

PRE-PREGNANCY BODY MASS INDEX AND GESTATIONAL WEIGHT GAIN AS RISK FACTORS ON MATERNAL AND BIRTH OUTCOMES

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Article Received on 15/05/2017

Article Revised on 04/06/2017

Article Accepted on 25/06/2017

ABSTRACT

Maternal pre-pregnancy body mass index (BMI) and gestational weight gain (GWG) have been reported to be associated with pregnancy outcomes. The aim of this study was to evaluate the effects of pre pregnancy BMI and gestational weight gain on maternal and birth outcomes. A prospective and a longitudinal cohort study was conducted among pregnant women who had attended antenatal centers in Constantine, Algeria, between 2013 and 2015. 200 pregnant women aged 19 to 41 years old were followed for 9 months of pregnancy. They underwent body weight measurement during routine examination at first, second and third trimester. Baby birth weight also measured after delivery. Data included age, parity and maternal outcomes. Results showed that mean BMI was 27.3 ± 4.7 kg/m² and mean GWG was 8.9 ± 5.4 kg. Of all subjects, 33% were in a normal weight range, which left 41 and 26% classified as overweight and obese before pregnancy. Among these subjects, only 27.5% of women had gained the recommended amount of weight, with 48.5% gaining less than recommended, and 24% gaining more than recommended by the IOM. The average birth weight of infants born to inadequate GWG women was lower than that of those born to adequate GWG women (3232 ± 564 g vs 3470 ± 464 g, $p=0.04$). The risk of gestational hypertension ($p=0.0006$) and diabetes ($p=0.04$) increased steadily with pre-pregnancy BMI. Also, the risk of hypertension increased with excessive GWG ($p<0.0001$). Conclusion; the effects of gestational weight gain on pregnancy outcomes depend on the woman's pre-pregnancy BMI.

KEYWORDS: Pre-pregnancy body mass index, gestational weight gain, maternal outcomes, birth outcomes.

INTRODUCTION

Low or high pre-pregnancy body mass index (BMI) and inadequate or excess gestational weight gain (GWG) are linked to an increased risk of adverse birth outcomes.^[1,2] Several studies have shown that maternal excessive gestational weight gain (GWG) was associated with increased risks of pregnancy-induced hypertension, gestational diabetes mellitus (GDM), caesarean delivery and large for gestational age infant, and maternal inadequate GWG was associated with increased risks of low birth weight and small for gestational age infant.^[3,4]

In 2009 the Institute of Medicine (IOM)^[5] published new recommendations regarding GWG. These guidelines state that healthy women who have a normal weight for their height (BMI 18.5–24.9) should gain 11.5–16 kg during pregnancy. Overweight women (BMI 25–29.9) should gain 7–11.5 kg and obese women (BMI greater than 30) should only put on 5–9 kg. It is also recommended to gain between 0.5 and 2 kg during the first trimester.^[6] In the second and the third trimesters, underweight women should gain 0.5 kg each week of

pregnancy, normal women 0.4 kg/week, overweight women 0.3kg/week and obese women 0.2kg/week.^[5]

The guidelines have been validated by several studies demonstrating that weight gain in accordance with the guidelines is associated with optimal birth weight and obstetric outcomes. Women gaining either above or below IOM guidelines have higher risks of many adverse outcomes.^[7,8] Despite these guidelines, over 55 % of obese women gain more than the recommended amount.^[6]

GWG is not linear over the course of pregnancy. It starts slowly in the first trimester and increases more consistently in the second and third trimesters.^[9] The ability to identify women at risk for excessive or inadequate gestational weight gain allows for weight management interventions.

In Algeria, this is the first study on weight gain in pregnant women. We do not have any previous data on the effect of pre-pregnancy BMI and gestational weight gain on maternal and birth outcomes.

Therefore, our study assessed each trimester and total GWG in pregnant women with the aim of evaluating the effects of gestational weight gain on maternal and birth outcomes in different body mass index (BMI) classes.

MATERIALS AND METHODS

We conducted a prospective and a longitudinal cohort study. We followed for 9 months a cohort of Algerian pregnant women, aged 19 to 41 years old, residing in the city of Constantine, Algeria. Among all women who presented to prenatal consultation centers, only 200 pregnant women were accepted to participate in the study. They were recruited at three different sites; at maternities, antenatal centers and private gynecologists, from December 2013 to December 2015. The participants were recruited and followed-up longitudinally, once at the end of each trimester of pregnancy. The trimesters were defined as first (less than 16 weeks of amenorrhea), second (16–28 weeks of amenorrhea) and third (29–41 weeks of amenorrhea).

Demographic characteristics of the pregnant women included: age, parity, pre-pregnancy weight and height, pre-pregnancy BMI, weight gain at the end of the first, second and third trimester of pregnancy and total GWG. Maternal outcomes evaluated included anemia, gestational hypertension, gestational diabetes and cesarean delivery. Gestational hypertension was defined according to the Canadian Hypertension Society as a diastolic blood pressure \geq 90mm Hg on at least two measurements.^[10] Birth outcomes evaluated included gestational age at delivery, preterm birth < 37 weeks of amenorrhea and birth weight (including low birth weight < 2500 g and high birth weight \geq 4000 g). These informations were obtained by face to face interview with each pregnant woman.

Women were eligible for participation if they entered prenatal care before the 16th week of amenorrhea, aged 18 years old and more and were healthy and mentally competent. We excluded women refusing to participate in the study, women with missing information on pre-pregnancy weight, known diabetes, hypertension and anemia before pregnancy.

Potentially eligible women were given an informational letter explaining the study and its objectives and requesting their participation. A signed consent was obtained from each study participant.

Weight and height were measured according to a standard protocol. Pre-pregnancy weight was self reported or measured if the pregnant woman consults at the early first trimester. Weight gain was measured at the end of each trimester of pregnancy (first, second and third) by using an electronic weighing balance Seca to the nearest 0.1 kg. Height was measured in cm using a locally made anthropometer. Pregnant women were asked to maintain an upright and erect posture with her feet together and the back of her heels touching the pole

of the anthropometer. The height was measured when the horizontal headpiece was lowered onto the women's head.

Pre-pregnancy body mass index (BMI) was calculated using a pre-pregnancy weight and height. Pre-pregnancy BMI was computed as weight (kg) divided by square of measured height (m). We categorized women's pre-pregnancy weight according to the World Health Organization (WHO) standards. Weight gain (in kg) at each prenatal visit (at the end of the first, second and third trimesters) and total GWG were collected. We used the 2009 Institute of Medicine (IOM) guidelines on GWG to categorize women's weight gain as below, within or above recommended.^[11] These guidelines have also been adopted by Health Canada.^[12]

Statistical analyses were performed using Stat View software. Data were expressed as means \pm standard deviation (SD) or percentages (number). Differences between groups were tested for statistical significance by using Student's t-test, or one-way ANOVA and multiple comparisons. Analysis was done to find out the association among body mass index, gestational weight gain and some maternal characteristics such as age and parity. The χ^2 test was used in comparison analyses. Comparisons were made between recommended weight gain, less than recommended weight gain, and more than recommended weight gain in each BMI class. A value of $P < 0.05$ was considered significant.

RESULTS

Demographic data of all subjects are shown in Table 1. Mean pre-pregnancy BMI was 27.3 ± 4.7 kg/m². GWG in the first, second and third trimester was respectively 1.2 ± 3.5 kg, 4.7 ± 2.9 kg and 3.1 ± 2.3 kg. Mean total GWG in this population was 8.9 ± 5.4 kg, and infant birth weight was 3335.9 ± 586.4 g.

Of all subjects, 33% were in a normal weight range, which left 41 and 26% classified as overweight and obese before pregnancy, respectively. Among these subjects, only 27.5% of women had gained the recommended amount of weight, with 48.5% gaining less than recommended, and 24% gaining more than recommended by the IOM.

Table 2 shows gestational weight gain (GWG) over pregnancy among different weight gain groups. Women with excessive and inadequate weight gain were more likely to begin pregnancy with a higher BMI compared to those with an adequate weight gain ($p = 0.005$). Over the first trimester, women with excessive GWG gained more weight compared to women with inadequate and adequate GWG ($p < 0.0001$).

Table 3 shows the distribution of participants according to total and each trimester weight gain by pre-pregnancy BMI. In general, as pre-pregnancy BMI increased, the amount of weight gained during pregnancy decreased.

During the first trimester, there are no significant differences in the three BMI groups. For second and third trimesters, weight gain is higher in normal weight women than in overweight ($p < 0.05$) and obese women ($p < 0.0001$).

Among the 200 pregnant women analyzed, 15.15% of women with a normal pre-pregnancy BMI, 20.7% of overweight and 40.4% of obese women had an excessive GWG. Whereas 56.1% of women with a normal pre-pregnancy BMI, 39.0% of overweight and 53.8% of obese women had an inadequate GWG, ($p < 0.0001$) (Fig 1).

There were no differences in gestational age at delivery, rates of gestational hypertension, gestational diabetes and mode of delivery between GWG groups. The average birth weight of infants born to inadequate and excessive GWG women was lower than that of those born to adequate GWG women ($p = 0.04$) (Table 4).

The risk of gestational hypertension increased steadily with pre-pregnancy BMI (26.9% of obese women vs. 3.0% of normal weight women, $p = 0.0006$). Similarly, gestational hypertension was significantly higher in women with excessive GWG than in those with adequate GWG ($p < 0.0001$). Gestational diabetes also increased with pre-pregnancy BMI ($p = 0.04$). The risk of both low and high birth weight was observed more in obese women ($p = 0.0007$) and in women with excessive GWG ($p = 0.04$) (Table 5).

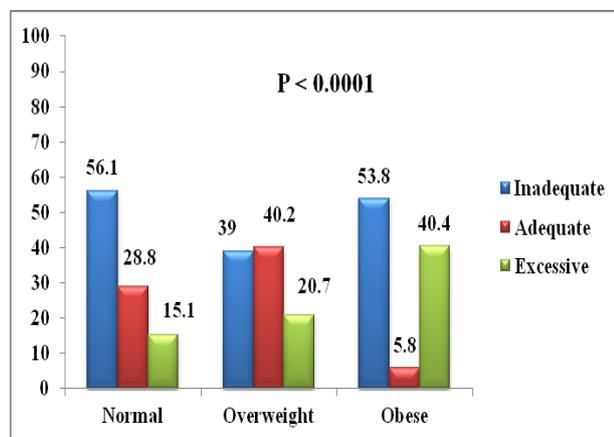


Fig 1: Maternal weight gain based on pre-pregnancy BMI.

Table 1: Characteristics of 200 pregnant women.

Category	Mean \pm SD
Age (years)	30.3 \pm 4.9
20-35	167 (83.5%)
> 35	33 (16.5%)
Parity	1.0 \pm 0.9
Primiparity	69 (34.5%)
Multiparity	131 (65.5%)
Pre-pregnancy weight (kg)	71.1 \pm 12.7
Height (m)	1.6 \pm 0.1
Pre-pregnancy BMI (kg/m ²)	27.3 \pm 4.7
Normal (18.5-24.9)	66 (33%)
Overweight (25-29.9)	82 (41%)
Obese (≥ 30)	52 (26%)
Total GWG (kg)	8.9 \pm 5.4
Inadequate	97 (48.5%)
Normal	55 (27.5%)
Excessive	48 (24%)
GWG (kg) based on trimester	
First trimester	1.2 \pm 3.5
Second trimester	4.7 \pm 2.9
Third trimester	3.1 \pm 2.3
Gestational age (weeks of amenorrhea)	38.9 \pm 2.0
Birth weight (g)	3335.9 \pm 586.4

Data are mean \pm SD or n (%) unless otherwise specified.

Table 2: Comparison of gestational weight gain (kg) between groups (n=200).

	Inadequate GWG N= 97	Adequate GWG N=55	Excessive GWG N= 48	p*
Pre-pregnancy BMI (kg/m ²)	27.5 \pm 5.4	25.8 \pm 3.1	28.7 \pm 4.3	0.005
First trimester GWG (kg)	-0.6 \pm 3.3	1.8 \pm 2.5	4.0 \pm 2.9	<0.0001
Second trimester GWG (kg)	3.4 \pm 2.8	5.5 \pm 2.4	6.2 \pm 2.7	<0.0001
Third trimester GWG (kg)	2.2 \pm 2.2	3.6 \pm 1.8	4.4 \pm 2.4	<0.0001
Total GWG (kg)	5.0 \pm 3.8	10.8 \pm 3.1	14.7 \pm 3.5	<0.0001

Data are Mean \pm SD, GWG: gestational weight gain

*Comparison performed using ANOVA analysis

Table 3: Distribution of participants according to weight gain in the three trimesters of pregnancy by pre-pregnancy BMI.

Pre-pregnancy BMI	Weight gain (kg) (M ± SD)			
	First trimester	Second trimester	Third trimester	Total weight gain
Normal	1,6 ± 2,9	5,8 ± 2,6	3,8 ± 2,5	11,2 ± 5,1
Overweight	1,0 ± 3,3	4,6 ± 2,4*	3,1 ± 1,9*	8,7 ± 4,8*
Obese	0,8 ± 4,5	3,3 ± 3,4 [§]	2,3 ± 2,5 [§]	6,5 ± 5,6 [§]

*: significant difference between overweight and normal ($p < 0.05$).

[§]: significant difference between obese and normal ($p < 0.0001$).

Table 4: Maternal and birth outcomes classified by gestational weight gain groups.

	Inadequate GWG	Adequate GWG	Excessive GWG	p
Maternal outcomes	38.7 ± 2.2	39.3 ± 1.6	38.6 ± 2.2	0.15*
Gestational age at delivery (weeks)				
Gestational hypertension	8 (8.2%)	3 (5.4%)	15 (31.2%)	0.26
Gestational diabetes	2 (2.1%)	1 (1.3%)	3 (6.2%)	0.75
Anemia	39 (44.3%)	17 (36.2%)	14 (31.1%)	0.18
Mode of delivery				
Vaginal delivery	61 (62.9%)	36 (65.4%)	25 (52.1%)	0.99
Cesarean delivery	36 (37.1%)	19 (34.5%)	23 (47.9%)	0.99
Birth outcomes				
Birth weight (g)	3232.1 ± 564.5	3470.9 ± 464.1	3391.0 ± 714.8	0.04*

Data are Mean ± SD or n (%) unless otherwise specified

*Comparison performed using ANOVA

Table 5: Maternal and birth outcomes classified by pre-pregnancy BMI and gestational weight gain.

Pregnancy Outcomes	Pre pregnancy BMI				Gestational weight gain (GWG)			
	Normal weight	Overweight	Obese	P-value*	Inadequate	Adequate	Excessive	p-value*
Gestational hypertension	2 (3.0%)	10 (12.2%)	14 (26.9%)	0.0006	8 (8.2%)	3 (5.4%)	15 (31.2%)	< 0.0001
Gestational diabetes	0	2 (2.4%)	4 (7.7%)	0.04	2 (2.1%)	1 (1.8%)	3 (6.2%)	0.3
Anemia	22 (36.1%)	31 (43.7%)	17 (35.4%)	0.5	39 (44.3%)	17 (36.2%)	14 (31.1%)	0.3
Cesarean delivery	23 (34.8%)	32 (39.0%)	23 (44.2%)	0.5	36 (37.1%)	19 (34.5%)	23 (47.9%)	0.3
Macrosomia [§]	7 (10.6%)	8 (9.8%)	18 (34.6%)	0.0007	12 (12.4%)	8 (14.5%)	13 (27.1%)	0.04
Low birth weight [§]	6 (9.1%)	7 (8.5%)	7 (13.5%)	0.0007	11 (11.3%)	2 (3.6%)	7 (14.6%)	0.04

Data are n (%) unless otherwise specified.

*Comparison performed using Chi-square test.

[§]Macrosomia is defined as birth weight ≥ 4000g

[§]Low birth weight is defined as birth weight < 2500g

DISCUSSION

In Algeria, this is the first study on weight gain in pregnant women. We do not have any previous data on the effect of pre-pregnancy BMI and gestational weight gain on maternal and birth outcomes. Therefore, our aim was to evaluate the effects of gestational weight gain on maternal and birth outcomes in different body mass index (BMI) classes and compared it with the recommended weight gain by IOM.

In this study, 15.15% of women with a normal pre-pregnancy BMI, 20.73% of overweight and 40.38% of obese women had an excessive gestational weight gain

($p < 0.0001$) greater than the IOM recommendations. In the other hand, 56.06% of normal pre-pregnancy BMI women, 39.02% of overweight and 53.85% obese women had an inadequate gestational weight gain ($p < 0.0001$) less than the IOM recommendations. The goal of these guidelines is to optimize both maternal and child outcomes, and to decrease the rates of both maternal postpartum and childhood obesity.^[13]

Our results showed that weight gain in pregnancy was lower when pre-pregnancy BMI was elevated. In particular, women who were overweight or obese before pregnancy generally gained less weight during pregnancy and very few women had an excessive weight

gain. However, during pregnancy, fat is stored to secure energy supply during fetal growth and lactation. In obese women, no additional storage is necessary, which suggests that pregnancy weight gain could be restricted because of physiological mechanisms.

In the present study, we found that maternal weight gain increase significantly during second and third trimester, with mean total maternal weight gain ranged at 8.95 ± 5.41 kg. This maternal weight gain was proper with the IOM recommendation about maternal weight gain during pregnancy. Ota *et al.*,^[14] and Yang *et al.*,^[15] found the same result with our study. Maybe, it is because of decreasing emesis symptoms in second and third trimesters and also increasing of uterine size and volume, so does the other maternal organic tissues. Maternal weight gain also affected by Leptin, a protein-like produced by adipose tissue that regulate appetite and body weight.

We found that maternal pre-pregnancy BMI plays a more important role than GWG in maternal outcomes, especially in pregnancy complications. Pregnancy-induced hypertension and gestational diabetes are the two key common pregnancy complications. Previous studies have reported that maternal obesity is associated with increased risks of adverse pregnancy outcomes including gestational diabetes and pregnancy-induced hypertension.^[16,17,18]

For neonatal outcomes, both higher pre-pregnancy BMI and excessive GWG could result in high maternal glucose, free fatty acid, and amino acid concentrations, thus leading to the risk of greater infant size at birth. Therefore, maternal pre-pregnancy BMI has similar effects as GWG in the neonatal outcomes.^[19] Our results are in accordance with Heude *et al.*^[20] who found that obese women were twice more likely to have high birth weight babies. In addition, those who gained weight above the recommended level are significantly at increased risk of high birth weight. This could be due to the life style and eating habits of pregnant obese women along with the genetic factors.

Also, similarly with our study, many investigators reported similar associations between pre-pregnancy BMI and birth weight. Fleten *et al.*^[21] reported a direct association between BMI and birth weight among 43,705 Norwegian mothers. The authors concluded that a one-unit increase in BMI resulted in a 20.3 gram increase in birth weight. Moreover, in a study among 292,568 singleton term Chinese pregnancies, pre-pregnancy underweight was associated with an increased risk of delivering a low birth weight infant (OR: 1.9, 95% CI: 1.3-1.6), while overweight and obese women had a 2.5- and 3.5-fold likelihood of giving birth to a macrosomic infant, respectively.^[22]

In addition, a systematic review of the effect of maternal weight gain during pregnancy on birth weight confirmed

our findings that excessive GWG increased risk of high birth weight in normal and obese pregnant women.^[23]

We acknowledge that the relationship between maternal health conditions and birth outcomes is complex since especially maternal anthropometry is the consequence of many other genetic or environmental factors such as eating habits, exercise and social economic conditions^[24] that themselves can impact on pregnancy outcomes.

CONCLUSIONS

The effects of gestational weight gain on pregnancy outcomes depend on the woman's pre-pregnancy BMI. Being overweight/obese and having a high weight gain, as well as being underweight and having a low weight gain, were associated with increased risks for adverse pregnancy outcomes in pregnant women. Our findings from the present study confirmed the association between pre-pregnancy BMI and GWG and adverse birth outcomes.

ACKNOWLEDGMENTS

We thankfully acknowledge all pregnant women and we are grateful to them who participated in the study and took time out of their busy lives to take part in our interviews.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors have no conflicts of interest.

REFERENCES

1. Flenady V, Koopmans L, Middleton P, Froen JF, Smith GC, Gibbons K, *et al.* Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. *Lancet*, 2011; 377: 1331–40.
2. Heaman M, Kingston D, Chalmers B, Sauve R, Lee L, Young D. Risk factors for preterm birth and small-for-gestational-age births among Canadian women. *Paediatr Perinat Epidemiol*, 2012; 27: 54–61.
3. Guelinckx I, Devlieger R, Beckers K, Vansant G. Maternal obesity: pregnancy complications, gestational weight gain and nutrition. *Obesity reviews: an official journal of the International Association for the Study of Obesity*, 2008; 9: 140–150.
4. Young TK, Woodmansee B. Factors that are associated with cesarean delivery in a large private practice: the importance of prepregnancy body mass index and weight gain. *American journal of obstetrics and gynecology*, 2002; 187: 312–318; discussion 318–320.
5. Institute of Medicine. *Weight gain during pregnancy: Re-examining the guidelines*. Washington, DC: National Academies Press, 2009.

6. CDC. Pregnancy nutrition surveillance nation. Summary of trends in maternal health indicators. http://www.cdc.gov/pednss/pnss_tables/tables_numeric.htm. Retrieved February 25, 2014; 2011.
7. Parker JD, Abrams B. Prenatal weight gain advice: an examination of the recent prenatal weight gain recommendations of the Institute of Medicine. *Obstet Gynecol*, 1992; 79: 664–9.
8. Schieve LA, Cogswell ME, Scanlon KS, Perry G, Ferre C, Blackmore-Prince C, et al. Prepregnancy body mass index and pregnancy weight gain: associations with preterm delivery. The NMIHS Collaborative Study Group. *Obstet Gynecol*, 2000; 96: 194–200.
9. Durie, D., Thornburg, L., & Glantz, J., Effect of second trimester and third-trimester rate of gestational weight gain on maternal and neonatal outcomes. *Obstetrics and Gynecology*, 2011; 118(3): 569–575.
10. Helewa ME, Burrows RF, Smith J, Williams K, Brain P, Rabkin SW. Report of the Canadian Hypertension Society Consensus Conference: 1. Definitions, evaluation and classification of hypertensive disorders in pregnancy. *CMAJ*, 1997; 157: 715–25.
11. Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines, Rasmussen KM, Yaktine AL. Weight gain during pregnancy: reexamining the guidelines. Washington (DC): The National Academies Press (US), 2009.
12. Health Canada. Prenatal Nutrition Guidelines for Health Professionals: gestational weight gain. Health Canada, 2010. Available from: <http://www.oxfordcounty.ca/Portals/15/Documents/Public%20Health/Healthy%20You/Nutrition/ewbambsa-eng.pdf> [Accessed 25 September 2014].
13. Rasmussen KM, Abrams B, Bodnar LM, Butte NF, Catalano PM, Maria Siega-Riz A. Recommendations for weight gain during pregnancy in the context of the obesity epidemic. *Obstet Gynecol*, 2010 Nov; 116(5): 1191–1195. [PubMed: 20966705].
14. Ota E, Haruna M, Suzuki M, Anh D D, Tho L H, Tam N T T et al. Maternal Body Mass Index and Gestational Weight Gain and Their Association With Perinatal Outcomes in Viet Nam. *Bull World Health Organ*, 2011; 89: 127-136.
15. Yang M J. Interrelationship of Maternal Serum Leptin, Body Mass Index and Gestational Age. *J Chin Med Assoc*, 2005; 68(10): 452-457).
16. Guelinckx I, Devlieger R, Beckers K, Vansant G. Maternal obesity: pregnancy complications, gestational weight gain and nutrition. *Obes Rev.*, 2008; 9: 140–150.
17. Nohr EA, Vaeth M, Baker JL, Sorensen T, Olsen J, 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.
18. Gibson KS, Waters TP, Catalano PM, Maternal weight gain in women who develop gestational diabetes mellitus. *Obstet Gynecol*, 2012; 119: 560–565.
19. Ogunyemi D, Hullett S, Leeper J, Risk A. Prepregnancy body mass index, weight gain during pregnancy, and perinatal outcome in a rural black population. *The J Matern Fetal Med*, 1998; 7: 190-3.
20. Heude B, Thiébauges O, Goua V, Forhan A, Kaminski M, Foligué B, et al. Pre-pregnancy body mass index and weight gain during pregnancy: relations with gestational diabetes and hypertension, and birth outcomes. *Matern Child Health J.*, 2012; 16: 355-63.
21. Fleten C, Stigum H, Magnus P, Nystad W. Exercise during pregnancy, maternal prepregnancy body mass index, and birth weight. *Obstet Gynecol*, 2010; 115: 331-7.
22. Liu Y, Dai W, Dai X, Li Z. Prepregnancy body mass index and gestational weight gain with the outcome of pregnancy: a 13-year study of 292,568 cases in China. *Arch Gynecol Obstet.*, 2012; 286: 905-11.
23. Siega-Riz AM, Viswanathan M, Moos MK, Deierlein A, Mumford S, Knaack J et al. A systematic review of outcomes of maternal weight gain according to the Institute of Medicine recommendations: birth weight, fetal growth, and postpartum weight retention. *Am J Obstet Gynecol*, 2009; 201: 339 e1-14.
24. Trotter LJ, Bowen DJ, Beresford SA. Testing for racial/ethnic differences in the association between childhood socioeconomic position and adult adiposity. *Am J Public Health*. 2010; 100: 1088–1094.