THE RELATIONSHIP BETWEEN MATERNAL BODY MASS INDEX AND OFFSPRING BIRTH WEIGHT

Elizabeta Zisovska
University Clinic for Gynecology and Obstetrics, Skopje, Republic of Macedonia, University "GoceDelcev" Stip elizabeta.zisovska@ugd.edu.mk
Svetlana Jovevska
University "GoceDelcev" Stip

Abstract: Increasing prevalence of obesity is presenting a critical challenge to healthcare services, and particularly in obstetrics, influencing the perinatal outcome. On the other hand, malnutrition also increases the risk of bad perinatal outcome. Body mass index (BMI) is a measure of body fat based on height and weight that applies to adult men and women and is used as objective parameter for measuring the nutritional status of the pregnant women before the entire pregnancy. The Institute of Medicine classified body mass index (BMI) as underweight (BMI <18.5 kg/m^2), normal (BMI = 18.5–24.9 kg/m^2), overweight (BMI = 25.0–29.9 kg/m^2), and obese (BMI ≧30 kg/m^2), and then published recommended guidelines for gestational weight gain according to these BMI categories. The goal of this retrospective cohort study was to determine the influence of the pre-pregnancy Body mass index on the outcome of the delivery of the newborn. The objectives were to determine the relationship between the pre-pregnancy Body Mass Index and some perinatal outcomes as mode of delivery and neonatal birth weight describes as appropriate, large or small for gestational age newborns. Data were extracted from the perinatal database of the University Clinic for Gynecology and Obstetrics in Skopje, Republic of Macedonia for 2017. Exclusion criteria were pregnant women with all types of diseases except obesity, focusing on normal pregnancies and pre-pregnancy BMI. The total group of investigated delivering women comprised of 4106 patients. The data were extracted from the patients' histories on successive deliveries occurring at gestational week 22 or later. During the investigation, the delivering women were divided in four groups stratified by pre-pregnancy BMI category. The groups comprised 634 underweight women, 2412 normal weight women, 936 overweight and, 124 obese women. The main outcomes were: small for gestational age (SGA), large for gestational age (LGA), preterm birth, post-term birth and cesarean delivery; the incidence of these outcomes was compared among the groups and analyzed. The higher the pre-pregnancy BMI, the higher the incidences of cesarean delivery, and post-term birth, but the lower the incidence of small for gestational age (SGA). Of 4106 pregnancies, the pre-pregnancy underweight group accounted for 15.4 % (n = 634), the pre-pregnancy normal weight group for 58.8% (n = 2412), the pre-pregnancy overweight group for 22.8% (n = 936), and the pre-pregnancy obese group for 3% (n = 124). The maternal characteristics according to the BMI categories showed that the primiparous rate was significantly higher in underweight and normal women (67%, 62%), compared to overweight and obese women (53% and 45%), respectively $p < 0.005$). The results showed that the incidences of SGA, LGA, preterm birth, cesarean delivery, and post-term birth differ according to the BMI category. As the pre-pregnancy BMI increased, the incidence significantly increased for LGA, cesarean delivery, and post-term birth ($p < 0.001$). On the other hand, the incidence of SGA significantly decreased with increasing pre-pregnancy BMI ($p < 0.001$). The findings raise the awareness of weight control and add value to the recommendations to shift the research focus towards effective public health measures that prevent obesity in women of reproductive age.
Keywords: Body mass index, pregnancy, newborn, outcome

INTRODUCTION

Increasing prevalence of obesity is presenting a critical challenge to healthcare services, and particularly in obstetrics, influencing the perinatal outcome. On the other hand, malnutrition also increases the risk of bad perinatal outcome [1].

Actually, what does it mean obesity and malnutrition in pregnancy?

Body mass index, calculated by the body weight and height of the women is used as objective parameter for measuring the nutritional status of the pregnant women before the entire pregnancy. Body mass index (BMI) is a measure of body fat based on height and weight that applies to adults.The **body mass index** (**BMI**) or **Quetelet index** is a value derived from the mass (weight) and height of an individual, and is defined as the body mass divided by the square of the body height, and is universally expressed in units of kg/m^2, resulting from mass in kilogramsand height in metres [2].

The BMI may also be determined using a tableor chart which displays BMI as a function of mass and height using contour lines or colours for different BMI categories, and which may use other units of measurement (converted to metric units for the calculation).

The BMI is an attempt to quantify the amount of tissue mass (muscle, fat, and bone) in an individual, and then categorize that person as underweight, normal weight, overweight, or obese based on that value. However, there is some debate about where on the BMI scale the dividing lines between categories should be placed.[2] Commonly accepted BMI ranges are those recommended by the World Health Organization (WHO) and confirmed by the Institute of Medicines in 2009 [3], as follows:

- BMI lies under 18.5 kg/m^{2}and suggests underweight person:
- BMI in the range of 18.5 to 25kg/m^2 indicatesnormal (optimal) weight:
- BMI 25 to 30kg/m^2 may indicate overweight person;
- BMI is over 30kg/m^2 suggests an obese person.

BMI provides a simple numeric measure allowing health professionals to discuss weight problems more objectively with their patients. BMI was designed to be used as a simple means of classifying average sedentary (physically inactive) populations, with an average body composition [4][5].
These ranges of BMI values are valid only as statistical categories.
The BMI ranges are based on the relationship between body weight and disease and death. Overweight and obese individuals are at an increased risk for the following diseases:coronary artery disease, dyslipidemia, diabetes type 2 diabetes, gallbladder disease, hypertension, osteoarthritis, sleep apnea, stroke [6], at least 10 cancers, including endometrial, breast, and colon cancer and epidural lipomatosis.
One of the most concerned persons about the weight and BMI are pregnant women, due to the increased risks whenever weight is not in the normal range. Even the weight gain through the pregnancy is one of the most relevant parameters assessing the health and weight state during this period. Abnormal BMI also increases the risk for pregnancy outcome, both for the mother and for the baby [7]. Therefore, there are many published recommended guidelines for gestational weight gain according to these BMI categories [3].

AIM OF THE STUDY

The goal of this study was to determine the influence of the pre-pregnancy Body mass index (BMI) on the outcome of the birth of the newborn.
The **objectives** were:

1. To determine the relationship between the pre-pregnancy Body Mass Index and the neonatal birth weight;
2. To present few outcomes in relationship with the pre-pregnancy Body mass index of the mother (maternal: mode of delivery) and neonatal (gestational age and trophic state of the baby)

MATERIAL AND METHODS

A retrospective cohort study was undertaken to assess the relationship between maternal pre-pregnancy body mass index (BMI) and neonatal birth weight, duration of pregnancy as well as the mode of delivery. Data were extracted from the perinatal database of the University Clinic for Gynecology and Obstetrics in Skopje, Republic of Macedonia.
A study was conducted in all successively delivered women and their singletons during 2017 at the University Clinic for Gynecology and Obstetrics in Skopje, Republic of Macedonia. Excluding criteria for the study were multiple births and pregnant women with all types of diseases but obesity, focusing on normal pregnancies and pre-pregnancy BMI. The total group of investigated delivering women comprised of 4106 patients. The Clinic is a teaching maternity hospital and in regard of this, majority high risk pregnancies are transferred *in utero* from all around the country.
Considering the fact that the patient records were anonymized and de-identified prior to analysis and the present study was a retrospective investigation of women with singleton pregnancies, no ethical approval was necessary by the committee. The data were extracted from the patients' histories on successive deliveries occurring at gestational week 22 or later.
The main outcomes investigated were:

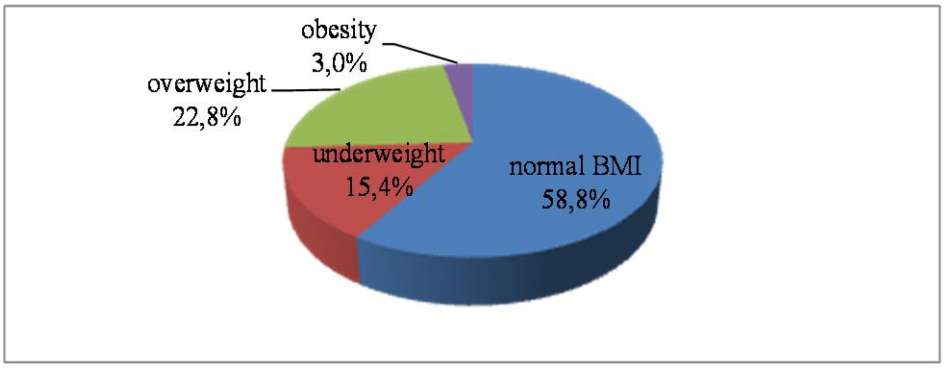
- mode of delivery (vaginal spontaneous or by use of vaginal operative interventions and cesarean delivery rate);
- mean birth weight of the newborns according to the pre-defined groups of mothers;
- proportion of appropriate for gestational age (AGA), defined as a neonatal birthweight between 10th and 90thpercentile of the reference curves of birthweight for gestational age;
- proportion of small for gestational age (SGA), defined as a neonatal birthweight below the 10thpercentile of the reference curves of birthweight for gestational age;
- proportion of the large for gestational age (LGA), defined as a neonatal birth weight above the 90thpercentile of the reference curves of birth weight for gestational age;
- preterm birth rate (preterm delivery defined as delivery before the beginning of the 37th gestational week;
- post-term birth rate (defined as a delivery at ≥42 and 0/7ths weeks of gestation).

The incidence of these outcomes was compared among the groups and analyzed.

During the investigation, the delivering women were divided in four groups stratified by pre-pregnancy BMI category according to the 2009 criteria recommended by the Institute of Medicine (IOM) and pre-existing identical WHO classification.

The group comprised 634 underweight women with BMI <18.5;2412 normal weight women with BMI 18.5–24.9; overweight women with BMI 25–29.9 were 936, and,124 obese women with BMI ≥30. The distribution of the subgroups is presented on Figure 1.

Figure 1. Distribution of the pregnant women according to their pre-pregnancy BMI



Of 4106 pregnancies, the pre-pregnancy underweight group accounted for 15.4 % (n = 634), the pre-pregnancy normal weight group for 58.8% (n = 2412), the pre-pregnancy overweight group for 22.8% (n = 936), and the pre-pregnancy obese group for 3% (n = 124).

Women with concomitant hypertension or diabetes as the underlying disease, with a history of cervical conization, who have increased risk for premature delivery, or whose data were unknown, were excluded.

The **BMI** was calculated based on the anamnestic data in the patient history.

The **birth weight** was measured by sensitive newborn scale with a resolution of 0.10 grams.

Gestational age was determined based onmorphologic criteria for assessment after the birth.

Mode of delivery: spontaneous delivery was considered birth through the vaginal canal, regardless of use of vaginal operative interventions as vacuum extractor or forceps; and caesarean section was determined extraction of the fetus through abdominal wall (abdominal operative delivery).

Data were expressed as means ± standard deviation or frequencies (percentages). SPSS Statistics software version 23 was used for the statistical analyses. A p value of <0.05 was considered statistically significant.

RESULTS

The maternal characteristics recorded were age, primiparous rate, and pre-pregnancy BMI. Data for all four subgroups are presented in Table 1.

Table 1. Comparison of maternal characteristics between pre-pregnancy underweight, normal weight, overweight and obese women

Pre-pregnancy weight	Normal weight **BMI=18.5-24.9 n=2412**	Underweight **BMI<18.5 n=634**	Overweight **25<BMI<30 n=936**	Obese **BMI ≥30 n=124**	p value
Maternal age (SD)	29.08 (4.9)	27.95(4.5)	30.06 (5.1)	31.25 (5.0)	<0.05
Proportion of first pregnancy (%)	1640 (68)	424 (67)	589 (63)	73 (59)	>0.05
Mean pre-pregnancy BMI (SD)	22.1 (2.2)	16.9 (1.4)	28.1 (1.4)	31.3 (2.5)	<0.005

BMI Body mass index in kg/m^2

Data are presented as mean ± SD (standard deviation) or n (%) unless otherwise specified

p-values represent the overall differences among the four subgroups that were evaluated

It is obvious that the primiparity between the groups has not statistical significance. On the other hand, older pregnant women had higher BMI within the investigated group. And, understandably, the mean BMI among the disaggregated groups had high statistical significance.

Table 2 summarizes the maternal pregnancy outcomes in relationship to pre-pregnancy BMI (by BMI category).

Table 2.Maternal pregnancy outcomes in relationship to pre-pregnancy BMI

Pre-pregnancy weight	Normal weight **BMI=18.5-24.9** **n=2412**	Underweight **BMI<18.5** **n=634**	Overweight **25<BMI<30** **n=936**	Obese **BMI ≥30** **n=124**	p value
Caesarean section (%)	24.2	27.5	28.5	35.9	<0.005
Spontaneous delivery (%)	75.7	72.3	71.2	63.6	<0.05
Vaginal operative birth (%)	0.1	0.2	0.3	0.3	<0.05
Preterm birth proportion(%)	119 (4.9)	32 (5.04)	71 (7.6)	9 (7.2)	<0.01
Postterm birth proportion (%)	32 (1.3)	6 (0.95)	9 (0.96)	1 (0.8)	>0.05

BMI Body mass index in kg/m^2
Data are mean ± SD (standard deviation) or n (%) unless otherwise specified
p-values represents the overall differences among the four subgroups that were evaluated
The higher the pre-pregnancy BMI, the higher the percentage of cesarean deliveries, vaginal operative interventions applied, and preterm birth proportion, and accordingly, the lower proportion of vaginal spontaneous deliveries. The proportion of preterm births was significantly higher, and without statistical significance was the proportion of the post-term deliveries.

Table 3.Neonatal birth outcomes in relationship to pre-pregnancy BMI

Pre-pregnancy weight	Normal weight **BMI=18.5-24.9** **n=2412**	Underweight **BMI<18.5** **n=634**	Overweight **25<BMI<30** **n=936**	Obese **BMI ≥30** **n=124**	p value
Mean birth weight (SD)	3050 (396)	2490 (525)	3302 (492)	3574 (426)	>0.05
AGA (%)	2215 (91.8)	538 (84.9)	813 (86.9)	96 (77.5)	<0.05
SGA (%)	123 (5.1)	82 (12.9)	63 (6.7)	17 (13.7)	<0.001
LGA (%)	74 (3.1)	14 (2.2)	60 (6.4)	11 (8.8)	<0.01
Gestational age at birth(SD)	37.2 (2.2)	35.9 (1.3)	35.5 (1.9)	34.7 (1.5)	<0.05

BMI Body mass index in kg/m^2
Data are mean ± SD (standard deviation) or n (%) unless otherwise specified
p-values represents the overall differences among the four subgroups that were evaluated

As the pre-pregnancy BMI increased, the incidence significantly increased for LGA. On the other hand, the incidence of SGA varied, although in all subgroups except the normal BMI, the proportion of SGA babies was significantly higher ($p < 0.001$).
Excessive leanness and obesity are associated with more adverse pregnancy outcomes for the newborn than any other subgroup of body weight and BMI. It implies higher risk for newborn complications.

DISCUSSION
The four pre-pregnancy BMI category groups demonstrated marked differences in the pregnancy outcome profile, indicating that the BMI classification suggested by WHO and IOM is valid inourpopulation of women.
There were differences in the incidence of adverse pregnancy outcomes in relationship to BMI categories. These findings also indicated that weight regulation prior to pregnancy was important in improving pregnancy outcomes. Poston et al. [10] reported findings of one of the largest randomised trials to assess the effects of interventions addressing diet and physical activity in obese pregnant women, demonstrating that a complex intervention in pregnantwomen with obesity is effective at improving diet quality and physical activity, reducing gestational weight gain, and decreasing surrogate measures of maternal body fatness, however the intervention does not prevent development of gestational diabetes nor change the incidence of LGA infants in this population, neither was evidence noted of a benefit on other pregnancy outcomes, including pre-eclampsia, which is associated with raised BMI [8]. In one study there was difference in findings in regard to macrosomia. Overweight and obese women had a higher risk of macrosomia and Caesarean delivery and lower risk of preterm delivery. The mechanism underlying this association is unclear and is worthy of further investigation [9]. This finding was not confirmed in our study.
These authors recommend a shift in research focus towards renewed efforts for effective public health measures that prevent obesity in women of reproductive age, which supports our suggestion.
The present part of the study has limitations. First, our data set included only small population of women studied. For such a study, greater number of patients should be included in order to get stronger statistical

power. It is important to note that these findings are just a part out of the broader study including much more indicators and greater number of patients. Second, we used the database of the Birth registry in tertiary center only, which is not representative sample for the overall country. This may have introduced selective bias in the patient background characteristics. Third, we calculated only the pre-pregnancy BMI, and didn't present the monthly or weekly weight gain, parameters which are very important to such an issue [10][11]. These parameters are included in the larger, abovementioned study.

Our results also demonstrated that obese women with BMI ≥30 had a higher risk of adverse pregnancy outcome, supporting the importance of pre-pregnancy weight control within the normal range.

CONCLUSION

This study has shown limited data on the influence of the weight status of the pregnant women on some simple perinatal outcomes for the mother and the baby. But, it stresses the importance of the pre-pregnancy maintenance of normal BMI as an effort to ensure optimal conditions for healthy pregnancy and good pregnancy outcome including the health of the newborn and starting basis for healthy life further on.

REFERENCES

[1] Enomoto K, Aoki S, Toma R, Fujiwara K, Sakamaki K, Hirahara F (2016) Pregnancy Outcomes Based on Pre-Pregnancy Body Mass Index in Japanese Women. PLoS ONE 11(6): e0157081, 2016

[2] "BMI Classification". Global Database on Body Mass Index. World Health Organization. 2006. Archived from the original on April 18, 2009. Retrieved February 2018.

[3] Rasmussen KM, Yaktine AL, Eds. Weight gain during pregnancy: reexamining the guidelines. Washington, DC: National Academies Press; 2009.

[4] "Assessing Your Weight and Health Risk". National Heart, Lung and Blood Institute. Archived from the original on 19 December 2014. Retrieved February 2018.

[5] "Defining obesity". NHS. Archived from the original on 18 December 2014. Retrieved 19 February 2018.

[6] "Executive Summary". Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report. National Heart, Lung, and Blood Institute. September 1998. xi–xxx. Archived from the original on 2013-01-03.

[7] Blomberg M. Maternal and neonatal outcomes among obese women with weight gain below the new Institute of Medicine recommendations. Obstet Gynecol. 117: 1065–1070, 2011

[8] Poston L, Bell R, Croker H, Flynn Angela C, Godfrey Keith M, Goff Louise, et al, on behalf of the UPBEAT Trial Consortium. Effect of a behavioural intervention in obese pregnant women (the UPBEAT study): a multicentre, randomised controlled trial. Lancet Diabetes Endocrinol; 3: 767–77.2015

[9] Khashan AS1, Kenny LC.The effects of maternal body mass index on pregnancy outcome.Eur J Epidemiol. 24(11):697-705, Epub 2009 Aug 4.2009

[10] Masho SW, Bishop GL, Munn M. Pre-pregnancy BMI and weight gain: where is the tipping point for preterm birth? BMC Pregnancy and Childbirth.; 13: 120; 2013

[11] Johnson J, Clifton RG, Roberts JM, Myatt L, Hauth JC, Spong CY, et al. Pregnancy outcomes with weight gain above or below the 2009 Institute of Medicine guidelines. Obstet Gynecol. 121: 969–975. 2013