THE JOURNAL OF OBSTETRICS AND GYNECOLOGY OF INDIA

The Journal of Obstetrics and Gynecology of India (July–August 2018) 68(4):258–263
https://doi.org/10.1007/s13224-017-1023-2

ORIGINAL ARTICLE

Impact of Gestational Weight Gain on Cesarean Delivery Risk, Perinatal Birth Weight and Gestational Age in Women with Normal Pre-pregnancy BMI

Reza Omani-Samani[1] · Mahdi Sepidarkish[1] · Saeid Safiri[2] · Arezoo Esmailzadeh[3] · Samira Vesali[1] · Farahnaz Farzaneh[4] · Amir Almasi-Hashiani[1]

Received: 2 March 2017 / Accepted: 1 June 2017 / Published online: 15 June 2017

About the Author

Dr. Reza Omani-Samani has been an academic staff of Royan Institute (as a referral center for fertility in I. R. Iran) for 14 years, and currently, he is the head of the Department of Epidemiology and Reproductive Health. His research field is health reproduction and bioethics.

Reza Omani-Samani, Assistant Professor; Mahdi Sepidarkish, Methodologist; Saeid Safiri, Assistant Professor; Arezoo Esmailzadeh, Gynecologist; Samira Vesali, Methodologist; Farahnaz Farzaneh, Gynecologist; Amir Almasi-Hashiani, Methodologist.

✉ Amir Almasi-Hashiani
Amiralmasi2007@gmail.com

1 Department of Epidemiology and Reproductive Health, Reproductive Epidemiology Research Center, Royan Institute for Reproductive Biomedicine, ACECR, Royan Institute, Bani Hashem Place, Hafez St., P.O. Box: 16635148, Tehran, Iran

2 Managerial Epidemiology Research Center, Department of Public Health, School of Nursing and Midwifery, Maragheh University of Medical Sciences, Maragheh, Iran

3 Department of Obstetrics and Gynecology, Zahedan University of Medical Sciences, Zahedan, Iran

4 Infertility Fellowship, Department of Obstetrics and Gynecology, Infectious Disease and Tropical Medicine Research Center, Zahedan University of Medical Sciences, Zahedan, Iran

Abstract

Background Gestational weight gain (GWG) proportional to body mass index before pregnancy is one of the factors on maternal and neonatal outcomes. The aim of the current study was to assess association between GWG, and cesarean section, birth weight and gestational age at birth in women with normal BMI prior to pregnancy.

Methods This was a cross-sectional study carried out in 103 hospitals in Tehran, the capital of Iran, from July 6 to 21, 2015. The data were extracted by 103 trained midwives. Finally, 2394 pregnant women with normal BMI before pregnancy and singleton birth were examined. GWG was categorized based on Institute of Medicine (IOM) recommendations.

Results Prevalence of low birth weight (LBW) was 5.41% and prevalence of macrosomia was 2.18%. The prevalence of LBW in women with GWG less than the weight gain recommended by IOM was 2.13 times [95% confidence interval (CI) 1.13–4.02, $P = 0.019$] more than in women

with GWG equal to the weight gain recommended by IOM. There was no statistically significant difference in the prevalence of LBW between women with GWG more than recommended weight gain by IOM and women with GWG equal to the weight gain recommended by IOM (OR = 1.21, 95% CI 0.61–2.38, $P = 0.580$).
Conclusion After controlling for confounding variables, the prevalence of cesarean section and preterm birth had no significant difference at various levels of GWG. Accordingly, the prevalence of LBW among women with GWG less than the recommended weight gain by IOM was significantly 2.13 more than that among women with GWG equal to the recommended weight gain by IOM.

Keywords Gestational Weight Gain · Preterm Birth · Low Birth Weight · Cesarean Delivery

Introduction

Maternal weight gain in pregnancy and its pattern in different trimesters influence the outcomes of pregnancy [1]. Excessive weight gain during pregnancy (with incidence about 50%) has a significant impact on fetal growth and weight change in next generations [2, 3]. Gestational weight gain (GWG) is one of the effective factors in the outcomes of pregnancy. Some studies have reported that excessive weight gain during pregnancy is related to an atypical increase in fetal growth, neonatal macrosomia, gestational diabetes mellitus and cesarean section [4]. In addition, GWG, an unusually high or low maternal body mass index (BMI) before pregnancy, can affect pregnancy outcome and fetal growth. Some related researches showed that pre-pregnancy maternal BMI is associated with an adverse pregnancy outcome and also is related to fetal growth in the second and third trimesters of pregnancy as well [5, 6].

Numerous factors can affect the preterm delivery. Some studies have pointed out the role of GWG in preterm delivery [7, 8]. Available data suggest that weight loss in obese women during pregnancy is associated with an increased risk of preterm delivery [9]. Another considerable issue is cesarean section whose prevalence has been rising in recent decades, especially among low- and middle-income countries [10–13]. Cesarean section in most countries is one of the main causes of surgery and nearly 18.5 million cases are delivered annually by the section around the world [14]. In some studies, it has been reported that there is a significant association between cesarean section and GWG [15, 16]. In some other studies, it was reported that GWG during pregnancy has a significant relationship with birth weight independent of genetic factors [17]. World Health Organization (WHO) declared that prevalence of low birth weight (LBW), as birth weight less than 2500 g, was 15.5% around the world. LBW includes annually almost 20 million infants of whom 96.5% can be observed in developing countries [18]. LBW like preterm birth is considered one of the main causes of mortality and morbidity in newborns and may be related to GWG [19–21].

The Institute of Medicine (IOM) pointed out the amount of appropriate GWG based on BMI before pregnancy and recommended to gain more weight in pregnant women with low BMI and less GWG in women with high BMI [22, 23]. However, given the higher prevalence of adverse childbirth outcomes in women with adequate weight gain during pregnancy based on recommendations made by IOM, some studies have suggested to revise the IOM guideline [15]. Consequently, the aim of this study was to assess an association between GWG and cesarean section, birth weight and gestational age at birth in women with normal BMI.

Materials and Methods

This was a cross-sectional study, which was a part of large survey on twin and multiple pregnancies in Tehran, the capital of Iran. Data collected were attributed to 5170 deliveries in 103 hospitals from July 6 to 21, 2015, equipped to obstetrics and gynecology wards. The data were extracted by 103 trained midwives. Pregnant women who had twin or multiple pregnancies and those with BMI less than 18.5 and more than 25 kg per square meter (kg/m^2) before pregnancy were excluded. Finally, 2394 pregnant women with normal BMI before pregnancy were studied. More details about design and methodology were reported elsewhere [24, 25].

The outcomes of interest were cesarean section, LBW and preterm birth, and GWG was considered an independent variable. Gestational weight gain was extracted from medical records during pregnancy. In Iran, there is a prenatal care and one of the main variables examined and recorded by caregivers, midwifes and gynecologists is maternal weight changes during pregnancy as GWG. Therefore, GWG was extracted from those records. Confounding variables, such as maternal age, socioeconomic status score, the number of previous gravida, the number of previous parity, a history of pre-eclampsia in the current pregnancy and maternal BMI before pregnancy, were controlled for data analysis. Economic status of pregnant women was measured based on asset base, in which the women were asked about having some equipment at home, including vacuum cleaner, handicraft carpet, laptop, freezer, dish-washing machines, private cars, touch mobile,

Table 1 Women's characteristics comparison in three groups by studied variables

Variable	All women $N = 2394$	GWG < IOM $N = 847$	GWG = IOM $N = 747$	GWG > IOM $N = 800$	P
Age	28.62 (5.24)	28.77 (5.39)	28.78 (5.22)	28.31 (5.10)	0.124
BMI	22.36 (1.70)	22.54 (1.66)	22.31 (1.73)	22.23 (1.71)	0.001
GWG	13.84 (6.33)	8.32 (2.78)	13.41 (1.15)	20.07 (6.27)	0.001
Birth weight	3165 (477.6)	3062 (516.7)	3187 (401.9)	3245 (485.2)	0.001
Gestational age at birth	37.82 (4.89)	36.47 (7.33)	38.48 (2.66)	38.63 (2.28)	0.001
Low birth weight	124 (5.41)	63 (8.18)	30 (4.08)	31 (3.96)	0.001
Macrosomia	50 (2.18)	10 (1.29)	12 (1.63)	28 (3.58)	0.001
Cesarean section	1584 (68.81)	488 (62.48)	510 (69.39)	586 (74.55)	0.001
Preterm delivery	193 (8.27)	122 (14.79)	40 (5.49)	31 (3.96)	0.001

three-dimensional TV, side-by-side refrigerator, a microwave, the number of rooms and area of residence. Principal components analysis (PCA) score was used to calculate the economic status of these pregnant women. GWG was categorized based on IOM recommendations. In other words, pregnant women with normal BMI before pregnancy should have weight gain between 25 and 35 lb during pregnancy (a range from 11.33 to 15.87 kg) [15]. In the present study, in terms of GWG, women were divided into three groups, including less than the recommended weight gain (less than 11.33 kg), equal to the recommended weight gain (between 11.33 and 15.87 kg) and more than the recommended weight gain (more than 15.87 kg).

Data for this study were collected using a questionnaire. Some of the variables were obtained through referring to medical records and conducting interviews with specialists and nurses.

Ethical Considerations

Ethical approval was obtained from the Ethics Committee of the Royan Institute. The aims of the study were clearly explained to all participants prior to the investigation and confidentiality and anonymity was assured. Filling up the questionnaire in voluntarily basis was considered as consent. Participation in or withdrawal from the study had no impact on their current or future relationship with the hospital. The current study was performed in compliance with Helsinki Declaration.

Data Analysis

Descriptive statistics (mean, standard deviation and percent) and logistic regression were used to analyze the data. Control of confounding variables was carried out on maternal age, economic status score, the number of previous gravida, the number of previous parity, a history of pre-eclampsia in current pregnancy and pre-pregnancy BMI, which entered to the logistic model. $P < 0.05$ was considered statistically significant. The statistical analysis was performed by Stata version 14 (Stata, College Station, TX, USA).

Results

In this study, 5170 pregnant women were enrolled, but 2394 women with recorded GWG and normal pre-pregnancy BMI were analyzed. The mean age of pregnant women was 28.62 years (95% CI 28.40–28.83 years). The mean pre-pregnancy BMI of participants was 22.36 kg/m^2 (95% CI 22.30–22.43 kg/m^2). The mean birth weight was 3165 g and mean gestational age at birth was 37.82 weeks. Prevalence of LBW was 5.41% and prevalence of macrosomia was 2.18%. Prevalence of cesarean section and premature delivery was 68.81 and 8.27%, respectively.

According to IOM recommendation for women with normal pre-pregnancy BMI category, 847 women (35.38%) had weight gain less than IOM recommendation, 747 women (31.20%) weight gain equal to the weight gain recommended by IOM and 800 women (33.42%) weight gain more than IOM recommendation.

As shown in Table 1, there was a statistically significant difference among the three groups of women by the IOM category in terms of mean pre-pregnancy BMI, mean birth weight, mean gestational age at birth, the prevalence of LBW, macrosomia, cesarean section and preterm delivery.

As shown in Table 2, after controlling for confounding variables using logistic regression model, no statistically significant difference was observed between prevalence of LBW at different levels of GWG and the weight gain recommended by IOM. Accordingly, after controlling for confounding variables, there was no statistically significant

Table 2 Adjusted relationship between GWG, and type of delivery, low birth weight and preterm birth

Outcome	GWG lower than IOM recommendation			GWG higher than IOM recommendation		
	Odd ratio	CI	*P*	Odd ratio	CI	*P*
Cesarean[a]	1.02	0.76–1.38	0.849	1.09	0.80–1.48	0.564
Low birth weight[b]	2.13	1.13–4.02	0.019	1.21	0.61–2.38	0.580
Preterm birth[c]	0.94	0.51–1.72	0.849	0.79	0.42–1.49	0.482

[a] Adjusted for maternal age, economic status score, the number of previous gravida, the number of previous parity, a history of pre-eclampsia in current pregnancy, pre-pregnancy BMI, preterm birth and low birth weight

[b] Adjusted for maternal age, economic status score, the number of previous gravida, the number of previous parity, a history of pre-eclampsia in current pregnancy, pre-pregnancy BMI, cesarean section and preterm birth

Adjusted for maternal age, economic status score, the number of previous gravida, the number of previous parity, a history of pre-eclampsia in current pregnancy, pre-pregnancy BMI, cesarean section and low birth weight

difference between prevalence of cesarean section at different levels of GWG and weight gain recommended by IOM, whereas the prevalence of LBW in women with GWG less than the weight gain recommended by IOM was 2.13 times (95% CI 1.13–4.02, $P = 0.019$) more than women with GWG equal to the weight gain recommended by IOM after controlling for variables such as mother's age, economic status, number of previous gravida, number of previous parity, a history of pre-eclampsia in the current pregnancy, gestational age, cesarean delivery and pre-pregnancy BMI, but there was no statistically significant difference in the prevalence of LBW between women with GWG more than recommended weight gain by IOM and women with GWG equal to the weight gain recommended by IOM (OR = 1.21, 95% CI 0.61–2.38, $P = 0.580$).

Discussion

The findings of the current study revealed that in women with normal pre-pregnancy BMI, the prevalence of LBW, macrosomia, cesarean section and preterm birth were 5.41, 2.18, 68.81 and 8.27%, respectively. The mean GWG was 13.84 kg and mean age at birth was 37.82 weeks.

After controlling for confounding variables, no statistically significant difference was observed between different levels of GWG, and the recommended prevalence of cesarean section and prevalence of preterm birth by IOM. The prevalence of LBW among women with GWG less than the recommended weight gain stipulated by IOM was significantly higher than among women with GWG equal to the recommended weight gain by IOM.

In the present study, the mean GWG was 13.84 kg, corresponding to the IOM recommendation. IOM recommends that pregnant women with normal pre-pregnancy BMI should have weight gain between 25 to 35 lb during pregnancy (a range from 11.33 to 15.87 kg) [15, 26]. In a study in China [27], GWG in women with normal pre-pregnancy BMI was 17.2 kg, of whom 17.5% had weight gain less than the IOM recommendation, 25% equal to the weight gain recommended by IOM and 55.7% weight gain more than the recommended weight gain by IOM. Esimai et al. [28] have shown that in Nigeria 99.6% of women with normal pre-pregnancy BMI had weight gain during pregnancy less than the IOM recommendation. However, the prevalence of GWG in the present study was 35.38%, which was widely different from results of Esimai's study in 2014.

In the present study, the prevalence of LBW and macrosomia was 5.14 and 2.18%, respectively. In a study conducted in China in 2015 [27], the prevalence of LBW was 2.9% and prevalence of macrosomia 6.5%. According to the WHO report, the prevalence of LBW is 15.5% worldwide [18]. The prevalence of LBW in Iran shows that the rate is lower than the global average (15.5%), but the prevalence of LBW in Iran is higher than in China. The present study was conducted on women with normal pre-pregnancy BMI, whereas WHO report and study of Yang et al. were carried out in all women.

The results of the present study revealed that after controlling for confounding variables, the prevalence of LBW among women with GWG less than the recommended weight gain by IOM was significantly more than that among women with GWG equal to the recommended weight gain by IOM (OR = 2.13). The prevalence of LBW among women with GWG which is higher than suggested weight gain by IOM was not significantly different from women with GWG equal to the given weight gain by IOM. In a study by Yang on women with normal pre-pregnancy BMI, it was found that in women with GWG less than the IOM recommendation the odds of LBW is greater in comparison with women with GWG equal to the recommended weight gain by IOM (OR = 1.27). Also, the odds of LBW in women with GWG more than the IOM recommendation was significantly less than women with GWG equal to the recommended weight gain by IOM (OR = 0.45) [27]. Similar to our results, in a meta-analysis

study [29] on 55 papers (37 cohort papers and 18 case–control studies), it has shown that in singleton births, lower GWG women have higher risk of preterm birth and LBW. However, Esimai et al. reported a significant association between GWG and birth weight. In a study conducted by Yang et al. [27], it was observed a significant association between macrosomia and GWG, and the prevalence of macrosomia in women with GWG less than the recommended weight gain was 0.75 times more than women with GWG equal to the recommended weight gain by IOM. The prevalence in women with GWG higher than IOM recommendation was 2.26 times more than in women with GWG equal to the recommended weight gain by IOM. In 2013, Nan Li [30] found that GWG more than the recommended weight gain by IOM had a significant association with cesarean section, macrosomia and lower risk of preterm birth and LBW. GWG less than the recommended weight gain by IOM had a significant association with lower risk of macrosomia and increased risk of preterm birth. However, in the present study after controlling for confounding variables a significant association was not observed between GWG, and cesarean section and preterm birth. Han et al. [29] revealed that GWG less than IOM recommendation is associated with an increased risk of preterm birth and LBW. In a study by McDonald et al. [31], women with GWG more than IOM recommendation had an increased risk of preterm birth and LBW.

Some studies have reported that maternal weight gain during the first trimester of pregnancy is not associated with birth weight, but this relationship is well established in the second and third trimesters. Michele Drehmer et al. [32] reported that insufficient weight gain in the third - trimester was not related to adverse outcomes, but they found that inadequate weight gain in the second trimester increases the risk of small for gestational age and excessive GWG increases the risk of large for gestational age. Also, excessive weight gain in third trimester is associated with preterm birth and cesarean section, and women with insufficient GWG in the second trimester showed a lower risk of cesarean section. In another study performed by Karachaliou et al. [33], the results show that excessive GWG during both second and third trimesters of pregnancy was associated with the higher risk of large for gestational age. In a long-term cohort study carried out by Mamun et al. [34], the results showed that weight gain during pregnancy predicts the long-term weight gain and obesity of women.

The strength of the study was recruitment of IOM guideline for GWG analysis, collecting data from all hospitals in the capital of country and controlling for confounding variables such as socioeconomic status. One of the limitations of the study was the lack of rural participants in the study that can reduce generalizability. Also, gestational diabetes, preexisting diabetes and other problems, like bleeding, were not measured in this study, and the results were not adjusted for them.

Conclusion

The results of the present study showed that after controlling for confounding variables the prevalence of cesarean section and preterm birth had no significant difference at various levels of GWG. Accordingly, the prevalence of LBW among women with GWG less than the recommended weight gain by IOM was significantly 2.13 more than women with GWG equal to the recommended weight gain by IOM. The prevalence of LBW among women with GWG higher than IOM recommended weight gain was not significantly different from that among women with GWG equal to the recommended weight gain by IOM.

Acknowledgments This project was financially supported by Royan Institute. We thank all pregnant women who participated, and midwives who collected data.

Compliance with Ethical Standards

Conflict of interest ROS has received research grants from Royan Institute. All authors declare no conflict of interest.

Ethical Approval The study was approved by the Ethical Committee of Royan Institute. All procedures performed in studies involving human participants were in accordance with the ethical standards of the research institution and/or nationwide research committee and in compliance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

References

1. Raje L, Ghugre P. Rate and pattern of weight gain in Indian women from the upper income group during pregnancy and its effect on pregnancy outcome. J Dev Orig Health Dis. 2012;3(05):387–92.
2. Galjaard S, Pexsters A, Devlieger R, et al. The influence of weight gain patterns in pregnancy on fetal growth using cluster analysis in an obese and nonobese population. Obesity. 2013;21(7):1416–22.
3. Chmitorz A, von Kries R, Rasmussen KM, et al. Do trimester-specific cutoffs predict whether women ultimately stay within the Institute of Medicine/National Research Council guidelines for gestational weight gain? Findings of a retrospective cohort study. Am J Clin Nutr. 2012;95(6):1432–7.
4. Amorim AR, Rössner S, Neovius M, et al. Does excess pregnancy weight gain constitute a major risk for increasing long-term BMI? Obesity. 2007;15(5):1278–86.
5. Savitz DA, Stein CR, Siega-Riz AM et al. Gestational weight gain and birth outcome in relation to prepregnancy body mass index and ethnicity. Ann Epidemiol. 2011;21(2):78–85.
6. Jolly MC, Sebire NJ, Harris JP, et al. Risk factors for macrosomia and its clinical consequences: a study of 350,311 pregnancies. Eur J Obstet Gynecol Reprod Biol. 2003;111(1):9–14.

7. Han Z, Mulla S, Beyene J, et al. Maternal underweight and the risk of preterm birth and low birth weight: a systematic review and meta-analyses. Int J Epidemiol. 2011;40(1):65–101.
8. McDonald SD, Han Z, Mulla S, et al. Overweight and obesity in mothers and risk of preterm birth and low birth weight infants: systematic review and meta-analyses. BMJ. 2010;341:c3428.
9. Beyerlein A, Schiessl B, Lack N, et al. Associations of gestational weight loss with birth-related outcome: a retrospective cohort study. BJOG. 2011;118(1):55–61.
10. Kaur H, Nagpal M. Is current rising trends of cesarean section–justified? Int J Reprod Contracept Obstet Gynecol. 2017;6(3):872–6.
11. Betrán AP, Merialdi M, Lauer JA, et al. Rates of caesarean section: analysis of global, regional and national estimates. Paediatr Perinat Epidemiol. 2007;21(2):98–113.
12. Stivanello E, Rucci P, Lenzi J, et al. Determinants of cesarean delivery: a classification tree analysis. BMC Pregnancy Childbirth. 2014;14(1):1–8.
13. Briand V, Dumont A, Abrahamowicz M, et al. Individual and institutional determinants of caesarean section in referral hospitals in Senegal and Mali: a cross-sectional epidemiological survey. BMC Pregnancy Childbirth. 2012;12(1):1–8.
14. Gibbons L, Belizan JM, Lauer JA, et al. Inequities in the use of cesarean section deliveries in the world. Am J Clin Exp Obstet Gynecol. 2012;206(4):331. e1–19.
15. Gante I, Amaral N, Dores J, et al. Impact of gestational weight gain on obstetric and neonatal outcomes in obese diabetic women. BMC Pregnancy Childbirth. 2015;15(1):249.
16. Kiel DW, Dodson EA, Artal R, et al. Gestational weight gain and pregnancy outcomes in obese women: How much is enough? Obstet Gynecol. 2007;110(4):752–8.
17. Ludwig DS, Currie J. The relationship between pregnancy weight gain and birth weight: a within family comparison. Lancet. 2010;376(9745):984–90.
18. World Health Organization. Care of the preterm and/or low-birthweight newborn 2016 [cited 2016]. http://www.who.int/maternal_child_adolescent/topics/newborn/care_of_preterm/en/ (2016).
19. Mishra S, Joshi M. Low birth weight babies-risk factors and complications: a clinical study. J Contemp Med Res. 2017;4(1):149–50.
20. Cottrell G, Moussiliou A, Luty AJ, et al. Submicroscopic Plasmodium falciparum infections are associated with maternal anemia, premature births, and low birth weight. Clin Infect Dis. 2015;60(10):1481–8.
21. Hussain SM, Wang Y, Wluka AE, et al. Association of low birth weight and preterm birth with the incidence of knee and hip arthroplasty for osteoarthritis. Arthritis Care Res. 2015;67(4):502–8.
22. Rasmussen KM, Catalano PM, Yaktine AL. New guidelines for weight gain during pregnancy: what obstetrician/gynecologists should know. Curr Opin Obstet Gynecol. 2009;21(6):521–6.
23. Yaktine AL, Rasmussen KM. Weight gain during pregnancy: reexamining the guidelines. Washington: National Academy of Sciences, National Academies Press (US); 2009.
24. Sepidarkish M, Almasi-Hashiani A, Maroufizadeh S, et al. Association between previous spontaneous abortion and pre-eclampsia during a subsequent pregnancy. Int J Gynecol Obstet. 2017;136(1):83–6.
25. Almasi-Hashiani A, Sepidarkish M, Safiri S, et al. Understanding determinants of unequal distribution of stillbirth in Tehran, Iran: a concentration index decomposition approach. BMJ Open. 2017;7(5):e013644.
26. Rasmussen KM, Yaktine AL. Committee to Reexamine IOM Pregnancy Weight Guidelines. Food and Nutrition Board, Board on Children, Youth and Families, Institute of Medicine, National Research Council: Weight Gain During Pregnancy: Reexamining the Guidelines Washington DC: The National Academies Press. 2009.
27. Yang S, Peng A, Wei S, et al. Pre-pregnancy body mass index, gestational weight gain, and birth weight: a cohort study in China. PLoS ONE. 2015;10(6):e0130101.
28. Esimai OA, Ojofeitimi E. Pattern and determinants of gestational weight gain an important predictor of infant birth weight in a developing country. Global journal of health science. 2014;6(4):148.
29. Han Z, Lutsiv O, Mulla S, et al. Low gestational weight gain and the risk of preterm birth and low birthweight: a systematic review and meta-analyses. Acta Obstet Gynecol Scand. 2011;90(9):935–54.
30. Li N, Liu E, Guo J, et al. Maternal prepregnancy body mass index and gestational weight gain on pregnancy outcomes. PLoS ONE. 2013;8(12):e82310.
31. McDonald SD, Han Z, Mulla S, et al. High gestational weight gain and the risk of preterm birth and low birth weight: a systematic review and meta-analysis. Journal of obstetrics and gynaecology Canada. J Obstet Gynaecol Can. 2011;33(12):1223–33.
32. Drehmer M, Duncan BB, Kac G, et al. Association of second and third trimester weight gain in pregnancy with maternal and fetal outcomes. PLoS ONE. 2013;8:e54704.
33. Karachaliou M, Georgiou V, Roumeliotaki T, et al. Association of trimester-specific gestational weight gain with fetal growth, offspring obesity and cardio-metabolic traits in early childhood. Am J Obstet Gynecol. 2015;212(4):502.e1–14.
34. Mamun AA, Kinarivala M, O'Callaghan MJ, et al. Associations of excess weight gain during pregnancy with long-term maternal overweight and obesity: evidence from 21 y postpartum follow-up. Am J Clin Nutr. 2010;91(5):1336–41.