

The Influence of Maternal Obesity on Pregnancy Complications and Neonatal Outcomes in Diabetic and Nondiabetic Women

Der Einfluss mütterlicher Adipositas auf Schwangerschaftskomplikationen und neonatale Ergebnisse bei Frauen mit und ohne Diabetes



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Key words

gestational diabetes, body mass index, obstetric outcomes, pregestational diabetes, pregnancy outcomes

Schlüsselwörter

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ABSTRACT

Introduction This study aimed to investigate the influence of obesity on pregnancy complications and neonatal outcomes in diabetic and nondiabetic women.

Materials and Methods This retrospective case control study was conducted on 1193 pregnant women and their neonates

at a tertiary level maternity hospital between March 2007 and 2011. The pregnant women were classified into 2 groups according to the presence of diabetes mellitus. Six hundred and seven patients with gestational diabetes or pregestational diabetes formed the diabetic group (study group) and 586 patients were in the nondiabetic group (control group). Demographic characteristics, body mass index, gestational weight gain, obstetric history, smoking status, type of delivery, gestational ages, pregnancy complications, neonatal outcomes were recorded for each patient. Multivariable logistic regression analysis was performed to evaluate the effect of obesity and diabetes on the pregnancy complications and neonatal outcomes.

Results The mean age and pre-pregnancy body mass indices of women with diabetes mellitus were significantly higher than the control group's ($p < 0.001$). Gestational weight gain and number of smokers were similar among the groups. Multiparity and obesity were more prevalent in the diabetic group compared to controls (both $p < 0.001$). Although gestational age at birth was earlier in the diabetic group, birth weights were higher in this group than in the control group (both $p < 0.001$). Cesarean delivery rates, the incidence of macrosomia, and neonatal intensive care unit admission rates were significantly higher in the diabetes group both with normal and increased body mass index (all $p < 0.001$). However, adverse pregnancy outcomes were comparable between the groups ($p = 0.279$). Multivariable logistic regression analysis showed that obesity is a significant risk factor for pregnancy complications (OR = 1.772 [95% CI, 1.283–2.449], $p = 0.001$) but not for adverse neonatal outcomes (OR = 1.068 [95% CI, 0.683–1.669], $p = 0.773$).

Conclusion While obesity increases risk of developing a pregnancy complication, diabetes worsens neonatal outcomes.

ZUSAMMENFASSUNG

Einleitung Ziel dieser Studie war es, den Einfluss von mütterlicher Adipositas auf Schwangerschaftskomplikationen sowie Neugeborenen-Outcomes bei Frauen mit und ohne Diabetes zu untersuchen.

Material und Methode Diese retrospektive Fallkontrollstudie wurde an 1193 schwangeren Frauen und ihren neugeborenen Kinder durchgeführt, die zwischen März 2007 und 2011 in einer Geburtsklinik der Regelversorgung betreut wurden. Die schwangeren Frauen wurden in 2 Gruppen eingeteilt, abhängig davon, ob sie Diabetes hatten oder nicht. 607 Patientinnen mit Gestations- oder Prägestationsdiabetes bildeten die Diabetesgruppe (Untersuchungsgruppe), die 586 Patientinnen in der Gruppe ohne Diabetes fungierten als Kontrollgruppe. Demografische Merkmale, Body-Mass-Index (BMI), Gewichtszunahme während der Schwangerschaft, geburts-hilfliche Anamnese, Raucherstatus, Art der Entbindung, Schwangerschaftsalter, Schwangerschaftskomplikationen und neonatales Outcome wurden für jede Patientin erfasst. Eine multivariable Regressionsanalyse wurde durchgeführt, um die Auswirkung von Adipositas und Diabetes auf Schwangerschaftskomplikationen und neonatales Outcome zu bewerten.

Ergebnisse Das Durchschnittsalter und der BMI vor der Schwangerschaft waren deutlich höher bei den Frauen mit Diabetes mellitus als in der Kontrollgruppe ($p < 0,001$). Die Gewichtszunahme während der Schwangerschaft und die An-

zahl der Raucherinnen waren in beiden Gruppen ähnlich. Es gab mehr Frauen mit Übergewicht und mehr Mehrgebärende in der Diabetesgruppe verglichen mit der Kontrollgruppe (beide jeweils $p < 0,001$). Obwohl die Neugeborenen der Diabetesgruppe ein jüngeres Schwangerschaftsalter hatten bei der Geburt, war das Geburtsgewicht bei den Neugeborenen der Diabetesgruppe höher verglichen mit der Kontrollgruppe (beide jeweils $p < 0,001$). Die Kaiserschnittraten, die Häufigkeit von Makrosomie und die Einweisungsrate in die Neugeborenen-Intensivstation waren deutlich höher für die Diabetesgruppe, sowohl für Frauen mit normalem BMI als auch für Frauen mit hohem BMI (jeweils $p < 0,001$). Die unerwünschten Schwangerschaftsausgänge waren aber in beiden Gruppen vergleichbar ($p = 0,279$). Die multivariable Regressionsanalyse zeigte, dass Übergewicht einen wesentlichen Risikofaktor für Schwangerschaftskomplikationen darstellt (OR = 1,772 [95%-KI 1,283–2,449], $p = 0,001$), aber nicht für ungünstige neonatale Ergebnisse (OR = 1,068 [95%-KI 0,683–1,669], $p = 0,773$).

Schlussfolgerung Während Adipositas das Risiko von Schwangerschaftskomplikationen erhöht, verschlechtert Diabetes das neonatale Outcome.

Introduction

Obesity is considered as an important health problem causing morbidity and mortality [1]. The prevalence of overweight or obese women increased globally from 29.8% in 1980 to 38.0% in 2013 [2]. According to the Turkish Epidemiology Survey of Diabetes, Hypertension, Obesity and Endocrine Disease (TURDEP-II) study performed by Satman et al., the prevalence of obesity in Turkish women is 44.2% and 27.3% in men [3].

Studies have shown that maternal obesity during the pre-pregnancy and early pregnancy periods may cause some obstetric or perinatal complications [4, 5]. Major pregnancy complications include gestational diabetes, pregnancy-induced hypertension, pre-eclampsia, postpartum hemorrhage, and increased risk of cesarean delivery. Infants of obese mothers are also at an increased risk of having low birth weights, preterm births, small for gestational ages (SGA), and stillbirths [6].

Gestational diabetes mellitus (GDM) if not treated, may adversely affect maternal or perinatal outcomes [7]. Recent studies have shown that excessive weight gain and obesity in the pre-pregnancy period, especially in patients with GDM, are risk factors for future pregnancy and neonatal complications [8, 9]. Likewise, in parallel with the increasing prevalence of obesity worldwide, pregestational and/or gestational weight gain (GWG) also gradually increases. For this reason, GWG in women with GDM should be restricted or limited to recommended values.

This study aimed to investigate the influence of obesity on pregnancy and neonatal outcomes in diabetic and nondiabetic women.

Materials and Methods

Study design and patient population

A total of 1193 pregnant women and their neonates were retrospectively reviewed in this study. Medical records of the patients were recruited from Zekai Tahir Burak Women's Health Education and Research Hospital from March 2007 to March 2011. This study was specifically approved by the institutional review board of the current hospital. Patients were classified into 2 groups according to the presence of diabetes mellitus (both those with pre-gestational diabetes and gestational diabetes ones). The control group was randomly selected from the patients without current or previous history of pregestational and/or gestational diabetes mellitus in the high risk pregnancy unit of our hospital during the study period. Co-morbidities such as asthma, hypothyroidism, epilepsy, familial Mediterranean fever, etc. were also recorded for each patient. Multiple pregnancies and patients with a history of thromboembolism were excluded from the study.

Diagnosis of diabetes mellitus

The diagnosis of overt diabetes was made according to the American Diabetes Association, when the glycosylated hemoglobin (HbA_{1c}) was $> 6.5\%$ or when the fasting plasma glucose level was > 7.0 mmol/L or the 2-hour plasma glucose level was > 11.1 mmol/L. Pregnant women were offered a fasting oral glucose tolerance test (oGTT) at 24–28 weeks gestation. GDM diagnosis was made when fasting blood glucose was ≥ 5.5 mmol/L or blood glucose was ≥ 7.8 mmol/L two hours after a 75-g carbohydrate (glucose) loading.

The initial evaluation involved obtaining a general, gynecological, and obstetric history. Next, the vital signs are measured, and

systemic, and ultrasound examinations performed in our high-risk pregnancy department. Demographic characteristics, pre-pregnancy body mass index (BMI), GWG, obstetric history, smoking status, gestational age at birth, route of delivery, pregnancy complications, neonatal weights, Apgar scores (1st and 5th minutes), and neonatal intensive care unit (NICU) admission ratios were recorded. Gestational ages were calculated according to the last menstrual period or first trimester measurement of crown-rump length. Pre-pregnancy BMI levels of all patients were calculated at first visit at 5–7th week of gestation. Gestational weight gain is the difference in weight from first visit to last visit before delivery. It was accepted that women with a BMI of 30 kg/m² or more were in the obese range.

Definition of adverse obstetric and neonatal outcomes

Pregnancies complicated with preeclampsia, gestational hypertension, preterm labor, preterm rupture of membranes (PROM), polyhydramnios, oligo/anhydramnios, intrauterine growth restriction (IUGR), stillbirth, abruptio placentae, placenta previa, intrahepatic cholestasis of pregnancy (ICP) were accepted as pregnancy complications. Preeclampsia was defined as elevated blood pressure (systolic \geq 140 mmHg or diastolic \geq 90 mmHg on at least 2 measurements with 4-hour intervals) plus proteinuria (\geq 300 mg/24 h) after 20 weeks of gestation. Preterm birth was accepted as any birth before 37 completed weeks of gestation. Polyhydramnios was defined as an amniotic fluid index (AFI) greater than 25 cm in the late second or third trimester whereas oligohydramnios was considered as AFI < 5 cm. The IUGR diagnosis was made in serial fetal biometrics, where measurements or estimated fetal weights were determined below the 10th percentile. Stillbirth was diagnosed as fetal death in utero after 20 weeks of gestation. The diagnosis of ICP was made by maternal itching having occurred during the second half of pregnancy without skin lesions and elevation of total fasting bile acid. With 12-hour dosing interval, 12 mg betamethasone was administered to all pregnant women at or below 34 weeks of gestation for fetal lung maturation. Macrosomia was defined as birth weight greater than 4000 g. Adverse neonatal outcomes were regarded as neonates who needed intensive care. The need for neonatal intensive care unit (NICU) was approved by a neonatologist.

Statistical analysis

Statistical analyses were performed with SPSS 11.5 software (SPSS Inc., Chicago, IL, USA). Normal distribution of data was assessed using the Shapiro-Wilk test. Variables were expressed as mean \pm standard deviation for continuous variables and frequencies for nominal variables. Intergroup differences were investigated using the Student t test for normally distributed variables and the Mann-Whitney U test for non normal distributions. Differences between categorical data were evaluated by using the χ^2 test. Receiver operator characteristics curve analysis was used to find the discriminative factors between the groups. Logistic regression method was used to evaluate the risk factors affecting pregnancy complications and NICU admission rates. The best predictors which discriminated groups from each other were determined by multiple logistic regression analysis, where applicable. Any vari-

able whose univariable test had a p value < 0.05 was accepted as a candidate for the multivariable model along with all variables of known clinical importance. Adjusted odds ratios, 95% confidence intervals were calculated for each variable. Two-sided p values were considered statistically significant at p < 0.05.

Results

Demographic data

Of the 1193 women with and without DM, 525 were diagnosed with GDM and 82 with pregestational diabetes (study group). There were 586 pregnant women in the nondiabetic group (control group). The mean age of women in DM group was significantly higher than in the controls (32.3 \pm 5.7 vs. 26.6 \pm 5.6 years, p < 0.001). Women in the study group had higher parity rates than the control subjects (p < 0.001). There was no statistical difference in smoking habits between the diabetic and nondiabetic groups (p = 0.222). The pre-pregnancy BMIs of women with GDM and DM were significantly higher than in the control group (27.7 \pm 5.0 vs. 23.3 \pm 3.8 kg/m², p < 0.001). Accordingly, the prevalence of obesity was higher in DM group than in the controls (29.5 vs. 5.8%, p < 0.001). However, GWGs were not statistically different between the diabetic and nondiabetic control groups (p = 0.132). Demographic and clinical characteristics of the patients were depicted in ► **Table 1**.

Gestational age at birth was significantly lower in the study group than in the controls (38.0 \pm 2.3 vs. 38.3 \pm 2.4 weeks, p < 0.001). Conversely, preterm birth rate was significantly lower in the diabetic group than in the controls (2 vs. 5.6%, p = 0.001), and mean birth weight of DM patients was statistically significantly higher compared to controls (3406 \pm 606 vs. 3130 \pm 521 g, p < 0.001). There was a meaningful difference in term of 1st minute Apgar scores between the groups, but 5th minute Apgar scores were similar in both groups (p < 0.001 and p = 0.348, respectively). Although labor induction was significantly more prevalent in the control group, cesarean delivery rates were significantly higher in the DM group when compared with the control group (both p < 0.001). Also, obese women had more cesarean delivery rates regardless of diabetes status than nonobese women (74.6 vs. 44.5%, p < 0.001). The number of macrosomic infants was significantly higher in GDM and DM women when compared to controls (p < 0.001). Similarly, obese women more frequently gave birth to a macrosomic infant (18.8 vs. 7.6%, p < 0.001).

Obstetric and neonatal outcomes

Pregnancy complications including preeclampsia, gestational hypertension, preterm labor, PROM, polyhydramnios, oligo/anhydramnios, IUGR, stillbirth, abruptio placentae, placenta previa, and ICP were similar among the two groups (p = 0.279). NICU admission rates were higher in those with GDM and DM than with the controls (17.1 vs. 9.7%, p < 0.001) (► **Table 2**). It was seen that the newborn intensive care indications are as follows; hyperbilirubinemia (10), hypoglycemia (15), polycythemia (14), respiratory distress (80), hypoglycemia plus polycythemia (1), low birth weight (27), fetal anomaly (3), extreme prematurity (2), and others (9). As to pregnancy complications and NICU admission

► **Table 1** Demographic and clinical characteristics of the patients.

	Diabetic group (n = 607)	Nondiabetic group (n = 586)	P value
Age (years)	32.3 ± 5.7	26.6 ± 5.6	< 0.001*
Body mass index (kg/m ²)	27.7 ± 5.0	23.3 ± 3.8	< 0.001**
Gestational weight gain (kg)	12.2 ± 6.3	12.6 ± 5.1	0.132**
Gravida	3.1 ± 1.8	2 ± 1.4	< 0.001**
Parity	1.5 ± 1.3	0.8 ± 1.0	< 0.001**
Gestational age at birth (weeks)	38.0 ± 2.3	38.3 ± 2.4	< 0.001**
Birth weight (g)	3406 ± 606	3130 ± 521	< 0.001*
Apgar score (1st min)	6.9 ± 0.9	6.9 ± 0.6	< 0.001**
Apgar score (5th min)	8.8 ± 1.2	8.9 ± 0.8	0.348**

* Student t test, ** Mann Whitney-U test. P < 0.05 is statistically significant.

► **Table 2** Comparison of the categorical variables between the groups.

	Diabetic group (n = 607)	Nondiabetic group (n = 586)	P value*
Maternal age (≥ 32 years)	363 (59.8)	133 (22.7)	< 0.001
Multiparity	460 (75.8)	316 (53.9)	< 0.001
Gestational weight gain (≥ 12 kg)	319 (52.6)	339 (57.8)	0.066
Smoker	46 (7.6)	56 (9.6)	0.222
Preterm birth (< 37 weeks)	12 (2.0)	33 (5.6)	0.001
Labor induction	139 (22.9)	257 (43.9)	< 0.001
Cesarean section	438 (72.3)	156 (26.6)	< 0.001
Macrosomia (≥ 4000 g)	89 (14.7)	25 (4.3)	< 0.001
NICU admission	104 (17.1)	57 (9.7)	< 0.001
Comorbidity	57 (9.4)	74 (12.6)	0.074
Obesity (≥ 30 kg/m ²)	179 (29.5)	34 (5.8)	< 0.001
Pregnancy complication	200 (32.9)	176 (30.0)	0.279

* χ^2 test. P < 0.05 is statistically significant.

rates in obese patients, the pregnancy complications (45.5 vs. 28.5%) and the need for NICU (18.3 vs. 12.4%) were higher in obese ones compared to controls.

Influence of obesity and diabetes on the outcomes

The receiver operator characteristics curve analysis showed that the best cut-off value of maternal age and gestational weight gain is 32 years and 11.5 kg for discriminating diabetic and nondiabetic patients. Multivariable logistic regression analysis revealed that obesity is the most significant risk factor for the occurrence of future pregnancy complications (OR = 1.772, 95% CI = 1.283–2.449, p = 0.001). According to the results, DM seems to have no effect on pregnancy complications (► **Table 3**). When we evaluated risk factors for NICU admission, obesity lost its significance for predicting NICU admission in multivariable analysis (OR = 1.068, 95% CI = 0.683–1.669, p = 0.773). However, DM was found to be an important parameter for adverse neonatal outcomes (OR = 1.706, 95% CI = 1.099–2.648, p = 0.017) (► **Table 4**).

On the other hand, it was shown that the only significant risk factor for both pregnancy complications and poor neonatal outcomes was the GWG (OR = 1.396 [95% CI = 1.085–1.795] and OR = 1.685 [95% CI = 1.176–2.415], respectively).

Discussion

This study investigated the influence of obesity and pregestational/gestational DM status on pregnancy complications and neonatal outcomes. We found that obesity and DM prevalence increased with age; obese women experienced DM more and the combination of obesity and DM increased cesarean delivery rates, macrosomic neonates, and NICU admission rates.

Obesity is a global problem, which includes pregnant women. The incidence of obesity has increased dramatically in recent years. One third of pregnant women are reported to be overweight or obese [10]. Recent studies have found that, in cases of the coexistence of DM with obesity, maternal and fetal risks are

► **Table 3** Risk factors for pregnancy complications among diabetic and nondiabetic patients.

	Univariate analysis		Multivariate analysis	
	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value
Gestational weight gain	1.465 (1.146–1.872)	0.002	1.396 (1.085–1.795)	0.009
Maternal age	1.551 (1.212–1.985)	<0.001	1.383 (1.063–1.800)	0.016
Diabetes	1.145 (0.896–1.462)	0.279	–	
Obesity	2.101 (1.551–2.845)	<0.001	1.772 (1.283–2.449)	0.001
Comorbidity	0.578 (0.303–0.752)	0.001	0.487 (0.307–0.773)	0.002
Smoking	1.894 (1.256–2.857)	0.002	1.847 (1.216–2.805)	0.004
Multiparity	1.007 (0.780–1.302)	0.956	–	

P < 0.05 is statistically significant.

► **Table 4** Risk factors for neonatal intensive care unit admission in diabetic and nondiabetic patients.

	Univariate analysis		Multivariate analysis	
	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value
Gestational weight gain	1.995 (1.423–2.798)	<0.001	1.685 (1.176–2.415)	0.004
Maternal age	1.595 (1.143–2.226)	0.006	1.289 (0.876–1.898)	0.198
Diabetes	1.919 (1.359–2.710)	<0.001	1.706 (1.099–2.648)	0.017
Obesity	1.576 (1.061–2.341)	0.023	1.068 (0.683–1.669)	0.773
Vaginal delivery	0.562 (0.400–0.791)	0.001	0.725 (0.468–1.121)	0.148
Macrosomia	1.138 (0.660–1.961)	0.642	–	
Comorbidity	0.557 (0.294–1.058)	0.070	–	
Labor induction	0.475 (0.317–0.711)	<0.001	0.663 (0.413–1.033)	0.069
Preterm birth	4.685 (2.516–8.724)	<0.001	5.206 (2.592–10.457)	<0.001
Pregnancy complication	5.809 (4.065–8.301)	<0.001	1.097 (1.065–1.129)	<0.001
Smoking	1.022 (0.566–1.843)	0.943	–	
Multiparity	0.863 (0.612–1.217)	0.401	–	

P < 0.05 is statistically significant.

increased [11]. In our study, obesity was more frequent among DM patients, and those patients with DM were older than the controls. These findings were similar with previous studies suggesting that obesity increases with age [12, 13].

Maternal hormones are antagonistic to insulin, therefore and insulin resistance state occurs during pregnancy. Three to five percent of pregnancies are complicated by DM. The prevalence of pregestational DM in the United Kingdom, including type 1 and type 2 DM, increased from 3.1 per 1000 births in 1996–1998 to 4.7 per 1000 births in 2002–2004 [13, 14]. Obesity is suspected to be one of the main factors of this increase. After delivery, 2–14% of obese women receive a type 2 DM diagnosis, and 3–35% of these have an impaired glucose tolerance [15]. Similarly, in our study, pre-pregnancy BMI values of diabetic women were significantly higher than in the controls.

Recommended optimal weight gain during pregnancy is 12.5–18 kg for underweight women (pre-pregnant BMI < 18.5), 11.5–16 kg for normal women (18.5 ≤ pre-pregnant BMI ≤ 24.9), 7–11.5 kg for overweight women (25 ≤ pre-pregnant BMI ≤ 29.9),

and 5–9 kg for obese women (pre-pregnant BMI ≥ 30) [16]. However, there are no recommendations on the optimal weight gain during pregnancy for women with GDM. According to our findings, although the obesity was more prevalent and mean BMIs were higher in DM patients than in controls, GWG was similar among the groups. This may be due to the effect of diet and lifestyle advice or interventions given to women with increased pre-pregnancy BMIs.

Pregnancy complications increased in the overweight/obese women; preterm labor is suspected as the reason for this increase. High pre-pregnancy BMI levels were found to be related with preterm deliveries and preterm infants large for gestational age (LGA) neonates [12, 17]. Although previous epidemiologic studies indicated that underweight mothers have a higher risk of having low-birth weight and SGA babies [18, 19], none of the previous meta-analyses considered underweight women in their analysis. In our study, we also did not consider underweight women. Unlike to these studies, we found that preterm delivery was lower in women with pregestational/gestational DM. This may be due to

the fact that normal/underweight women had smaller uteri and lower uterine blood flow, which may have caused the preterm births.

Cesarean delivery rates in diabetic women were 2.651-fold (95% CI = 2.311–3.042) higher than the controls in our study. Also, obese women had more cesarean delivery rates regardless of diabetes status than non-obese women (OR = 2.190, 95% CI = 1.727–2.776). Martin stated that obese women had increased cesarean delivery rates independent of their diabetes status [13]. Adipocytes are abundant in obese women, so they may cause inflammatory responses and the birth canal could be narrowed by pelvic soft tissue resulting in an increase in cesarean deliveries. Alternatively, increased macrosomic fetus rates also cause increased cesarean deliveries. Previous studies have suggested that overweight and obese women were more likely to give birth to macrosomia babies than women with normal BMI [20, 21]. Not only pre-pregnancy BMI but also GWG is suggested to cause macrosomia [22]. Similarly, in our study, neonatal birth weights were higher in the DM group than in controls. Also, obese women more frequently gave birth to a macrosomic infant. Although antenatal care has been shown to improve perinatal mortality, NICU admissions are still higher in diabetic women than in nondiabetics [12, 23]. Our findings were similar to the findings in the literature indicating that NICU admission rates were significantly higher in the DM group than in the controls. The incidence of shoulder dystocia, brachial plexus injury, or malpresentations was increased in macrosomic fetuses [24]. However, since cesarean rates in GDM/DM patients were high in our study population, these complications were rare for the statistical analysis.

Pregnancies complicated with DM are under the risk for some well known pregnancy complications such as preeclampsia, gestational hypertension [25], and polyhydramnios [26]. Preeclampsia incidence has also been found to be higher in diabetic pregnant females with vascular complications [27]. Polyhydramnios incidence is 1–2% in all pregnant women, however, in diabetic pregnant its incidence increases to 6–31%. Fetal hyperglycemia occurs due to maternal hyperglycemia, which then leads to fetal polyuria [26]. Although there is some disagreement on the relationship between obesity and the amnion fluid index, some stated that obesity accompanied with polyhydramnios increases GDM and macrosomia [24]. The hypertensive disorders of pregnancy (n = 136) and polyhydramnios (n = 75) were the two leading causes of pregnancy complications in our study population. Although there was no significant difference between the diabetic and nondiabetic groups in terms of overall pregnancy complications, preeclampsia, gestational hypertension and polyhydramnios were more frequent in the diabetic patients.

There are some limitations in this study. First, we did not separate DM group as pregestational DM and GDM. It is well known that pregestational DM is a more serious disease than GDM [28]. However, according to our records all of them were under the regular antenatal follow-up. Secondly, BMI was not categorized as underweight, normal, overweight, and obese. Since our study population was small, studies with a higher number of pregnant females who are further classified as underweight and obese are needed. A third limitation is the retrospective nature of the study, and another limitation is that our study was insufficient in analyzing

perinatal macrosomia complications that included shoulder dystocia and brachial plexus injuries. The reason for this was due to the higher rates of cesarean delivery in our center.

In conclusion, maternal obesity is more common among pregnant women with DM. Obesity seems to be associated with pregnancy complications whereas DM is related with increased rate of NICU admission in newborns. However, the main risk factor for both adverse pregnancy outcomes is the weight gaining during pregnancy. Clinicians and family doctors should consult women before pregnancy on the risks of obesity and GWG on pregnancy complications and neonatal outcomes. Also, during antenatal care, clinicians should pay more attention to GWGs and advise pregnant women on the appropriate calorie/protein intake to prevent fetal macrosomia. Public and private organizations should introduce adequate nutrient supplementation during adolescent and pre-pregnancy periods to prevent obesity, and to prevent child marriages in order to decrease maternal complications in low–middle income developing countries.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

- [1] Lu Y, Hajifathalian K, Ezzati M et al.; Global Burden of Metabolic Risk Factors for Chronic Diseases Collaboration (BMI Mediated Effects). Metabolic mediators of the effects of body-mass index, overweight, and obesity on coronary heart disease and stroke: a pooled analysis of 97 prospective cohorts with 1.8 million participants. *Lancet* 2014; 383: 970–983
- [2] Ng M, Fleming T, Robinson M et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014; 384: 766–781
- [3] Satman I, Omer B, Tutuncu Y et al. Twelve-year trends in the prevalence and risk factors of diabetes and prediabetes in Turkish adults. *Eur J Epidemiol* 2013; 28: 169–180
- [4] Chen Z, Du J, Shao L et al. Prepregnancy body mass index, gestational weight gain, and pregnancy outcomes in China. *Int J Gynaecol Obstet* 2010; 109: 41–44
- [5] Kumar A, Chaudhary K, Prasad S. Maternal indicators and obstetric outcome in the north Indian population: a hospital-based study. *J Postgrad Med* 2010; 56: 192–195
- [6] Çınar M, Timur H, Aksoy RT et al. Evaluation of maternal and perinatal outcomes among overweight women who experienced stillbirth. *J Matern Fetal Neonatal Med* 2017; 30: 38–42
- [7] O'Sullivan EP, Avalos G, O'Reilly M et al.; Atlantic DIP collaborators. Atlantic Diabetes in Pregnancy (DIP): the prevalence and outcomes of gestational diabetes mellitus using new diagnostic criteria. *Diabetologia* 2011; 54: 1670–1675
- [8] Liu X, Du J, Wang G et al. Effect of pre-pregnancy body mass index on adverse pregnancy outcome in north of China. *Arch Gynecol Obstet* 2011; 283: 65–70
- [9] Nohr EA, Vaeth M, Baker JL et al. Combined associations of prepregnancy body mass index and gestational weight gain with the outcome of pregnancy. *Am J Clin Nutr* 2008; 87: 1750–1759
- [10] Simas TA, Liao X, Garrison A et al. Impact of updated Institute of Medicine guidelines on prepregnancy body mass index categorization, gestational weight gain recommendations, and needed counseling. *J Womens Health (Larchmt)* 2011; 20: 837–844

- [11] Wildschut HJ. Chapter 2: Constitutional and environmental Factors leading to a high Risk Pregnancy. In: James DK, Steer PJ, Weiner CP, Gonik B, eds. *High Risk Pregnancy: Management Options*. 4th ed. Oxford: Elsevier Ltd.; 2011: 19–25
- [12] Sun D, Li F, Zhang Y et al. Associations of the pre-pregnancy BMI and gestational BMI gain with pregnancy outcomes in Chinese women with gestational diabetes mellitus. *Int J Clin Exp Med* 2014; 15: 5784–5789
- [13] Martin KE, Grivell RM, Yelland LN et al. The influence of maternal BMI and gestational diabetes on pregnancy outcome. *Diabetes Res Clin Pract* 2015; 108: 508–513
- [14] Bell R, Bailey K, Cresswell T et al. Trends in prevalence and outcomes of pregnancy in women with pre-existing type I and type II diabetes. *BJOG* 2008; 115: 445–452
- [15] Kim C, Tabaei BP, Burke R et al. Missed opportunities for type 2 diabetes mellitus screening among women with a history of gestational diabetes mellitus. *Am J Public Health* 2006; 96: 1643–1648
- [16] Blomberg M. Maternal and neonatal outcomes among obese women with weight gain below the new Institute of Medicine recommendations. *Obstet Gynecol* 2011; 117: 1065–1070
- [17] Khalak R, Cummings J, Dexter S. Maternal obesity: significance on the preterm neonate. *Int J Obes (Lond)* 2015; 39: 1433–1436
- [18] Saareepomcharenkul K. Correlation of BMI to pregnancy outcomes in Thai women delivered in Rajavithi Hospital. *J Med Assoc Thai* 2011; 94: 52–58
- [19] Hauger MS, Gibbons L, Vik T et al. Prepregnancy weight status and the risk of adverse pregnancy outcome. *Acta Obstet Gynecol Scand* 2008; 87: 953–959
- [20] Sebire NJ, Jolly M, Harris JP et al. Maternal obesity and pregnancy outcome: a study of 287 213 pregnancies in London. *Int J Obes Relat Metab Disord* 2001; 25: 1175–1182
- [21] Ducarne G, Rodrigues A, Aissaoui F et al. Pregnancy in obese patients: which risks is it necessary to fear? *Gynecol Obstet Fertil* 2007; 35: 19–24
- [22] Kabali C, Werler MM. Pre-pregnant body mass index, weight gain and the risk of delivering large babies among non-diabetic mothers. *Int J Gynaecol Obstet* 2007; 97: 100–104
- [23] Metzger BE, Couston DR. Summary and recommendations of the Fourth International Workshop-Conference on Gestational Diabetes Mellitus. *Diabetes Care* 1998; 21 (Suppl. 2): B161–B167
- [24] Robinson H, Tkatch S, Mayes DC et al. Is maternal obesity a predictor of shoulder dystocia? *Obstet Gynecol* 2003; 101: 24–27
- [25] Egger M, Smith GD, Schneider M et al. Bias in metaanalysis detected by a simple, graphical test. *BMJ* 1997; 315: 629–634
- [26] Cullen MT, Reece EA, Homko CJ et al. The changing presentations of diabetic ketoacidosis during pregnancy. *Am J Perinatol* 1996; 13: 449–451
- [27] Garner P. Type 1 diabetes mellitus and pregnancy. *Lancet* 1995; 346: 157–161
- [28] Ray JG, Vermeulen MJ, Shapiro JL et al. Maternal and neonatal outcomes in pregestational and gestational diabetes mellitus, and the influence of maternal obesity and weight gain: the DEPOSIT study. *Diabetes Endocrine Pregnancy Outcome Study in Toronto*. *QJM* 2001; 94: 347–356