between the risk of maternal (**a**) and neonatal (**b**) adverse outcomes with maternal BMI is presented for twin (blue line) and singleton (red line) pregnancies. Values reflect the results of multivariable modified Poisson regression analysis while adjusting for the following variables: maternal age, nulliparity, smoking, previous preterm birth and fetal sex (for neonatal outcomes). For neonatal outcomes in the twins group, the models were fitted with GEE to account for correlation within a pair of twins from the same mother. Values are expressed as adjusted relative risk (95% confidence interval). The adjusted relative risks for each outcome were compared between the twin and singleton groups using relative risk ratios to identify differential association with BMI in twins compared with singleton gestations. Relative risk ratio < 1 indicates lower association in twins compared with singletons while a relative risk ratio > 1 indicates higher association in twins compared with singletons. The vertical line represents relative risk of 1.0. *Defined as preeclampsia, gestational diabetes or preterm birth before 32 weeks. †Defined as any of the following: perinatal mortality, 5-min Apgar score < 7, Umbilical Artery pH < 7.1, admission to NICU, birth trauma or neonatal respiratory. ‡Based on Canadian birth weight reference [60]

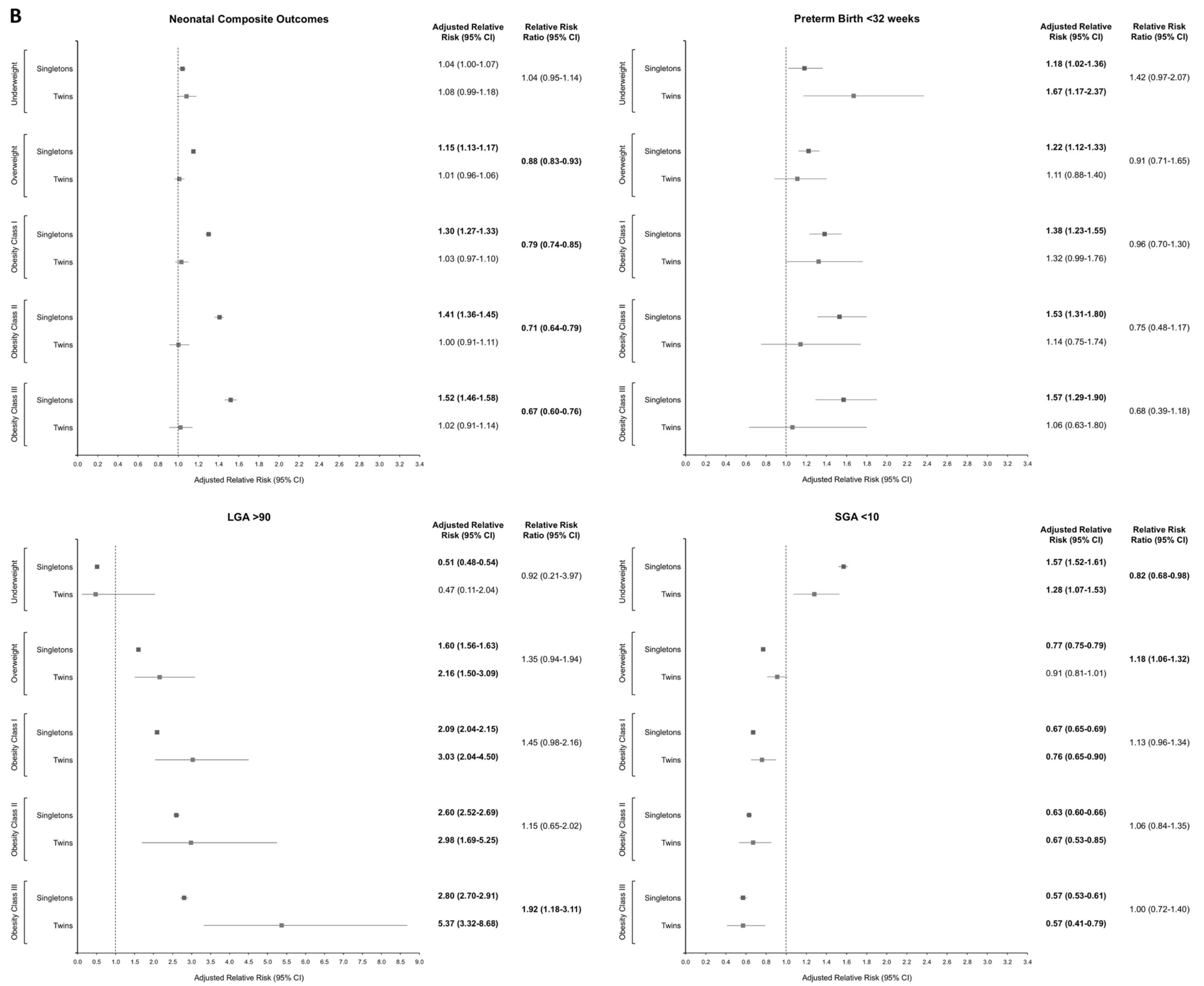

Fig. 4 Continued

conflicting. Few studies reported an association between maternal obesity and preterm births [48, 49, 52, 57], while others failed to detect such an association [50]. Possible reasons for this inconsistency include small sample size, lack of adjustment for potential confounding factors, differences in the definition of preterm birth, combining overweight and obese women into a single group, and lack of distinction between spontaneous and provider-initiated preterm birth. Data regarding the association between underweight and preterm birth in twin pregnancies are even more limited given the small number of underweight women with twins in many of these studies ($n = 5$–30) [46, 50, 52] and the fact that other studies focused only on women with high BMI and did not consider underweight women in the analysis [48]. In fact, we were able to identify only one study that addressed this question. Sung et al. investigated the relationship between maternal BMI and the risk of preterm birth in a retrospective cohort of 1959 women with twin pregnancies, of whom 292 were underweight [49]. The rate of both total and spontaneous preterm birth at 34 weeks in underweight women (14.1% and 11.0%, respectively) was similar to that found in our study (16.3% and 11.5%, respectively), and was higher than the rates observed in their control group of women with normal weight (11.9% vs. 8.0%), although the differences were not statistically significant, possibly due to insufficient power. In another retrospective study on the relationship between maternal BMI and the risk of placental abruption (a potential cause of spontaneous preterm birth) in twin pregnancies, Alilyu et al. reported that underweight women had the highest incidence of placental abruption (19.3%, compared with 16.1% in normal weight women and 9.5% in obese women) [51]. These findings overall provide some support for our finding regarding the association between underweight and spontaneous preterm birth in twins.

Strengths and limitations

Our study has several strengths. The large sample size enabled us to study women at different subclasses of obesity as well as underweight women as individual groups, a limitation faced by many of the previous studies. The large sample size and the availability of data on maternal characteristics allowed us to adjust the analysis for important potential confounding variables. Finally, the population-based nature of the study which is based on women from across the province of Ontario contributes to the generalizability of our findings.

The main limitations of the current study are those inherent to all retrospective studies. Thus, for example, we did not have information on factors such as maternal nutritional status, which may be especially relevant in underweight women. In addition, we have no information on whether the maternal pre-pregnancy weight and height are based on measurements or are self reported.

Conclusion

Data on the association of maternal BMI with pregnancy outcomes in twin pregnancies are limited, especially with regard to the outcomes of underweight women with twins. The findings of the current study confirm our hypothesis that the association between maternal pre-pregnancy BMI and adverse pregnancy outcomes differ between twin and singleton pregnancies. Care providers should be aware that the impact of high pre-pregnancy BMI in twin pregnancies may be lower than that observed in singletons, and that attention should be especially focused on underweight women who are at the highest risk of preterm birth.

It should be emphasized that our findings are limited to healthy women with twin gestations, as women with co-morbidities such as hypertension and diabetes were excluded. Further studies are needed to confirm these findings as well as to determine whether underweight women undergoing fertility treatments (who therefore might be at risk of twin pregnancy) may benefit from nutritional consultation prior to conception and whether increased gestational weight gain may have a protective effect in underweight women with twin pregnancy.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Affiliations

Maya Ram[1,2] · Howard Berger[3] · Hayley Lipworth[1] · Michael Geary[4] · Sarah D. McDonald[5] · Beth Murray-Davis[6] · Catherine Riddell[7] · Haroon Hasan[7] · Jon Barrett[1] · Nir Melamed[1] for the DOH-Net (Diabetes, Obesity and Hypertension in Pregnancy Research Network) and SOON (Southern Ontario Obstetrical Network) Investigators

[1] Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, Sunnybrook Health Sciences Centre, University of Toronto, Ontario, Canada

[2] Departments of Obstetrics and Gynecology (affiliated to the Sackler Faculty of Medicine), Lis Maternity Hospital, Tel Aviv Sourasky Medical Center, Tel Aviv University, Tel Aviv, Israel

[3] Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, St. Michael's Hospital, University of Toronto, Ontario, Canada

[4] Department of Obstetrics & Gynaecology, Rotunda Hospital, Dublin, Ireland

[5] Division of Maternal-Fetal Medicine, Departments of Obstetrics & Gynecology, Radiology, and Health Research Methods, Evidence & Impact, McMaster University, Hamilton, Ontario, Canada

[6] Department of Obstetrics and Gynecology, Midwifery Education Program, McMaster University, Hamilton, Ontario, Canada

[7] Better Outcomes Registry & Network (BORN) Ontario, Children's Hospital of Eastern Ontario (CHEO), Ottawa, Ontario, Canada