An Investigation of the Relationship between Body Mass Index at the Beginning of Pregnancy and Pregnancy and Delivery Outcomes

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Abstract

Background: Proper weight gain is essential for the mother's health and pregnancy. On the other hand, insufficient weight gain is directly related to a decrease in the growth and preterm birth. The present study aimed to determine the relationship between the mother's Body Mass Index (BMI) and pregnancy and delivery outcomes in mothers referred to Gerash health centers in 2014.

Methods: This retrospective, cohort study was conducted on the data from 554 pregnant mothers referred to Gerash health centers to receive pregnancy healthcare from April to November 2014.

Results: The mothers' mean age was 25.9 ± 5.4 years and their mean weight gain was 11.6 ± 4.0 kg. In addition, 62.6% and 37.5% of the babies were born through natural delivery and cesarean section, respectively. About 9% of the children were pre-term, while 91% were term and post-term. Besides, 5.4% and 5.1% of the mothers got gestational diabetes and anemia, respectively. The results of logistic regression analysis showed positive relationships between the type of delivery and BMI (OR: 1.10(95% CI: 1.05-1.14)), history of cesarean section (OR: 0.02(95% CI: 0.01-0.07)), and mother's age (OR: 1.06(95% CI: 1.03-1.10)) (P<0.05). Moreover, a positive relationship was found between the gestational weight gain and infant's birth weight (g) (OR: 18.42(95% CI: 8.02 – 28.82)) (P<0.05).

Conclusion: According to the finding, it seems that it would be necessary to plan educational and counseling programs before the pregnancy for the mothers. Therefore, the role of health authorities is more important than ever in promoting the general knowledge to reach the proper weight before and during pregnancy.

Introduction

Pregnancy is a critical period during which the mother's health plays a vital role in her infant's health. Pregnancy is considered a healthy one in case it is continues without any complications from impregnation to birth.[1] Each year, almost 20% of the infants in the United States are born at the two ends of the embryo growth spectrum, with low weighted infants (less than 2500 grams) comprising half of these cases.[2] One of the most significant changes during pregnancy is weight gain in the pregnant woman as a result of the psychological process, which is a part of growth and development of the mother and her embryo. This weight gain is related to the growth of the embryo,[3] placenta, amniotic fluid, uterus tissues, lipid supplies,[3,4] and increase in the volume and compositions of blood and size of the breasts.[3] Mother's weight gain is one of the valid scales to control her nutrition.[4] Proper weight

gain is essential for the mother's health,[5, 6] pregnancy,[5] and embryo's growth and development.[5-7] In this respect, mother's Body Mass Index (BMI) before pregnancy is a useful index that is calculated by dividing weight in kilograms by height in meters squared.[6] Additionally, the process of weight gain during pregnancy affects its outcomes,[8, 9] and is an important index in predicting the infant morbidity and/or mortality.[2, 6] At the beginning of pregnancy, the mother must be ideally weighted to prevent the problems resulting from obesity or low weight.[6, 10] The least maternal mortality rate during pregnancy occurred in the mothers who had normal BMI before pregnancy.[2]

Generally, BMI<18.5, between 18.5 and 24.9, between 25 and 29.9, and >30 is regarded as low weight, normal weight, overweight, and obese, respectively.

The mother's weight before pregnancy is the most important index to determine BMI. It should be mentioned that the mother's weight three months before pregnancy can be considered as her pre-pregnancy weight in case it does not change significantly during this period.

In general, pregnant mothers should have a proper weight gain regardless of their nutrition. Insufficient weight gain is directly related to a decrease in growth and preterm birth.[3] Weight gain less than the recommended measures is also connected to preterm birth and low weight infants. On the other hand, neural tube defects are more prevalent in the children of obese mothers. The risk of preeclampsia is also twice higher by 5-7 kg/m^2 increase in BMI before pregnancy.[11, 12] Moreover, high weight gain during pregnancy affects obesity during childhood, metabolic diseases in the upcoming years, and mother's overweight and obesity after delivery.[3] Furthermore, weight gain more than normal along with macrosomia results in the mismatch of the embryo's head with pelvis, leading to delivery complications.[6] Several researches have proved that being overweight is accompanied by birth of huge infants[10, 13] and increase in the rate of caesarean deliveries, gestational diabetes,[4, 10, 13, 14] gestational hypertension,[4, 13] delivery bleedings,[2, 4, 10] infections, and intrauterine fetal death rates.

Considering the fact that the incidence of maternal and infantile complications is among the unpleasant pregnancy and delivery outcomes, healthcare before and during pregnancy should consider methods that decrease such unfavorable complications. However, no studies have been conducted in this field in Gerash, Iran. Thus, the present study aimed to determine the relationship between the mother's BMI and pregnancy and delivery outcomes in the mothers referred to Gerash health centers in 2014.

Materials and Methods

This retrospective, cohort study was conducted through census and we used the data of 554 pregnant cases referred to Gerash health centers to receive pregnancy healthcare from April to November 2014. Gerash is a city located in the south of Fars province in Iran with a population of about 35000 people. Because most of the men in this city earn money in Arab countries, the lifestyle of most people is similar to those of the Gulf States. Gerash has two health centers with 246 and 290 live births during this period. All health care for all age groups is provided at these two centers and all the residents of Gerash go to these two centers to receive health services. This research has been carried out using health records in these centers, which were previously collected by interviewing and testing the pregnant mothers.

Pregnant women with positive B-HCG test results also refer to these health centers within the first 12 weeks of gestation when healthcare providers measure their height, weight, and BMI and place them in low weight, normal, overweight, or obese groups based on their BMI. They also record the pregnant women's personal information, including age, occupation, number of pregnancies, deliveries, abortions, and live births, blood type, education level, the probable date of delivery, history of previous pregnancies, condition of the present pregnancy, history of diseases, and high-risk behaviors of the mother and father, in a special form. Based on the usual pregnancy care program, pregnant mothers refer to the health centers once in 6-10, 16-20, and 26-30 weeks of gestation, once in three weeks during 31-37 weeks, and every week from the 38th week.

The recommended weight gain during pregnancy based on BMI before pregnancy is as follows:[3] 12.5-18 kg in low weight mothers, 11.5-16 kg in mothers with normal weight, 7-11.5 kg in overweight mothers, and 5-9 kg in obese ones (details in appendix 1). The recommended weight gain in the first 3 months is 0.5-2 kg. However, the proper weight gain for mothers with BMI>35 must be determined by a nutritionist. Short women (less than 150 cm) should also gain the minimum weight presented in the above-mentioned ranges.

Weight gain pattern is also important. In fact, weight should be gained gradually. It is better for teenage mothers to reach the top of the above-mentioned recommended ranges.[3] Moreover, two series of tests were given to the pregnant women during the care period (in the first visit and 26-30 weeks) and the results were recorded.

The pregnant women were diagnosed with gestational hypertension in case their systolic and diastolic blood pressures were equal to or more than 90 and 140 mm/Hg, respectively or their systolic and diastolic blood pressures increased by 30 and 15 mm/Hg respectively or more compared to the baseline.

Diabetes mellitus is defined as the state of not tolerating glucose and causing a discord with body in the pregnant mother without any diabetes history.[3] In this study, the women with Fasting Blood Sugar (FBS) levels between 93 and 125 and >126 mg/dL were diagnosed as pre-diabetic and diabetic, respectively (more details in Appendix 3). The pregnant women who were diagnosed as normal or pre-diabetic in the first blood sugar test took the glucose tolerance test (75 gr glucose) in 24-28 weeks of gestation. In case FBS and one-hour and two-hour glucose levels were respectively equal to or more than 92, 180, and 153 mg/dl, the women were considered to be diabetic.

Delivery complications were extracted from the care forms, which were completed three times by the healthcare workers after evaluating the mother and measuring the child's birth weight. The pregnant mothers who had referred to the health centers after 12 weeks of gestation and did not know their pre-pregnancy weight were excluded from the study.

Firstly, the data were inserted into Excel 2010 software and accuracy of the information was assessed. Then, the data were analyzed using SPSS statistical software, version 19 of the IBM Company. At first, normal distribution of the data was checked using Kolmogorov-Smirnov test. Then, descriptive statistics, simple logistic regression, and simple linear regression were used to analyze the data. BMI at the beginning of pregnancy, number of pregnancies, mother's occupation, mother's age, and less-than-three-year interval with the previous pregnancy were inserted into regression model as independent variables, while gestational diabetes, hypertension, anemia, delivery type, length of pregnancy, and newborn's weight, height, and head circumference were regarded as dependent variables. It should be noted that total weight gain during pregnancy was once considered as an outcome variable for the mother's BMI, number of pregnancies, and age and once as an independent variable for different outcomes, such as newborn's birth weight, height, and head circumference. After that, the variables with P<0.25 in simple logistic regression and simple linear regression were entered into multiple regression model. In this study, the significance level was set at 0.05.

Results

Description of the Study Population

From 544 cases, only 467 with complete pregnancy data were studied. Among these cases, 16 (3.40%) were below 18 years old, 422 (90.40%) were 18-35 years old, and 29 (6.20%) were over 35 years old. In addition, 431 mothers (92.30%) were homemakers and 36 (7.70%) were employees. Besides, 200 participants (42.80%) were nulliparous, while 267 (57.20%) were multiparous.

Also, 236 (50.50 %) and 231 (49.50%) infants were boy and girl, respectively. The mean±SD of the mothers' age was 25.93±5.44 years. Additionally, mean±SD of the infants' height and weight was 50.43±2.47 cm and 3.04±0.47 kg, respectively.

Among the study subjects, 292 (62.50%) had Normal Vaginal Delivery (NVD), while 175 (37.50%) had caesarian section. Moreover, 90 pregnancies (19.30%) had occurred within a less-than-three-year interval with the previous pregnancy, while 377 of them (80.70%) had occurred with a more-than-three-year interval.

Based on BMI, 47 mothers (10.10%) were low weight, 240 (51.40%) were normal, 132 (28.30%) were overweight, and 48 (10.30%) were obese. The number of NVDs was 35 (74.50%) in low weight mothers, 168 in mothers with normal weight (70.00 %), 70 in overweight mothers (53.00%), and 19 in obese ones (39.60%). On the other hand, the number of cesarean sections in these groups was 12 (25.50%), 72 (30.00%), 62 (47.00%), and 29 (60.40%), respectively. Furthermore, the number of natural and cesarean deliveries were respectively 20 (52.60%) and 18 (47.40%) in low weight newborns, 268 (63.70%) and 153 (36.30%) in newborns with normal weight, and 4 (50.00%) and 4 (50.00%) in overweight newborns.

Out of all the pregnancies, 459 (98.30%) were singleton and 8 (1.70%) were multiple. Besides, 41 pregnancies (8.80%) were premature, 425 (91.00%) were term, and 1 (0.20%) was post-term. To analyze the data, the frequency of post-term infants was merged with that of the term ones. Considering pregnancy complications, 25 (5.40%), 24 (5.10%), 5 (1.10%), and 16 (3.40%) mothers got gestational diabetes, anemia, hypertension, and abnormal bleeding postpartum, respectively.

The overall mean of weight gain in the pregnant mothers was 11.67 kg; 11.61 kg (95% CI: 3.10-22.30) in NVDs and 11.77 kg (95% CI: 3.40-26.7) in cesarean sections. Mothers' weight gain based on other variables are shown in Table 1.

Analytical Data of the Study Population
Regression Analysis

The results of simple logistic regression analysis are presented in Table 2.

According to Table 2, a positive relationship was observed between BMI at the beginning of pregnancy and type of delivery (Odds Ratio (OR): 1.10 (95% CI: 1.05-1.14), P<0.001). After dividing BMI into its constitutent components and reanalyzing them, it was found that this relationship was due to the association between the mother's weight and type of delivery (OR: 1.03 (95% CI: 1.02-1.05), P<0.001). The results also

Table 1: Descriptive statistics of total weight gain in pregnancy according to the mothers' BMI and infants' birth weight

Mother's BMI (kg/m²)	Infant's birth weight (kg)	Number	Total weight gain in pregnancy (kg)			
			Mean	SD	Minimum	Maximum
Under weight	Normal	47	12.61	3.22	7.00	19.30
	Low birth weight	0	-	-	-	-
	Overweight	0	-	-	-	-
Normal	Normal	220	12.38	4.03	3.10	26.70
	Low birth weight	18	11.41	5.34	5.60	26.70
	Overweight	2	17.50	0.70	17.00	18.00
Overweight	Normal	114	10.51	3.90	3.70	22.30
	Low birth weight	15	9.97	4.98	3.80	20.00
	Overweight	3	14.13	2.96	11.90	17.50
Obese	Normal	40	10.46	3.35	3.30	16.50
	Low birth weight	5	11.48	6.19	4.00	17.70
	Overweight	3	8.66	1.25	7.50	10.00

Table 2: The results of simple logistic regression on the relationship between the study variables and different outcomes

Variable	Outcome				
	Diabetes	Hypertension in pregnancy	Anemia	Type of delivery*	Gestational age**
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
BMI (kg/m²)	0.92 (0.85-1.00)	0.99 (0.78-1.11)	0.99 (0.94-1.03)	1.10 (1.05-1.14)	0.93 (0.87-1.001)
Total weight gain (kg)	1.01 (091-1.11)	0.92 (0.75-1.12)	1.02 (0.97-1.07)	0.96-1.05))1.01	0.97 (0.90-1.05)
Number of pregnancies	0.83 (0.59-1.15)	1.49 (0.52-4.28)	0.95 (0.78-1.15)	1.17 (0.98-1.39)	0.94 (0.71-1.25)
Mother's age (years)	0.95 (0.98-1.03)	0.95 (0.82-1.12)	1.01 (0.97-1.05)	1.06 (1.03-1.10)	0.98 (0.92-1.04)
Interval between pregnancies (≤3 years)	1.34 (0.52-3.47)	0.001> (.000-)	0.73 (0.41-1.28)	1.04 (0.64-1.68)	1.34 (0.63-2.85)

*Type of delivery (normal / cesarean); **Gestational age (term / preterm)

showed that choosing the type of delivery was related to having experience of cesarean section (OR: 0.02 (95% CI: 0.01-0.077), P<0.001). However, according to the OR, it may not be indicated an important clinical significance.

Analysis of the quantitative variables using simple linear regression method revealed considerable results, as shown in Table 3.

The results of simple linear regression analysis showed no significant relationship between BMI at the beginning of pregnancy and newborn's height (P=0.60). However, dividing BMI into its components and reanalyzing revealed a significant relationship between the mother's height and newborn's height (P=0.03). Accordingly, 10% of the newborns' height changes were determined by changes in mothers' height.

The results of linear regression analysis for predicting the extent of weight gain during pregnancy and newborn's height are presented in Table 4. In this part, the number of pregnancies, age, and BMI at the beginning of pregnancy was inserted into model 1. The final analysis showed that BMI at the beginning of pregnancy and number of pregnancies had a greater effect on predicting weight gain during pregnancy (P<0.001). Moreover, weight gain during pregnancy and mother's height were inserted into

model 2. The results demonstrated that only weight gain during pregnancy was effective in prediction of the newborns' height.

Discussion

In the recent decades, the prevalence of obesity has increased in total and during pregnancy. The frequency of normal, obese, and overweight individuals in this study was 51.4%, 28.3%, and 10.3%, respectively. These measures were respectively reported as 69.9%, 11.5%, and 6.6% in Australia in 2006,[15] and 42.6%, 33.9%, and 23.5% in Iran in 2007.[13]

The results of simple analysis of the quantitative variables showed that BMI at the beginning of pregnancy was associated with weight gain during pregnancy and 3.9% of the changes were due to change in BMI. Accordingly, each unit of increase in BMI resulted in 0.173 unit decrease in weight gain. Similar results were also obtained by Gashtaspi et al.[7] In our study, weight gain was desirable among the women because of checking and nutritional advice given by the health staff during pregnancy healthcare. In fact, a minimum weight gain had occurred in the mothers with higher BMI to fulfill both mother's and embryo's nutritional needs.

Table 3: Simple linear regression on the relationship between the study variables and different continuous outcomes

Variable	Outcome											
	Infant's birth weight (g)			Infant's birth height (cm)			Infant's birth head circumference (cm)			Total weight gain duration pregnancy (kg)		
	Relative mean difference	95% CI	P value	Relative mean difference	95% CI	P value	Relative mean difference	95% CI	P value	Relative mean difference	95% CI	P value
BMI (kg/m2)	4.59	-4.64 - 13.82	0.32	-0.01	-0.06 – 0.03	0.60	0.00	-0.02 – 0.03	0.77	-0.17	-0.25 - -0.09	0.001>
Total weight gain (kg)	18.42	8.02-28.82	0.001	0.09	0.04 – 0.15	0.001	0.03	-0.002 – 0.07	0.06	---	---	---
Number of pregnancies	16.36	-22.92 -55.64	0.41	-0.55	-0.26 – 0.15	0.60	0.09	-0.03 - 0.23	0.16	-0.73	-1.06 - -0.402	0.001>
Mother's age (years)	-3.17	-11.05 – 4.70	0.43	-0.03	-0.07 – 0.005	0.08	0.008	-0.01 – 0.03	0.55	-0.13	-0.19- -0.06	0.001>

Table 4: Multiple logistic regression on the relationship between different variables and total weight gain duration pregnancy and infant's birth height

Variable	Outcome	Relative mean difference	Relative mean difference	95% CI	P value	
Constant	Total weight gain (kg)	16.15	-	14.25-18.56	<0.001	*Adjusted for mother's age
BMI	Total weight gain (kg)	-0.15	0.05	-0.21- -0.05	0.001	
Number of pregnancies	Total weight gain (kg)	-0.15	0.05	-0.93- -0.25	0.001	
Constant	Infant's birth height	49.32	-	48.651-50.006	<0.001	*Adjusted for mother's height
Total weight gain during pregnancy	Infant's birth height	0.15	0.02	0.04-0.15	0.001	

The results also showed that weight gain during pregnancy, as an indicator of the pregnancy condition, was related to the newborn's weight and height independently from BMI. According to the results, each unit increase in weight gain during pregnancy resulted in 18.423 units increase in newborn's weight and 0.095 units increase in its height. Furthermore, 2.5% of the changes in the newborn's weight ($R^2=0.025$) and 2.4% of those in its height ($R^2=0.024$) were due to changes in the weight gain at the beginning of pregnancy. This was confirmed by the results of other studies.[16, 17] In fact, the embryo's growth depends on the mother's nutrition, especially during pregnancy. On the other hand, the mother's weak nutrition leads to the placenta's lower weight and smaller circumference, which might affect the ability to transfer food from the mother to the growing embryo.

In the study by Zohoor,[18] weight gain during pregnancy had no relationship with the newborn's weight, which was in contrast to the results of other studies and the present one, as well. This difference might be due to the fact that weight gain during pregnancy and newborn's weight depend on various factors, such as mother's age, number of pregnancies, interval between pregnancies, disease during pregnancy, nutritional supplies during pregnancy, and mother's mental and psychological conditions.

In our study, the number of pregnancies was another effective variable in weight gain during pregnancy. Based on the findings, one unit increase in the number of pregnancies resulted in 0.735 units decrease in weight gain, and 3.9% of changes in the weight gain were due to changes in the number of pregnancies. Mother's age was also related to weight gain during pregnancy in simple analysis. Accordingly, one unit increase in the mother's age led to 0.131 units decrease in weight gain, and 3.1% of changes were the related to the mother's age. In fact, increase in age leads to increase in the number of pregnancies, eventually increasing the probability of obesity.

In the current study, the results of univariate analysis showed a significant relationship between the mother's age and height and newborn's height. However, this relationship was not seen in adjusted analysis. Therefore, these variables can play a confounding role in relation to other dependent variables.

In general, advice for weight control especially between pregnancies, proper education, and considering proper weight gain during pregnancy can decrease the complications of pregnancy and delivery. In this study, the pregnant women were visited regularly by healthcare providers and advised to follow a healthy diet and gain proper weight during pregnancy.

The strong point of this study was the representativeness of Gerash's pregnant women. However, the main limitation of the study was lack of access to the data related to some pregnancies due to immigration or mother's untimely reference and lack of weight records at the beginning of pregnancy. Since other factors than BMI at the beginning of pregnancy can affect the complications of pregnancy and delivery, future studies are suggested to assess other factors, such as nutrition, physical activity, embryo's anthropometric indicators during pregnancy, sonographic measures of growth, and weekly weight gain.

Conclusion

Based on the results of the present study, BMI at the beginning of pregnancy was related to weight gain and type of delivery. Also, weight gain was independently related to the newborn's weight and height. Therefore, prevention is the best way to avoid problems. It is necessary for health caretakers in health centers to do educational planning and advise the mothers to reach their ideal weight. Moreover, considering the importance of weight gain during pregnancy and its effects on pregnancy and delivery outcomes, the role of health officials will be more important than ever in promoting the general knowledge about proper nutrition and weight gain during pregnancy.

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