IZVORNI ČLANAK
ORIGINAL PAPER

Gynaecol Perinatol 2015;24(3):99–105

School of Medicine, University of Zagreb;
Clinical Department of Gynecology and Obstetrics, Hospital Medical Center Zagreb,

BODY MASS INDEX AND PREGNANCY OUTCOME

Josip Đelmiš, Mato Pavić, Marina Ivanišević, Josip Juras, Mislav Herman, Slavko Orešković

Original scientific paper

Key words: pregnancy, body mass index, gestational weight gain, gestational diabetes, gestational hypertension, fetal macrosomia, cesarean section

Summary. According to the World Health Organization criteria, underweight, normal weight, overweight and obesity are defined by body mass index (BMI). Underweight, overweight and obesity in pregnancy increase the risk of unfavorable maternal and perinatal outcome. The aim of the study was to analyze the impact of maternal BMI before and during pregnancy, and the impact of gestational weight gain on the occurrence of maternal and neonatal morbidity. ***Subjects and methods.*** This retrospective study included 4646 pregnant women that underwent oral glucose tolerance test between 24th and 32nd week of gestation and gave birth to their children at Clinical Department of Gynecology and Obstetrics, Zagreb University Hospital Center during the 2013–2015 period. There were 176 (3.8%) underweight, 3054 (66%) normal weight, 949 (20.4%) overweight and 467 (10.1%) obese women. The following data were analyzed: maternal age, BMI, gestational weight gain, parity, prevalence of preeclampsia, method of delivery termination (cesarean section, vaginal delivery or vacuum extraction), and neonatal birth weight, ponderal index, fetal macrosomia, and Apgar index at 1 min and 5 min. Results were expressed as mean value and standard deviation. The SPSS ver. 17 statistical software was used on data analysis. The χ^2-test and ANOVA were calculated. Study parameters were compared between study groups and control group. The level of statistical significance was set at $p<0.05$. Relative risk (RR) and standard error (95% confidence interval, 95% CI) were calculated according to Altman. ***Results***. The prevalence of gestational diabetes was 18.5% and 20.5% in normal weight and underweight women, respectively, *versus* 30.5% and 39.2% in overweight and obese women, respectively. Manifest diabetes (diabetes in pregnancy or overt diabetes) was recorded in 0.8%, 0.6%, 1.3% and 3% of normal weight, underweight, overweight and obese women, respectively. RR for gestational diabetes was 1.64 (95% CI 1.4-1.8) in overweight women and 2.1 (95% CI 1.8-2.4) in obese women (P<0.001 both). The prevalence of gestational diabetes increased with BMI increase. Gestational hypertension developed in 1.7%, 2.8%, 7.4% and 25.7% of underweight, normal weight, overweight and obese women, respectively. RR for gestational hypertension was 2.6 (95% CI 1.9-3.6) in normal weight women *versus* 8.9 (95% CI 6.9-11.6) in obese women (P<0.001 both). The prevalence of gestational hypertension also increased with BMI increase. In comparison to normal weight women, the risk of macrosomia was greater in overweight women (RR=1.3; 95% CI 1.2-1.6; P<0.001) and obese women (RR=1.4; 95% CI 1.2-1.6; P<0.001). RR for cesarean section was increased in underweight (RR=1.9; 95% CI 1.4-2.6; P<0.001), overweight (RR=1.3; 95% CI 1.1.1.6; P<0.01) and obese women (RR=2.1; 95% CI 1.8-2.5; P<0.001). Out of 4646 women, gestational weight gain ≤8 kg was recorded in 348 (7.5%), 9–15 kg in 2836 (56.7%) and ≥16 kg in 1662 (35.8%) women. The prevalence of macrosomic infants was 10.6%, 12.6% and 22.6% in women with gestational weight gain ≤8 kg, 9–15 kg and ≥16 kg, respectively (RR=1.9; 95% CI 1.7-2.2; P<0.001). The prevalence of hypotrophic newborns was 11.9% in underweight, 3.0% in normal weight, 3.1% in overweight and 1.7% in obese women. ***Conclusion***. The risk of maternal and neonatal complications was increased in underweight, overweight and obese women, as well as in those with excess gestational weight gain.

Introduction

Almost every fourth woman of generative age is overweight or obese. According to the World Health Organization (WHO) criteria, obesity is defined by body mass index (BMI), calculated by the formula: BMI (kg/m^2) = body weight (kg)/body height (m^2). Body built in individuals with BMI <18.5 kg/m^2 is considered as underweight, BMI 18.5–24.9 kg/m^2 normal weight, BMI 25–29.9 kg/m^2 overweight, and BMI ≥30 kg/m^2 obesity. There are three degrees of obesity: BMI 30.0–34.9 (first degree); BMI 35–39.9 (second degree); and BMI ≥40 (third degree or extreme obesity). The advantage of BMI is ease of calculation, while its drawback is the inability to differentiate obesity and high muscle mass as the cause of high body weight. BMI correlates well with mortality, so that the risk of premature death is low in individuals with BMI 20–25 kg/m^2, but is high in those with BMI >25 kg/m^2, and in particular in those with BMI >30 kg/m^2.

The association of overweight with higher insulin resistance, gestational diabetes, diabetes mellitus type 2, hepatic dysfunction, cardiovascular disease and metabolic syndrome is well known.[1] Metabolic syndrome includes insulin resistance, obesity, dyslipidemia and hypertension. Pregnancy is a specific metabolic-endocrinologic condition. In pregnancy, virtually all the symptoms related to metabolic syndrome are worsened, e.g., increase in insulin resistance, BMI increase, and elevated concentrations of prothrombotic and proinflammatory factors. Elevated blood lipid level is a com-

mon finding in pregnant women. Insulin has an important role in the glucose and lipid metabolism. Lipid concentration increases with the progression of pregnancy. In obese pregnant women and pregnant women with gestational diabetes, elevation of blood lipid concentration is even more pronounced.[2]

Association of maternal obesity and fetal growth has long been recognized. As early as 1996, Brown *et al*. established correlation of pre-pregnancy waist and hip circumference with neonatal birth characteristics, calculated as follows: each 0.1 increase in this value increased neonatal birth weight by 120 g, birth length by 0.5 cm, and cranial circumference by 0.3 cm.[3] Association of pre-pregnancy obesity and pregnancy obesity with accelerated fetal growth has been demonstrated when used to estimate the occurrence of neonatal hypertrophy or macrosomia alike.

Association of preeclampsia and obesity has been demonstrated in a number of studies, yielding a two- to threefold greater risk.[4] It can in part be explained by the considerably higher proportion of pregnant women with chronic hypertension in the population of obese women of reproductive age (12% *vs*. 3%).[4] In their meta-analysis of 13 cohort studies, O'Brien *et al*. found each pre-pregnancy 0.6 kg/m^2 BMI increase to nearly double the risk of subsequent preeclampsia.[4] Weight loss or weight gain in-between pregnancies will reduce or increase the risk of hypertension in overweight and obese women.

The rate of cesarean section is on an increase in almost all studies of the effect of pre-pregnancy obesity on pregnancy outcome, with a relative risk slightly greater than two. Urgent cesarean section is generally described as a predominant component of the overall increase, unlike elective cesarean section where there is no significant difference. It is attributed to the more than twofold higher likelihood of breech presentation, threefold higher likelihood of intrapartum dystocia, expected accelerated fetal growth, and all other comorbidities accompanying pregnancy in obese women.

Fetal growth and development in obese women do not only determine perinatal factors but also entail long-term consequences. The higher prevalence of childhood and adolescence obesity in infants born to obese mothers as compared to those born to mothers with normal BMI is well known.[5]

The aim of the study was to assess the impact of pre-pregnancy BMI and gestational weight gain on the occurrence of maternal and neonatal morbidities.

Subjects and methods

This retrospective study included 4646 pregnant women that underwent 75 g oral glucose tolerance test (OGTT) according to IADPSG recommendation at Clinical Department of Gynecology and Obstetrics, Zagreb University Hospital Center between January 1, 2013 and December 31, 2015. Data on pregnancy and perinatal outcome were retrieved from medical records of women having given birth to their children at our Department. The diagnosis of gestational hyperglycemia was based on 75 g glucose OGTT, while IADPSG criteria were used to diagnose gestational diabetes. According to these criteria, at least one of the following glucose concentrations in maternal venous plasma should be equal or greater than the borderline value: fasting ≥5.1 mmol/L; at 1 h of 75 g OGTT ≥10 mmol/L; and at 2 h of 75 g OGTT ≥8.5 mmol/L. IADPSG criteria for overt diabetes (diabetes in pregnancy) are as follows: fasting plasma glucose ≥7 mmol/L; or after 75 g OGTT ≥11.1 mmol/L; or incidental blood glucose concentration ≥11.1 mmol/L. An incidental finding of blood glucose concentration ≥11.1 mmol/L (diabetes in pregnancy) is then confirmed by fasting blood glucose ≥7 mmol/L or HbA1c ≥6.5%.[6]

The US Institute of Medicine recommendations suggest gestational weight gain of 11–15 kg in normal weight women, 6–10 kg in overweight women and ≤7 kg in obese women.[7] Gestational weight gain is difference between pre-pregnancy weight and weight at the end of pregnancy. In our study, women were divided into three groups according to gestational weight gain, as follows: ≤8 kg, 9–15 and ≥16 kg.

The diagnosis of gestational hypertension was based on blood pressure elevation to ≥140/90 mm Hg after 20th week of gestation, without proteinuria or other symptoms of preeclampsia, while the diagnosis of preeclampsia was established upon blood pressure elevation ≥140/90 mm Hg after 20th week of gestation and proteinuria ≥0.3 g/L. Women with hypertension diagnosed before 20th week of gestation were considered as having chronic hypertension.

Statistics

The following parameters were analyzed: maternal age, BMI, gestational weight gain, parity, prevalence of gestational hypertension/preeclampsia, chronic hypertension, and method of delivery termination (cesarean section, vaginal delivery or vacuum extraction); neonatal birth weight, ponderal index, macrosomia, and Apgar score at 1 min and 5 min. Results were expressed as mean and standard deviation (SD). The SPSS ver. 17 statistical software was used on data analysis. The χ^2-test and ANOVA were calculated. Study parameters were compared between control group (normal pre-pregnancy body weight) and study groups (underweight, overweight and obese women). The level of statistical significance was set at $p<0.05$. Relative risk (RR) and standard error (95% confidence interval, 95% CI) were calculated according to Altman method.[8]

Results

The study included 4646 pregnant women with OGTT performed between 24th and 32nd week of gestation. The subjects were divided into groups according to BMI as follows: underweight 176 (3.8%), normal BMI 3054 (65.7%), overweight 949 (20.4%) and obese 467 (10.1%). The groups of underweight, overweight and

obese women were study groups compared with normal BMI women as a control group.

Underweight women were youngest of all study groups. Comparison of maternal age, method of delivery termination and body height in overweight and obese women *versus* control group showed no statistically significant difference. However, comparison of pre-pregnancy body weight, BMI and gestational weight gain yielded statistically significant differences in overweight and obese women *versus* control group. Body weight and BMI were statistically significantly higher, while gestational weight gain was statistically significantly lower in overweight and obese women as compared with control group *(Table 1)*.

The prevalence of gestational diabetes increased with BMI increase. The prevalence of gestational diabetes was 18.5%, 30.5% and 39.2% in the groups of normal weight, overweight and obese women, respectively. The prevalence of gestational diabetes was also higher in the group of underweight women as compared with control group (20.5% *vs*. 18.5%). Manifest diabetes was recorded in 0.8%, 1.3% and 3% of normal weight, overweight and obese women, respectively. The prevalence of gestational hypertension, chronic hypertension and preeclampsia increased with BMI increase *(Table 2)*.

The prevalence of gestational diabetes showed a statistically significant difference between control group and study groups *(Table 2)*. A higher prevalence of manifest diabetes was found in obese women as compared with control group (P<0.001). In comparison with control group, gestational hypertension and chronic hypertension were more common in the groups of overweight and obese women, while preeclampsia was more common only in obese women *(Table 2)*. There was no statistically significant difference in the prevalence of premature delivery between control group and study groups. In study groups, delivery was more frequently terminated by cesarean section as compared with control group, yielding a statistically significant difference *(Table 2)*.

Table 1. Demographic data of control group and study groups

	BMI <18.5 kg/m^2 (n=176)	BMI 18.5–24.9 kg/m^2 (n=3054)	BMI 25–29.9 kg/m^2 (n=949)	BMI >30 kg/m^2 (n=467)
Age (yrs)	29.0±5.5 P<0.001	30.6±4.9	31.2±5.1 P=0.02	30.7±4.9 NS
Body height (cm)	167.8±8.3 NS	168.4±6.2	167.4±6.4 NS	166.9±6.6 NS
Body weight (kg)	49.5±3.8 P<0.001	61.9±8.3	75.6±6.8 P=0.04	95.0±11.5 P<0.001
Gestational weight gain (kg)	15.8±5.5 NS	15.5±5.9	14.8±6.0 P<0.001	11.5±6.3 P<0.001
BMI (kg/cm^2)	17.5±0.9 P<0.001	21.8±1.6	27.0±1.4 P<0.001	34.1±3.6 P<0.001
Week of delivery	30.8±1.1 NS	39.7±1.0	39.6±1.2 NS	39.7±1.1 NS

BMI = body mass index; NS = nonsignificant

Table 2. Pre-pregnancy body mass index (BMI) and pregnancy complications

	BMI <18.5 kg/m^2 (n=176)	BMI 18.5–24.9 kg/m^2 (n=3054)	BMI 25–29.9 kg/m^2 (n=949)	BMI >30 kg/m^2 (n=467)	Ukupno (N=4646)
Gestational diabetes n (%)	36 (20.5%) P=0.02	565 (18.5%)	290 (30.5%) P<0.001	183 (39.2%) P<0.001	1074
Diabetes in pregnancy n (%)	1 (0.6%) NS	23 (0.75%)	12 (1.3%) NS	14 (3%) P<0.001	50
Preeclampsia n (%)	1 (0.6%) NS	10 (0.3%)	6 (0.6%) NS	13 (2.8%) P<0.001	30
Gestational hypertension n (%)	3 (1.7%) NS	85 (2.8%)	70 (7.4%) P<0.001	120 (25.7%) P<0.001	278
Chronic hypertension n (%)	0 (0%) NS	9 (0.3%)	9 (0.9%) P=0.02	10 (2.1%) P<0.0001	28
Premature delivery n (%)	1 (0.6%) NS	19 (0.6%)	8 (0.9%) NS	2 (0.5%) NS	30
Cesarean section n (%)	34 (19.3%) P<0.001	403 (13.1%)	166 (17.5%) P<0.001	129 (27.6%) P<0.001	732

χ^2-test; NS = nonsignificant

Table 3. Relative risk (RR) for pregnancy outcome in overweight women

	RR	95% CI	
Gestational diabetes	1.6356	1.4486–1.8466	p<0.0001
Diabetes in pregnancy	1.6790	0.8387–3.3614	p=0.1434
Gestational hypertension	2.5834	1.9054–3.5926	P<0.0001
Preeclampsia	1.9385	0.7065–5.3197	p=0.1968
Chronic hypertension	3.2308	1.28–8.1157	p=0.0126
Fetal macrosomia	1.3554	1.1795–1.5574	p<0.0001
Cesarean section	1.2822	1.2822	p=0.0032

Table 3 shows RR and 95% CI in the group of overweight women. Statistically significantly higher RR was obtained for the following variables: gestational diabetes (RR=1.6356; 95% CI 1.4486-1.8466); gestational hypertension (RR=2.5834; 95% CI 1.9054-3.5926); chronic hypertension (RR=3.2308; 95% CI 1.28-8.1157); macrosomia (RR=1.3554; 95% CI 1.1795-1.5574); and cesarean section (RR=1.2822; 95% CI 1.2822).

Table 4 shows RR and 95% CI in the group of obese women. Statistically significantly higher RR was obtained for the following variables: gestational diabetes (RR=2.0973; 95% CI 1.8320-2.4011); diabetes in pregnancy (RR=31.8584; 95% CI 20.6936-49.0486); gestational hypertension (RR=8.9634; 95% CI 6.9385-11.5792); preeclampsia (RR=8.5348; 95% CI 3.7641-19.3524); chronic hypertension (RR=7.2948; 95% CI 2.9797-17.8978); macrosomia (RR=1.4089; 95% CI 1.2045-1.6480); and cesarean section (RR=2.0248; 95% CI 1.7038-2.4062).

Table 4. Relative risk (RR) for pregnancy outcome in obese women

	RR	95% CI	
Gestational diabetes	2.0973	1.8320–2.4011	P<0.0001
Diabetes in pregnancy	31.8584	20.6936–49.0486	P<0.0001
Gestational hypertension	8.9634	6.9385–11.5792	P<0.0001
Preeclampsia	8.5348	3.7641–19.3524	P<0.0001
Chronic hypertension	7.2948	2.9797–17.8978	P<0.0001
Fetal macrosomia	1.4089	1.2045–1.6480	P<0.0001
Cesarean section	2.0248	1.7038–2.4062	P<0.0001

Neonatal birth weight increased with maternal BMI increase. Comparison of neonatal birth weight in control group with neonatal birth weight in overweight and obese women yielded a statistically significant difference. Ponderal index was higher only in neonates born to obese mothers as compared with control group (P=0.002). Apgar score at 1 min and 5 min was statistically significantly lower in neonates born to mothers from all study groups as compared with control group. The lowest prevalence of fetal macrosomia was recorded in the group of underweight women (7.4%) and the highest in the group of obese women (24.3%). The group of underweight women had the highest prevalence of hypotrophic newborns (11.8%) and preterm newborns (2.8%), which was statistically significantly higher in comparison with control group. There was no difference in the prevalence of 5-min Apgar score ≤7 between control group and study groups. Neonatal hypoglycemia was most common in the group of obese women *(Table 5)*.

Gestational weight gain ≤8 kg was recorded in 348 (7.5%), 9–15 kg in 2836 (56.7%) and ≥16 kg in 1661 (35.8%) women.

Table 5. Pre-pregnancy body mass index (BMI) and neonatal complications

	BMI <18.5 kg/m^2 (n=176)	BMI 18.5–24.9 kg/m^2 (n=3054)	BMI 25–29.9 kg/m^2 (n=949)	BMI >30 kg/m^2 (n=467)
Birth weight (g)	3237.4±453.3 NS	3054±450.5	3583±517.6 P<0.0001	3653.9±493.8 P=0.014
Ponderal index	2.6±0.2 NS	2.6±0.2	2.7±0.2 NS	2.8±0.2 P=0.002
Apgar at 1 min	9.8±0.8 P=0.001	9.9±0.6	9.8±0.7 P<0.001	9.8±0.8 P<0.0001
Apgar at 5 min	9.9±0.5 P=0.002	9.9±0.3	9.9±0.4 P=0.002	9.9±0.4 P<0.001
Neonatal complications				
Fetal macrosomia n (%)	13 (7.4%) P=0.0004	526 (17.2%)	222 (23.4%) P<0.0001	157 (24.3%) P<0.0001
Fetal hypotrophy n (%)	21 (11.9%) P=0.013	93 (3%)	29 (3.1%) NS	11 (1.7%) NS
Premature n (%)	5 (2.8%) P=0.0138	22 (0.7%)	10 (1.1%) NS	2 (0.3%) NS
Congenital malformations n (%)	2 (1.1%) NS	28 (0.9%) NS	10 (1.0%) NS	3 (0.5%) NS
Asphyxia Apgar score <7 at 5 min	0 (0%) NS	22 (0.7%)	10 (1.9%) NS	1 (0.2%) NS
Neonatal hypoglycemia n (%)	0 (0%) NS	3 (0.1%)	3 (0.3%) NS	6 (0.9%) P=0.0015

NS = nonsignificant

Table 6. Effect of gestational weight gain on the prevalence of fetal macrosomia and fetal hypotrophy

Gestational weight gain	Fetal hypotrophy	Fetal eutrophy	Fetal hypertrophy	Total
≤8 kg n=348	29 (8.3%)	277 (79.6%)	42 (12.1%)	348 (100%)
9–15 kg n=2836	98 (3.7%)	2092 (79.4%)	446 (16.9%)	2636 (100%)
≥16 kg n=1662	27 (1.6%)	1236 (74.4%)	399 (24.0%)	1662 (100%)

The prevalence of fetal hypertrophy increased and the prevalence of fetal hypotrophy decreased with gestational weight gain increase *(Table 6)*.

Discussion

The prevalence of obese pregnant women increases with the increasing rate of obesity in the general population. A study conducted by Kanagalingam *et al*. in 2005 showed the prevalence of obesity in Scotland to have

increased from 9.4% to 18.9% during a 12-year period.[9] Based on the WHO obesity categorization, 5% of pregnant women with second degree obesity and 2% of pregnant women with third degree (extreme) obesity were recorded in the United Kingdom.[10] In our study, there were 949 (20.4%) overweight women and 467 (10.1%) obese women out of 4646 pregnant women that underwent 75-g OGTT. Overweight and obesity in pregnancy are associated with an increased risk of adverse pregnancy outcome such as gestational diabetes, gestational hypertension/preeclampsia, fetal macrosomia and an increased rate of cesarean section. Underweight pregnant women are also at an increased risk of poor pregnancy outcome such as higher prevalence of hypotrophic newborns and an increased rate of delivery termination by cesarean section as compared with control group of normal weight women.

Elevated level of blood lipids in obese women leads to increased tissue fat deposits, increased inflammatory protein secretion and insulin resistance. Obesity is the most common risk factor for insulin resistance. In pregnancy, insulin sensitivity is reduced by 50%–60%. The prevalence of gestational diabetes is increased in pre-pregnancy overweight or obese women. The risk of gestational diabetes increases with BMI increase. Adipose tissue increase is an important factor contributing to insulin resistance, in particular visceral obesity. Obesity is considered as the major risk factor for metabolic syndrome development. It is found in 4.6% of women with BMI 18.5–25 kg/m^2 and in 60% of obese women. Therefore, it is no surprise that gestational diabetes is several fold more common in obstetric history of obese pregnant women. The expected incidence of gestational diabetes in obese pregnant women varies among various settings and exceeds 25% in those with BMI >35 kg/m^2. Each 1 kg/m^2 rise in BMI increases the rate of gestational diabetes by 0.92%; thus, in obese pregnant women, a twofold to fivefold greater prevalence of gestational diabetes recorded in the general population can certainly be expected irrespective of the particular setting specificities.[11] Considering the higher subsequent rates of diabetes mellitus type 2 in women with gestational diabetes and their association with obesity, the role of post-puerperium endocrinologic work-up in these women is of utmost importance. Weight loss and healthy lifestyle help prevent diabetes mellitus type 2 development and reduce the prevalence of gestational diabetes. However, increased gestational weight gain results in an increased prevalence of gestational diabetes in obese women. According to the IADPSG criteria, gestational diabetes occurs in about 15% of women from general population and is considerably more common in overweight and obese pregnant women. In a meta-analysis of 20 studies, the risk of gestational diabetes is fourfold to fivefold greater in these women.[12] For example, odds ratio for developing gestational diabetes is 1.97 for overweight women, 3.01 for obese women, and 5.55 for extremely obese women.[11] In their prospective study, El-Gilany and Hammad[13] found the risk of gestational diabetes to be increased in overweight (RR=4.4; 95% CI 1.2-16.3) and obese women (RR=8.6; 95% CI 2.6-28.8); their figures are several fold higher as compared with our findings (RR=1.6; 95% CI 1.45-1.85 for overweight women and RR=2.1; 95% CI 1.8-2.4).

Gestational hypertension and preeclampsia occur in about 7% of women from general population and are important causes of unfavorable pregnancy outcome. Epidemiological studies point to the association of a higher risk of gestational hypertension/preeclampsia and maternal obesity.[14,15] Comparison of the prevalence of gestational hypertension and preeclampsia in overweight and obese women revealed a higher risk in these groups of women (RR=4.9; 95% CI 1.6-11.1 and RR=6.1; 95% CI 2.1-17.8, respectively).[13] In our study, an increased risk of gestational hypertension, preeclampsia and chronic hypertension was recorded in the groups of overweight women (RR=2.6; 95% CI 1.90-3.59; RR=1.9; 95% CI 0.71-5.32; and RR=3.23; 95% CI 1.28-8.116, respectively) and obese women (RR= 8.96; 95% CI 6.94-11.58; RR=8.53; 95% CI 3.76-19.35; and RR=7.29; 95% CI 2.98-17.89, respectively).

Neonatal birth weight increases with maternal BMI increase. Comparison of neonatal birth weight between control group and study groups of overweight and obese women yielded a statistically significant difference. In comparison with control group, ponderal index was higher only in the neonates born to obese mothers (P=0.002). Studies have demonstrated that obesity and the above mentioned disorders are independent variables of accelerated fetal growth with a potentiated synergistic effect, whereas the pre-pregnancy waist to hip ratio is the major primary factor for both fetal hypertrophy and macrosomia. The factor of correlation between pre-pregnancy BMI and neonatal birth weight is 0.20, while the likelihood of macrosomia (birth weight >4500 g) increases with the degree of obesity, as follows: RR 2.0 (95% CI 1.4-3.0) with BMI >30 kg/m^2 and RR=2.4 (95% CI 1.5-3.8) with BMI >35 kg/m^2.[16] Although increased pre-pregnancy peripheral insulin resistance and/or gestational diabetes are more common in obese women, still more than 80% of them have normal glucose metabolism.

Overweight and obesity result in an increased rate of cesarean section, as well as of pregnancy complications such as bleeding and infections.[17] In most countries, the number of cesarean section is additionally on an increase due to conservative clinical practice and potential legal suits.[18]

The association of maternal obesity and an increased rate of cesarean section have been demonstrated in many studies.[14,19,20] Our study results also yielded a higher rate of cesarean section in study groups as compared with control group. In the group of underweight women, the rate of cesarean section was 19.3%, which was statistically significantly higher as compared with control group (13.1%). In the groups of overweight and obese women, the rate of cesarean section was 17.5%

and 27.6%, respectively, yielding a statistically significant difference from the figure recorded in control group. A meta-analysis from 2007 investigated the association of obesity and cesarean section. The risk of cesarean section was increased in obese women (RR=2.05; 95% CI 1.86-2.27) and extremely obese women (RR=2.89; 95% CI 2.28-3.79).[12] Another meta-analysis found a twofold greater rate of cesarean section in obese women as compared with normal weight women.[18] In their meta-analysis, Poobalan *et al*., report on a higher risk of cesarean section in obese women (RR=2.26; 95% CI 2.04-2.51) and morbidly obese women (RR=3.38; 95% CI 2.49-4.57) as compared with normal weight women (21). In our study, RR for cesarean section was 2.024 (95% CI 1.704-2.406), which is consistent with previous studies.

It is estimated that a 1% reduction in the number of obese pregnant women would decrease the number of cesarean sections by 160,000 in the USA.

Conclusion

Underweight women, as well as overweight and obese women and those with excessive gestational weight gain are at an increased risk of maternal and neonatal complications.

References

1. Ferrada C, Molina M, Cid L. Relationship between gestational diabetes and metabolic syndrome. Rev Med Child. 2007; 135(12):1539–45.

2. Catalano PM, Nizielski SE, Shao J, Preston L, Qiao L, Friedman JE. Downregulated IRS-1 and PPARgamma in obese women with gestational diabetes: relationship to FFA during pregnancy. Am J Physiol Endocrinol Metab. 2002;282:E522–E533.114.

3. Brown JE, Potter JD, Jacobs DR Jr, Kopher RA, Rourke MJ, Barosso GM, Hannan PJ, Schmid LA. Maternal waist-to-hip ratio as a predictor of newborn size: results of the Diana Project. Epidemiology. 1996;7:62–6.

4. O'Brien TE, Ray JG, Chan WS. Maternal body mass index and the risk of preeclampsia: a systematic overview. Epidemiology. 2003;14:368–74.

5. Boney CM, Verma A, Tucker R, Vohr BR. Metabolic syndrome in childhood: association with birth weight, maternal obesity, and gestational diabetes mellitus. Pediatrics 2005;115: 290–6.

6. International Association of Diabetes and Pregnancy Study Groups Consensus Panel. International Association of Diabetes and Pregnancy Study Groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. Diabetes Care. 2010;33(3):676–82.

7. Rasmussen KM, Catalano PM, Yaktine AL. New guidelines for weight gain during pregnancy: what obstetrician/gynecologists should know. Curr Opin Obstet Gynecol. 2009 Dec; 21(6):521–6.

8. Altman DG. Practical statistics for medical research. London: Chapman and Hall, 1991.

9. Kanagalingam MG, Forouhi NG, Greer IA, Sattar N. Changes in booking body mass index over a decade: retrospective analysis from a Glasgow Maternity Hospital. BJOG. 2005;112:1431–3.

10. Centre for Maternal and Child Enquiries (CMACE). Maternal obesity in the UK: findings from a national project. London: CMACE, 2010.

11. Torloni MR, Betran AP, Horta BL, *et al*. Prepregnancy BMI and the risk of gestational diabetes: a systematic review of the literature with meta-analysis. Obes Rev. 2009;10:194–203.

12. Chu SY, Schmid CH, Dietz PM, Callaghan WM, Lau J, Curtis KM. Maternal obesity and risk of cesarean delivery: a meta-analysis. Obes Rev. 2007;8:385–94.

13. El-Gilany AH, Hammad S. Body mass index and obstetric outcomes in Saudi Arabia: a prospective cohort study. Ann Saudi Med. 2010;30(5):376–80. doi: 10.4103/0256-4947.67075

14. Weiss JL, Malone FD, Emig D, Ball RH, Nyberg DA, Comstock CH, *et al*. Obesity, obstetric complications and cesarean delivery rate – a population-based screening study. Am J Obstet Gynecol. 2004;190:1091–7.

15. Abenheim HA, Kinch RA, Morin L, Benjamin A, Usher R. Effect of prepregnancy body mass index categories on obstetrical and neonatal outcomes. Arch Gynecol Obstet. 2007;275: 39–43.

16. Oken E. Excess gestational weight gain amplifies risks among obese mothers. Epidemiology. 2009;20:82–3.

17. Yu CKH, Teoh TG, Robinson S. Obesity in pregnancy. BJOG. 2006;113:1117–25.

18. MacDorman MF, Menacker F, Declercq E. Cesarean birth in the United States: epidemiology, trends, and outcomes. Clin Perinatol. 2008;35:293–307.

19. Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. Obstet Gynecol 2004;103:219–24.

20. Rode L, Nilas L, Wojdemann K, Tabor A. Obesity-related complications in Danish single cephalic term pregnancies. Obstet Gynecol 2005;105:537–42.

21. Poobalan AS, Aucott LS, Gurung T, Smith WCS, Bhattacharya S. Obesity as an independent risk factor for elective and emergency caesarean delivery in nulliparous women – systematic review and meta-analysis of cohort studies. Obes Rev. 2009;10:28–35.

Address for corespondence: Prof. dr. sc. Josip Đelmiš, Nova cesta 124, 10000 Zagreb; *e-mail:* josip.djelmis@zg.t-com.hr

Paper received: February 1st 2016

Paper accepted: March 4th 2016

Medicinski fakultet Sveučilišta u Zagrebu,
Klinika za ženske bolesti i porode KBC-a Zagreb

INDEKS TJELESNE MASE I ISHOD TRUDNOĆE

Josip Đelmiš, Mato Pavić, Marina Ivanišević, Josip Juras, Mislav Herman and Slavko Orešković

Izvorni znanstveni članak

Ključne riječi: trudnoća, indeks tjelesne mase, prirast tjelesne težine u trudnoći, gestacijski dijabetes, gestacijska hipertenzija, fetalna makrosomija, carski rez

Sažetak. Prema kriterijima Svjetske zdravstvene organizacije mršavost, normalna, prekomjerna tjelesna težina i pretilost su definirani prema indeksu tjelesne mase. Mršavost, prekomjerna tjelesna težina i pretilost u trudnoći povećavaju rizik za lošiji majčin i perinatalni ishod. Cilj istraživanja je bio analizirati utjecaj indeksa tjelesne mase kod žena prije i za vrijeme trudnoće i prirasta težine tijekom trudnoće na pojavu majčinog i neonatalnog pobola. ***Ispitanice i metode istraživanja***. Istraživanje je bilo retrospektivno. Ukupno je analizirano 4646 trudnica u kojih je oralni test tolerancije glukoze učinjen između 24. i 32. tjedna trudnoće, a koje su rodile u razdoblju od 2013. do 2015. godine u Klinici za ženske bolesti i porođaje, KBC Zagreb. U skupini mršavih je bilo 176 (3,8%) trudnica, u skupini s normalnom težinom je bilo 3054 (66%) trudnica, u skupini s prekomjernom tjelesnom težinom je bilo 949 (20,4%) trudnica, a u skupini pretilih je bilo 467 (10,1%) trudnica. Analizirani su sljedeći podaci: dob trudnica, indeks tjelesne mase trudnica, prirast težine trudnica, paritet, učestalost preeklampsije, način dovršenja trudnoće (carski rez, vaginalni porođaj, vakuum ekstrakcija), novorođenačka težina, ponderalni indeks, fetalna makrosomija, Apgar indeksi u 1. i 5. minuti. Prikazane su srednje vrijednosti i standardne devijacije. U analizi podataka korišten je statistički program SPSS ver. 17. Izračunati su c^2-test, i ANOVA. Istraživani podaci su uspoređivani između kontrolne skupine i istraživanih skupina. Vrijednost $p<0,05$ se smatrala značajnom. Relativni rizik (RR) i njegova standardna greška 95% CI se računala prema Altmanu. ***Rezultati***. U skupini trudnica s normalnom tjelesnom težinom i mršavih učestalost gestacijskog dijabetesa je bila 18,5% odnosno 20,5%, dok je u skupinama trudnica s prekomjernom tjelesnom težinom i pretilih trudnica učestalost gestacijskog dijabetesa bila 30,5% odnosno 39,2%. Manifestni dijabetes (*diabetes in pregnancy* ili *overt diabetes*) se javlja kod 0,8% trudnica s normalnom tjelesnom težinom i 0,5% mršavih trudnica, 1,2% trudnica s prekomjernom tjelesnom težinom te 3% pretilih trudnica. Relativni rizik za gestacijski dijabetes u trudnica s prekomjernom težinom je 1,64 (95% CI 1,45-1,85; P<0,001), a u pretilih trudnica 2,1 (95% CI 1,8-2,40; P<0,001). S povećanjem indeksa tjelesne mase povećava se učestalost gestacijskog dijabetesa. Gestacijska hipertenzija se javlja u 1,7% mršavih trudnica, 2,8% trudnica s normalnom tjelesnom težinom, 7,4% trudnica s prekomjernom tjelesnom težinom i 25,7% pretilih trudnica. Relativni rizik za gestacijsku hipertenziju trudnica s normalnom težinom iznosi 2,6 (95% CI 1,9-3,6 ; P<0,001), a za skupinu pretilih trudnica 8,9 (95% CI 6,9-11,57 (P<0,001). I učestalost gestacijske hipertenzije se povećava s povećanjem indeksa tjelesne mase. U usporedbi s trudnicama normalne tjelesne težine, veći rizik za makrosomiju imaju trudnice s prekomjernom tjelesnom težinom (RR=1,4; 95% CI 1,18-1,6; P<0,001) i pretile trudnice (RR= 1,4; 95% CI 1,2-1,7; P<0,001). Povećan je i rizik za veću učestalost carskog reza: 1,9 (95% CI 1,4-2,6; P<0,001) za mršave trudnice, 1,3 (95% CI 1,1-1,6; P<0,01) za trudnice s prekomjernom težinom, a i za skupinu pretilih trudnica (RR=2,1; 95% CI 1,8-2,; P<0,001). Od ukupno 4646 trudnica, 348 (7,5%) je imalo prirast tjelesne težine do 8 kg, 2836 (56,7%) je imalo prirast tjelesne težine između 9–15 kg, a 1662 (35,8%) je imalo prirast težine ≥16 kg. Učestalost rađanja makrosomne djece u skupini trudnica koje su dobile na težini do 8 kg iznosi 10,6%. U skupini trudnica koje su imale prirast težine između 9–15 kg učestalost rađanja makrosomne djece iznosi 12,6%, a u skupini trudnica koje su imale prirast tjelesne težine ≥16 kg učestalost rađanja makrosomne djece iznosi 22,6% (RR=1,9; 95% CI 1,7-2,2; P<0,001). Učestalost rađanja hipotrofične novorođenčadi iznosi 11,9% kod mršavih trudnica, 3% kod trudnica normalne tjelesne težine, 3,1% kod trudnica s prekomjernom tjelesnom težinom te 1,7% kod pretilih trudnica. ***Zaključak***. Mršave trudnice kao i trudnice s prekomjernom tjelesnom težinom i pretile te one koje su imale prekomjeran prirast težine tijekom trudnoće imaju povišen rizik za majčine i neonatalne komplikacije.