Arch Iran Med. February 2018;21(2):61-66

http www.aimjournal.ir

ARCHIVES OF IRANIAN MEDICINE

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Original Article

Maternal Anthropometric Characteristics and Adverse Pregnancy Outcomes in Iranian Women: A Confirmation Analysis

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Abstract

Background: Adverse pregnancy outcome are frequent in developing countries. Pregnancy outcomes are influenced by numerous factors. It seems that maternal anthropometric indices are among the most important factors in this era. The aim of this study was to determine any association between maternal anthropometric characteristics and adverse pregnancy outcomes in Iranian women and provide a predictive model by using factors affecting birth weight (BW) via the pathway analysis.

Methods: This study was performed in Alborz province between September 2014 and December 2016. In this cross-sectional study, 1006 pregnant women who had the study criteria were selected from 1500 pregnant women. The data were collected in 2 phases: at their first prenatal visit and during the postpartum period. Demographic data, history of previous pregnancy, fundal height (FH), gestational weight gain (GWG), and abdominal circumference (AC) were recorded. Pathway (path) analysis was used to assess effective factors on pregnancy outcomes.

Results: The mean and standard deviation of participant age at delivery was 25.97 ± 5.71 years. Overall, 4.6% of infants were low BW (LBW) and 5.8% had macrosomia. The final model, with a good fit accounting for 22% of BW variance, indicated that AC and FH (both $P < 0.001$), and pre-pregnancy body mass index (BMI) ($P = 0.01$) had positive direct effect on BW, while pre-pregnancy BMI and GWG (both $P < 0.001$) affected BW indirectly through their effect on FH and AC.

Conclusion: Based on the path analysis model, FH and AC of neonates with the greatest impact on BW, could be predicted by mother's BMI before pregnancy and weight gain during pregnancy. Therefore, close observation during prenatal care can reduce the risk of abnormal BW.

Keywords: BMI, Maternal anthropometric, Predictive model, Pregnancy outcome, Pregnant women

Cite this article as: Hoorsan H, Alavi Majd H, Chaichian S, Mehdizadehkashi A, Hoorsan R, Akhlaqghdoust M, et al. Maternal anthropometric characteristics and adverse pregnancy outcomes in Iranian women: a confirmation analysis. Arch Iran Med. 2018;21(2):61–66.

Received: May 29, 2016, Accepted: January 2, 2018, ePublished: February 1, 2018

Introduction

Adverse pregnancy outcomes are frequent in developing countries, which are affected by several factors such as maternal anthropometric indices.[1] One of the important aspects of obstetrics science is pregnancy outcomes that could be evaluated by different factors such as term delivery rate, normal birth weight (BW), and preterm rupture of membranes (PROM), preterm labor (PTL) and its complications.[1,2]

Incidence of abnormalities such as PTL and low birth weight (LBW) is about 10%.[2] Optimum prenatal care may reduce incidence of adverse pregnancy outcomes, for example for a model to be drawn from the factors, PROM and infection which may induce PROM, LBW, and macrosomia could be maternal health-threatening factors. Thus, we can protect mothers and their babies from severe morbidities and financial burden.[1,2]

The obesity epidemic in reproductive age women is an important influence on pregnancy outcomes.[3] Pregnant women are at increased risk of enhanced and rapid weight gain and hence maternal obesity.[4] According to a cohort study in the United States, the incidence of obesity in pregnancy has increased from 15% in 1980 to 35% in 2000.[5] Accordingly, recent research is focusing on the effects of weight gain in pregnancy on the health of the mother and her baby, which is a critical issue since today's mothers seem to become pregnant at an older age.[3] In addition, nowadays that women's body mass index (BMI)

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has increased globally, a greater percentage of women are entering pregnancy being overweight or obese, and many are gaining too much weight during pregnancy. Many of these changes add to the burden of chronic diseases, which can put the health of the mother and the newborn at risk.[6]

The incidence of obesity has increased among men and women at different ages and different races. Incidence of being overweight and obese was 28% and 25%, respectively, in Iran in 2005.[2]

New American weight gain guidelines are based on revised BMI categories.[6] US data shows that the proportion of women with excessive gestational weight gain (GWG) has increased during the past 15 years. Maternal and neonatal complications associated with BMI and GWG are public health issues because they add to disease burden in women and children and increase medical costs.[7] Fundal height (FH) and abdominal circumference (AC) in umbilical level are 2 predictive factors of fetal growth.[8] Several studies have shown that excessive GWG can lead to an increased risk of gestational diabetes, preeclampsia, failed induction, cephalopelvic disproportion or failure to progress, lacerations, instrumental delivery, PTL, cesarean delivery (C/S), macrosomia, low 5-minute Apgar score, postpartum infection, and weight retention.[9-11]

In the present study, the association of maternal anthropometric indicators (BMI before pregnancy, GWG, maternal AC, and FH) with pregnancy outcomes (BW, gestational age and birth method) were assessed and a predictive model from the factors affecting BW using path analysis based on a regression model was drawn.

Patients and Methods

This study was performed on women aged 18–45 years between Sep 2014 and Dec 2016. In this cross-sectional study, 1006 pregnant women who had all of the study criteria were selected from 1500 pregnant women. Data collection was done in 2 phases; at their first visit for prenatal care and after the delivery period.

Inclusion criteria were pregnant women admitted to our ward for delivery with a singleton alive fetus. Exclusion criteria were fetal head engagement, PROM, multi fetal pregnancy, pregnancy complications such as placenta previa, placenta abruption, preeclampsia, eclampsia, oligohydramnios, polyhydramnios, uterus and ovarian or abdominal tumors, and fetal abnormalities which can affect uterine height and abdominal girth measurement such as hydrocephaly, macrocephaly, and hydrops fetalis. In this study, sample size was calculated at 600 based on the number of independent variables (approximately 20) obtained according to Lubin and colleagues.[12] Thus, to increase the power and fit of the path analysis model, the final sample size was considered 1000 pregnant women who were recruited based on a random sampling method.

Data Collection

Demographic data, weight before pregnancy, medical history, history of previous pregnancy/pregnancies, the last menstrual period (LMP) gestational age, previous child's age, maternal weight changes during pregnancy, gravidity, parity and history of abortion, as well as weight, height, FH and AC of mothers were collected in their first visit to the gynecologist and recorded in the checklist and record sheets. Again gestational age was assessed by sonography. The newborn's information such as gender, weight, height, head and chest circumferences and calculated Ponderal index were recorded.

Height was measured with bare feet, on a flat surface to the nearest 0.1 cm using a digital stadiometer (Seca Inc, USA). Weight was measured in light clothing to the nearest 0.1 kg using a digital weight scale. Newborn's weight was measured by digital baby weight scale (Toddler Inc, BT20, and USA). BMI was calculated according to the following formula: [(kg/m^2) = weight (kg)/ squared height (m^2)].

Statistical Analysis

Odds ratio (OR) and chi-square test was used to determent the association between variables. Data were analyzed using SPSS, version 22.0 (SPSS Inc, Chicago, IL, USA) and P values less than 0.05 were considered significant. For assessing the effect of factors on pregnancy outcomes AMOS software (version 22.0) was used. According to the aim of this study, to answer the research questions about the effect of independent variables (such a demographic data, weight before pregnancy, medical history, history of previous pregnancy/pregnancies, the LMP gestational age, previous child's age, maternal weight changes during pregnancy, gravidity, parity and history of abortion, weight, height, FH and AC of mothers) on the dependent variable, path analysis model was used.

Results

The median age of the 1006 participants at delivery was 25.97 ± 5.71 years (14–43 years); 516 (51.3%) of the participants were primipara, 686 (68.2%) were Kurdish, and 517 (51.4%) of infants were male. Forty-five (77%) of neonates with macrosomia (weight over 4 kg) were delivered by cesarean. Maternal and neonatal characteristics based on BW are shown in Table 1 which indicates statistically significant differences among different BW categories considering GWG (χ^2 = 13.29, P=0.04), FH (χ^2 = 101.8, P < 0.01), maternal AC (χ^2=17.58, P < 0.01), neonatal gender (χ^2=32.6, P < 0.01), gestational age (GA) (χ^2 = 31.63, P < 0.01) and

Table 1. Maternal and Neonatal Characteristics by Birth Wight

Characteristics		Total	Birth Weight			Chi-square	*P* Value
			Below 2500 g, 46 (4.6%)	2500–4000 g, 902 (89.7%)	Over 4000 g, 58 (5.8%)		
Employment	Yes	66	1 (2.2%)	61 (6.8%)	4 (6.9%)	1.52	0.47
	No	939	45(97.8%)	840(93.2%)	54(93.1%)		
Ethnicity	Kurdish	686	26(56.5%)	616(68.3%)	44(75.9%)	7.75	0.26
	Persian	203	14 (30.4%)	179 (19.8%)	10 (17.2%)		
	Turkish	107	5 (10.9%)	99 (11%)	3 (5.2%)		
	Afghan	83	1 (2.2%)	81 (0.9%)	1 (1.7%)		
Prepregnancy BMI (kg/m^2)	<18.5	81	7 (16.2%)	69 (7.7%)	5 (8.2%)	7.2	0.3
	18.5-24	597	25(54.1%)	543(60.2%)	29(51%)		
	25-29	250	11 (24.3%)	224 (24.8%)	15 (26.5%)		
	≥30	76	2 (5.4%)	66 (7.3%)	8 (4.3%)		
GWG (kg)	<10	444	27(59.5%)	393(43.6%)	24(40.8%)	13.29	0.04
	10–14	67	15 (32.4%)	32 (35.5%)	20 (34.7%)		
	15–19	139	2 (5.4%)	132 (14.6%)	5 (8.2%)		
	≥20	68	1 (2.7%)	58 (6.4%)	9 (6.3%)		
Fundal high (cm)	<30	78	13 (28.3%)	65 (7.2%)	—	101.8	<0.01
	30–34	337	25 (54.3%)	307 (34%)	5 (8.6%)		
	35–39	475	7(15.2%)	438(48.6%)	30(51.7%)		
	≥40	116	1 (2.2%)	92 (10.2%)	23 (39.6%)		
Maternal AC (cm)	>90	85	14 (30.4%)	71 (7.9%)	—	49.78	<0.01
	90–99	350	20 (43.5%)	318 (35.3%)	12 (20.7%)		
	100–109	391	9(19.6%)	353(39.1%)	29(50%)		
	≥110	294	3 (6.5%)	264 (29.3%)	17 (29.3%)		
Neonatal gender	Male	518	11 (23.9%)	460 (51%)	46 (79.3%)	32.06	<0.01
	Female	489	35 (76.1%)	442 (49%)	12 (20.7%)		
Delivery method	Vaginal	488	26 (56.5%)	449 (49.8%)	13 (29.4%)	17.58	<0.01
	C/S	518	20(43.5%)	453(50.2%)	45(77.6%)		
Parity	Primipara	783	38 (82.6%)	707 (78.4%)	38 (65.5%)	6.74	0.15
	Multipara	223	8 (7.39%)	195 (21.6%)	20 (34.5%)		
Maternal age (y)	<20	178	10 (21.7%)	160 (17.7%)	8 (13.8%)	8.31	0.47
	20–24	273	16 (34.8%)	245 (27.2%)	12 (20.7%)		
	25–29	287	10(21.7%)	260(28.8%)	17(29.3%)		
	30–34	175	7 (15.2%)	157 (17.4%)	11 (19%)		
	≥35	93	3 (6.5%)	80 (8.9%)	10 (17.2%)		
Gestational age (wk)	<37	49	10 (21.7%)	38 (4.2%)	1 (1.7%)	31.63	<0.01
	37–42	929	36(78.3%)	837(92.8%)	56(96.6%)		
	>42	28	-	27 (3%)	1 (1.7%)		

delivery method (χ^2 = 13.29, P = 0.04) (Table 1).

Pregnancy weight gain varied by pre-pregnancy BMI and lean and normal weighted women gained more weight during pregnancy than overweight or obese women (Table 2).

Pregnancy outcome (macrosomia, LBW and PTL) according to GWG, pre-pregnancy BMI, and neonatal gender, FH, maternal AC are shown in Tables 3 and 4.

Factors affecting BW, observed using path analysis, are shown in Figure 1. The path model was used to test the direct and indirect relationships among the variables. Neonatal weight was the dependent variable. Exogenous independent variables were prepregnancy BMI and GWG. Endogenous independent variable were FH and AC. Goodness-of-fit of the final model was assessed by chi-square test and the goodness of fit indices, such as root mean square error of approximation (RMSEA), goodness-of-fit index (GFI), adjusted GFI (AGFI), normed fit index (NFI), relative fit index (RFI), incremental fit index (IFI), Tacker-Lewis index (TLI) and comparative fit index (CFI). Values for GFI, AGFI, NFI, RFI, IFI, TLI and CFI ranged from 0 to 1 with recommending values greater than 0.90 indicating a good fit. Conventionally, there was a good fit, if RMSEA is less than 0.05, and adequate fit if RMSEA is less than 0.08.[2]

Path coefficients were calculated by a series of multiple regression analyses based on the hypothesized model. The final model had a good fit with chi-square =2.08 (df = 1, P = 0.149), GFI = 0.999, AGFI = 0.985, NFI = 0.998, RFI = 0.984, IFI = 0.999, TLI = 0.992, CFI = 0.999 and RMSEA = 0.036. The AC (β = 0.25, P < 0.001), FH (β = 0.36, P < 0.001), and prepregnancy BMI (β = 0.11, P = 0.016) had positive direct effect on BW. The results also showed that prepregnancy BMI (β = 0.69, P < 0.001), GWG (β = O.32, P < 0.001) and FH (β = 0.23, P < 0.001) had positive indirect effect on BW

Table 2. Frequency of Maternal Weight Gain Per BMI and Suggested Weight Gain

Maternal Weight Gain (kg)		<7	7–11.5	11.5–16	12.5–18	>18
BMI (kg/m^2), No. (%)	<18.5	8 (11.94)	21 (31.34)	6 (8.96)	24 (35.82)	8 (11.94)
	18.5–24.99	70 (29.14)	197 (40.2)	142 (28.98)	39 (7.96)	42 (8.57)
	25–29.99	44 (21.46)	80 (39.02)	35 (17.07)	29 (14.15)	17 (8.29)
	30	22 (34.92)	22 (34.92)	8 (12.7)	7 (11.11)	4 (6.35)

Abbreviations: BMI, body mass index.

Table 3. Pregnancy Outcome (Cesarean Section and Macrosomia) According to GWG, Prepregnancy BMI, Neonatal Gender, FH and Maternal AC

	Cesarean Section				Macrosomia			
	Crude OR (CI 95%)	*P* Value	Adjusted OR (95% CI)	*P* Value	Crude OR (95% CI)	*P* Value	Adjusted OR (95% CI)	*P* Value
GWG (>20 kg)	2.4 (1.4–4.4)	0.03	2.2 (1.2–4)	<0.01	2.96 (1.3–6.7)	<0.01	3.6 (1.6–8.3)	<0.01
Prepregnancy BMI (>30 kg/m^2)	1.4 (0.9–2.4)	0.17	1.4 (0.8–2.3)	0.15	2.1 (0.9–5)	0.07	1.89 (0.8–4.5)	0.15
Neonatal gender (female)	1.1 (0.8–1.35)	0.69	1.1 (0.9–1.4)	0.49	0.26 (0.14–0.5)	<0.01	0.26 (0.13–0.5)	<0.01
Fundal high (>40 cm)	2.1 (1.4–3.2)	<0.01	1.77 (1.2–2.7)	<0.01	6.04 (3.4–10.7)	<0.01	5.83 (3.2–10.6)	<0.01
Maternal AC (>110)	2.36 (1.7–3.3)	<0.01	2 (1.4–2.9)	<0.01	2 (1.1–3.6)	<0.01	1.84 (1–3.4)	0.05

Adjusted for age, parity, employment and Ethnicity
Abbreviations: GWG, gestational weight gain; BMI, body mass index; OR, odds ratio; AC, abdominal circumference; FH, fundal height.

Table 4. Pregnancy Outcome (LBW and PTL) According to GWG, Prepregnancy BMI, Neonatal Gender, FH and Maternal AC

	LBW				PTL			
	Crude OR (CI 95%)	*P* Value	Adjusted OR (95% CI)	*P* Value	Crude OR (95% CI)	*P* Value	Adjusted OR (95% CI)	*P* Value
GWG (>20 kg)	1.97 (1–3.9)	0.049	1.9 (0.98–3.7)	0.058	1.5 (0.8–2.9)	0.21	1.5 (0.78–2.9)	0.23
Prepregnancy BMI (>30 kg/m^2)	2.3 (0.9–5.7)	0.07	1.8 (0.7–4.7)	0.22	4.4 (2.1–9.5)	<0.01	4.2 (1.9–9.5)	<0.01
Neonatal gender (female)	3.55 (1.8–7.1)	<0.01	3.5 (1.8–7)	<0.01	1.7 (0.95–3.1)	0.07	1.7 (0.9–3.1)	0.08
Fundal high (>40 cm)	3.4 (2.3–5.1)	<0.01	3.5 (2.3–5.4)	<0.01	2.9 (2–4.3)	<0.01	3 (2–4.4)	<0.01
Maternal AC (>110)	2.58 (1.8–3.8)	<0.01	2.8 (1.9–4.2)	<0.01	1.9 (1.3–2.6)	<0.01	2.3 (1.6–3.3)	<0.01

Adjusted for age, parity, employment and Ethnicity
Abbreviations: GWG, gestational weight gain; BMI, body mass index; OR, odds ratio; AC, abdominal circumference; FH, fundal height; LBW, low birth weight; PTL, preterm labor.

through their effect on AC. In addition, prepregnancy BMI ($\beta = 0.34$, $P < 0.001$), GWG ($\beta = 0.23$, $P < 0.001$) had positive indirect effects on BW through their effect on FH. In Table 5 the direct and indirect and total effect factors on BW have been shown.

In this study GFI of the final model was assessed by chi-square test and the goodness of fit indices, such as RMSEA, GFI, AGFI, NFI, RFI, IFI, TLI and CFI. Values for GFI, AGFI, NFI, RFI, IFI, TLI, and CFI ranged from 0 to 1, with values greater than 0.90 indicating a good fit. Conventionally, there is a good fit if RMSEA is less than 0.05, and there is adequate fit if RMSEA is less than 0.08. In this study GFI = 0.999 and RMSEA = 0.036.

Discussion

BW represents the most important risk indicator for neonatal and infant morbidity and mortality. An accurate EFW is valuable information for planning the mode of delivery and management of labor. This study consisted of 59.39% normal prepregnancy BMI, 65.8% normal weight, 23.6% overweight and 10.6% obese women based on Institute of Medicine (IOM) guidelines. The results of this study showed about 32.48% of women had a GWG = IOM recommended, 41.94% had a GWG < IOM recommended and 25.58% had a GWG > IOM recommended. De Vader et al showed that about 40% of normal weight women in their study population gained the recommended amount of weight (25–35 lb) during their pregnancy, whereas 18% and 43% gained less or more weight than recommendations, respectively.[9]

We found that over 52% of the overweight and 65% of obese mothers had a GWG > IOM recommended and similar results have been reported in other studies.[13,14] Haugen et al. found that over 50% of the overweight and obese women had a GWG > IOM recommended. Seventy-four percent of the overweight nulliparous women and 66% of the obese women had a GWG > IOM recommended.[15]

The result of this study showed that greater than standard weight gain in mothers who were overweight was about 39.51% which is in accordance with the

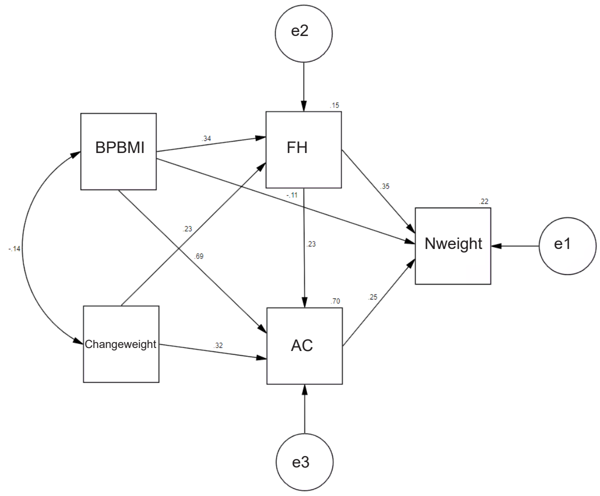

Figure 1. Predictive Model for Pathway Analysis of Effective Factors on Birth Weight.

results of other studies (36.6%). In the present study, in obese mothers, excessive weight gain was about 66.08%, however Khosravi showed about 75% weight gain in their study.[14]

The present study was carried out to determine the effective factors on PTL and showed that chance of PTL will increase in slim mothers with low BMI (CI = 1.9–2.5, OR = 4.2) and in mothers with female babies (CI = 0.9–3.1, OR = 1.7), chance of LBW will increase. However, a study by Han et al revealed that the risk of PTL in mothers with pre-pregnancy BMI<18.5, was higher (CI = 1, 2–6.74, OR = 2.85), [16] which is consistent with the results of the present study. Khashan and Kenny showed that the risk of PTL decreased about 10% in overweight and increased in slim mothers (CI = 1.16–1.53, OR = 1.33), which is consistent with results in our study regarding the chance of PTL in slim mothers.[17] Peterson et al also reported that increase in BMI can increase the rate of PTL significantly.[18] These results, confirming results of the present study, indicate the significant role of mother's BMI before and during pregnancy on PTL and suggests that PTL can be prevented by close observation of mother's BMI during prenatal visits.

According to the present study, increasing parity will increase the risk of PTL by 23%. Although it was incompatible with an investigation that showed if parity increased, the rate of PTL will decrease (CI = 1.08–2.21, OR = 1.47).[19] The correlation between weight gain and macrosomia is stronger than weight gain and LBW.[20] According to an investigation, the lowest sex ratio (Male/Female = SR) was in BW group of 2500–2599 g and maternal weight gain of lower than 11 pound (SR = 0.72). The highest sex ratio was in BW over 4499 g and weight gain over 40 pounds (SR = 2.25).[21]

The overweight mothers had 2.32 times risk of macrosomia.[22] It was consistent with a study showing that the relative risk of macrosomia in mothers with pre-pregnancy BMI <18.5 (OR: 0.48, CI: 0.03–0.77) was lower.[23] In one study, direct and significant correlation between BW and maternal parity was found. They concluded that FH and parity could be considered as a simple and inexpensive method of BW estimation.[24] In another study, it was concluded that the relationship between FH and estimated BW was not significant (P = 0.74).[25]

Table 5. Standardized Direct, Indirect and Total Effects Factors on Birth Weight - 2 Tailed Significance

Factors		Direct Effect	Indirect Effect	Total Effect
Birth weight	GWG	-	0.003	0.003
	Prepregnancy BMI	0.004	0.003	0.025
	FH	0.010	0.006	.009
	AC	0.009	—	0.009

Abbreviations: GWG, gestational weight gain; BMI, body mass index; AC, abdominal circumference; FH, fundal height.

Our results revealed that the risk factors for LBW are: maternal weight gain <10 kg, FH < 30 cm, AC < 90 cm and female offspring. Another study revealed that weight gain lower than optimal level is related to LBW.[14] Similar results were reported in the Dietz study (OR: 2.79, CI: 1.16–6.73).[20] It was reported that the incidence of LBW in slim mothers (51%) was higher than others (CI = 0.83–0.95, OR = 1.51).[26] A strong correlation between LBW and maternal FH and AC was found.[27]

The results of this study showed that maternal weight change of more than 20 kg, FH > 40 cm, and AC > 110 cm are correlated with higher rates of caesarean section (C/S). Haugen et al in their study concluded that weight gain more than optional level can be correlated with macrosomia and C/S.[14] The Frederick study also revealed that mothers 27.2% overweight underwent more C/S deliveries.[26] In this study the rate of C/S was 51.5%. According to an investigation, obesity was defined as a C/S risk factor (CI = 1.2–4.1, OR = 2.2).[28]

The purpose of this study was to identify and confirm the direct and indirect effect of factors on BW. The direct and indirect effects on coefficient and total effective factors on BW are shown in Table 5; the most effectual factors were FH. FH and maternal AC had direct impact on BW but pre-pregnancy BMI and weight gain during pregnancy were indirectly effective. As shown in Figure 1, the BW variance is 22% and it is determined by FH and maternal AC.

In conclusion, based on data of this data, some maternal anthropometric indicators have adverse effects on pregnancy outcomes. Subsequently, special attention to women health issues during reproductive ages is very important. More attention should be given to establishing health policies concerning effective strategies for controlling GWG. We should also provide suitable prenatal care and sensitize pregnant women regarding recommended weight gain. For further understanding, more relevant research is required.

Authors' Contribution

SC, MA and RH contributed to project design and its development. HAM and AM wrote the manuscript. HH and YM analyzed data.

Conflict of Interest Disclosures

The authors have no conflicts of interest.

Ethical Statement

The Research Ethics Committee of Alborz University of Medical Sciences approved this study and participants provided written informed consent for voluntary participation in the study (Ethical code: 94/5004).

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