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Original article

Gestational weight gain during pregnancy and its determinants: A longitudinal study

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Abstract

Background: Gestational weight gain during pregnancy is supposedly associated with the increased risk of some adverse outcomes. Thus, assessing the trend of gestational weight gain and its associated risk factors for each population may reduce the related harms. We examined the trend of gestational weight gain and some of its associated risk factors in a sample of Iranian pregnant women.

Methods: From five health centers in Isfahan, 458 pregnant women were selected through a multi-stage sampling method. The gestational weight gain was measured nine times during pregnancy. The latent growth curve model was used to investigate the trend of gestational weight gain and a random effects model was used to identify the factors affecting gestational weight gain during pregnancy.

Results: The mean weight at the baseline was 58.7 ± 0.1 kg. It increased by a mean of 301 ± 0.0 grams per week. The pre-pregnancy weight ($p<0.001$) and parity ($p<0.001$) had a significant indirect effect, and mother's height ($p=0.028$) had a significant direct effect on gestational weight gain. Mother's age showed no significant effect on weight gain during pregnancy.

Conclusion: More than 50% of our sample had an abnormal weight gain. Thus, according to the criteria proposed by the American Institute of Medicine (IOM), it is vital to promote the knowledge of women and health care providers and raise their awareness about the determinants of abnormal gestational weight gain and their consequences.

Keywords: Gestational weight gain, Longitudinal study, Pregnancy, Trend analysis

Introduction

It is generally assumed that pregnancy is one of the most challenging experiences in a woman's life. Prenatal care can supposedly play an important role in the health of mothers and their fetuses during this stage of life (1). It is also believed that lack of access to appropriate prenatal care can, nevertheless, lead to an increased risk of premature birth, even stillbirth, and can further exacerbate other complications of pregnancy such as high blood pressure (2).

One of the major concerns of pregnant women, as it seems, is the appropriate weight gain during pregnancy. Normal weight gain is presumed to be one of the determinants of neonatal survival and future physical and mental growth of children (3). To avoid adverse consequences, according to American institute of medicine (IOM), the gestational weight gain should be in a range of 11 to 16 Kg during pregnancy(4). According to the results of a study by Centers for Disease Control and Prevention (CDC), which was conducted on a large sample of women who delivered

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live infants in the USA during 2000 to 2009, 36% of all the studied women gained weight within the recommended range, 44% more than the recommended range, and 20% less than the recommended range (5). It is worth noting that the determinants of gestational weight gain such as pre-pregnancy weight, age, height, the number of previous birth (parity), the history of alcohol consumption, smoking, and blood pressure have been assessed by previous studies (6), but the results are rather controversial and vary across different populations. In addition, previous studies on gestational weight gain in Iran had cross-sectional design and did not use proper statistical methods to evaluate the trends and determinants (7).

Thus, this study followed two main objectives. The first one was to describe the trend of weight gain in Iranian pregnant women using latent growth models as a powerful statistical approach for the longitudinal evaluation of the trend, and the second one was to determine some effective factors leading to weight gain during pregnancy through Grows Latent Models (GLM).

Materials & Methods

All procedures performed in this historical cohort study, involving human participants, were approved and confirmed by the ethics committee of Shahid Beheshti University of Medical Sciences and its later amendments or comparable ethical standards.

In this study, 458 pregnant women were selected in Isfahan through a multistage sampling technique. First, Isfahan was divided into five different districts (northern, southern, eastern, western, and the center), and then one health center was randomly selected in each district. After that, the health documents of the pregnant women in these five centers were reviewed. To investigate the intra-individual variation over time, the mother's weight was recorded at 9 different time intervals during pregnancy. In addition, to assess how other factors affected the gestational weight gain, we recorded some potential explanatory variables such as maternal pre-pregnancy weight, height, age, and the number of previous pregnancies (parity). Maternal weights had been measured at different times, and some cases did not attend the health centers for some measurements: as a result, we had some missing values in our collected data. Therefore, in order to increase the accuracy of results, the multiple imputation method for estimating the missing longitudinal data was used (8).

The trend of gestational weight gain was assessed through latent growth curve models. Latent growth curve models are supposedly powerful statistical tools, which can combine the random effects modeling approach with the structural equation models. This is done to take both the intra and inter-individual variations into account, which is helpful in analyzing trends in longitudinal studies (9-11).

To achieve the second objective, i.e., to evaluate the effect of different explanatory variables on maternal weight gain during pregnancy, we used the random intercept model (also called the generalized linear mixed model). Using this type of statistical model, one can account for heterogeneity among subjects through adding random terms to the model (12).

In this study, the utilized random intercept model can be written as:

$$(4) g[E((\text{Weight gain})it|bi)] = \boldsymbol{\beta}_0+\boldsymbol{\beta}_1(\text{Baseline Weight})_I + \boldsymbol{\beta}2(\text{Height})_I +\boldsymbol{\beta}_3(\text{No of Births})_i +\boldsymbol{\beta}4(\text{Age})_i+\boldsymbol{\beta}5(\text{Time})_{ij}+b0_i$$

Where the base line weight is the weight before pregnancy in kg, the height is the mother's height in cm, the no of births is the number of previous pregnancies, the age is the mother's age in years, and the time is the gestational age in week.

In order to analyze the data, we used the M-plus software (version 6.0) for fitting the growth curve model and STATA software (version 14.0) for fitting the random intercept model.

Results

The means (SD) for age, height, and body mass index of mothers were 26.4 (4.4) years, 160.7 (6.0) cm, and 23.5 (3.9) kg/m2, respectively. About 44.1% of pregnant women had at least one previous pregnancy, and 14.6% had a history of at least one abortion. In addition, 26.9% of mothers had a history of cesarean delivery, 5.6% of mothers had experienced gestational diabetes, and 20.6% had a history of diabetes in their families.

The mean (SD) for the total weight gain of mothers during pregnancy was 12.3 (4.1). Table 1 shows the descriptive statistics for the gestational weight gain at different times of measurement, and Figure 1 displays the trend of gestational weight gain over time. The

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maximum gestational weight gain was in 26 to 30 weeks of pregnancy (about 2.7 kg). About 19.2% of pregnant women who had body mass index (BMI) of less than 19.8 Kg/m2 before pregnancy experienced a gestational weight gain over the recommended values by IOM (more than 16 kg). Among women with normal BMI before pregnancy (19.8 to 26.0 kg), about 57.4% of them experienced a normal weight gain (11 to 16 kg) during their pregnancies. About twenty four percent of them experienced less than the recommended gestational weight gain by IOM (under 16 kg), and 18.3% experienced more than the recommended rang (over 16 kg) among women who were overweight or obese before pregnancy (BMI more than 26), 46.9% of them experienced gestational weight gain in the recommended range by IOM (under 11kg).

Table 1: Descriptive statistics of maternal weight gain during the study period

Time	Min	Max	Mean	SD
11 to 15 weeks	-2.0	4.0	0.2	0.5
16 to 20 weeks	-5.0	11.5	2.1	2.1
21 to 25 weeks	-2.8	12.5	4.0	2.4
26 to 30 weeks	-1.0	21.0	6.7	3.4
31 to 34 weeks	0.0	22.5	8.9	3.7
35 to 37 weeks	1.0	27.0	10.7	4.0
38th weeks	1.7	27.0	11.6	4.0
39th weeks	1.5	27.4	12.1	4.1
40th week	1.7	27.5	12.3	4.1



Figure 1: Trend of weight gain in pregnant women under study

Table 2 represents the trend of gestational weight gain by latent growth curve model. The average weight gain was estimated to be 307 gr per week among Iranian pregnant women.

Table 3 indicates that the random intercept model with 1 cm increased in maternal height, and the gestational weight increased by an average of 54 gr, which was significant (p=0.028). It is worth noticing that with 1 kg increase in pre-pregnancy weight, the gestational weight decreased by an average of 45 gr (p<0.001). With an increase in the number of previous pregnancies, the gestational weight decreased by an average of 786 gr (0.001). With one week increase in gestational age, the gestational weight increased by an average of 310 kg per week (p<0.001). We did not found any significant relationship between the maternal age and the gestational weight gain (p=0.303).

The significant estimated variance in the random intercept model demonstrates the presence of heterogeneity among maternal weights at the outset of the study (p<0.001).

Table 2: Results of fitting the latent growth curve model for assessing the trend of maternal weight gain Significant at 5% level

Model component	**Estimated mean**	**Estimated variance**
Intercept	58.710 (0.531)*	0.089 (0.025)*
Slope	0.307 (0.005)*	0.011 (0.001)*

*Significant at 5% level

Table 3: Results of fitting the random effects model for assessing the effect of different factors on weight gain

Variables	**Coefficients**	**Standard error**	**P-value**
Age (years)	-0.040	0.038	0.303
Height (cm)	0.054	0.240	0.028
Weight (kg)	-0.045	0.013	0.001
parity	-0.786	0.233	0.001
Time (weeks)	0.310	0.002	<0.001
Variance Component	7.12	-	<0.001

*Significant at 5% level

Discussion

In this study, the gestational weight gain was lower than normal in 28% of pregnant women, normal in 49%, and higher than normal in 23%. According to the

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results of a study conducted by the American Centers for Disease Control and Prevention (CDC) from 2000 to 2009, the gestational weight gain of women was within the recommended range in 36% of pregnant women, while in 44% was higher than recommended rang of IOM, and in 20% was lower than the recommended range (13). Wong et al. reported that only 28% of Australian women gained weight within the recommended range (14). It should be noted that the normal weight gain, as recommended by IOM, is higher in our study. Yekta et al. conducted a study on pregnant women in Urmia and found that about 43% of women gained weight within the recommended range (13), which was consistent with the results of our study in Isfahan. It is worth mentioning that the mean gestational weight gain in this study is similar to those of the previous studies in Brazil and Indonesia. In contrast, other studies in the United States found higher average gestational weights than our study (15, 16).

In our study, the utilized model showed an indirect relationship between parity and weight gain during pregnancy. This means that with the increase in the number of previous pregnancies, the mean of the maternal weight gain decreases. In order to reduce the risk of high birth weight, the IOM, based on clinical judgment, recommends that short women gain less weight during pregnancy than taller ones (17). In the present study, height was one of the significant factors, influencing maternal weight gain during pregnancy. It is worth noting that with an increase in height, the maternal weight gain during pregnancy increased, too. This finding is consistent with the results of some other studies. For instance, Akbladet et al., in Finland, investigated the effect of important variables affecting maternal weight gain, and reported a direct effect of height on maternal weight gain in pregnant women (6). In addition, Abrams et al., in San Francisco, examined pregnant mothers every three months and concluded that height had a significant direct impact on maternal weight gain in all the three trimesters. Also, Straube et al. found that weight gain during pregnancy differed in height groups among German mothers with the same BMI (18, 19).

In the present study, the maternal weight before pregnancy had a significant indirect effect on the maternal weight gain during pregnancy. In other words, it was found that women with higher weights before pregnancy experienced lower weight gain during pregnancy. In a study on Chinese mothers, the results of multiple regression model showed that pre-pregnancy weight had a significant indirect effect on weight gain in pregnant women (20). In another study on Mexican women, it was stated that pre-gestational BMI was indirectly associated with the weight gain during pregnancy (21).

In this study, as expected, an upward trend was observed for women's weight during pregnancy. In other words, the weight of women under study showed a mean increase of 310 gr per week during the pregnancy period. In a study on Brazilian pregnant women, which was conducted between 2005 and 2007, the researchers used longitudinal data models to investigate the effect of time on maternal weight gain. According to the results, time had a significant effect on maternal weight gain during pregnancy, and for each increase of week in the gestational age, there was an increase of 0.41 kg in weight gain (22). In addition, a non-linear (quadratic and cubic) relationship between gestational age and pregnant mothers' weight was found in another research using the multilevel analysis (23).

In the present study, we found no significant relationship between maternal age and weight gain during pregnancy. This finding is in agreement with a study in Finland (24). The association between maternal age and weight gain during pregnancy is somewhat sophisticated. In the same vein, a study reported a significant direct relationship between maternal age and weight gain during pregnancy, on the other hand, another reported a negative association (18, 22). The lack of relationship between mother's age and weight gain could be attributed to the presence of parity variable in the random effects model. Since the number of previous pregnancies increases with the increase of maternal age (significant correlation between age and parity), the significant relationship between parity and weight gain may result in an insignificant association between maternal age and weight gain in the modeling process.

Variables such as smoking, the history of diabetes, the history of alcoholism, and the status of blood pressure in mothers are among the other factors, which could be considered and examined in this study. However, we did not include them in our random effects model because of the lack of enough information in women health files. Nevertheless, these

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variables have been investigated and discussed in some previous studies (15, 21, 23, 25, 26).

Our research had some limitations, too. Inadequate sample size could be regarded as a major limitation for the present study. To overcome this problem, we gathered repeated observations, as longitudinal data, for each woman under study to compensate for the lack of sufficient sample size. Another limitation of our study was the presence of missing data in some measurement over time. To overcome this problem, we used the multiple imputation methodology for estimating the missing observations in longitudinal data (11). The first advantage of this study was the longitudinal data gathering process, which provided more accurate information about the gestational weight gain over time. Second, to the best of our knowledge, the previously published studies in this field mostly applied unvaried tests for cross-sectional data analysis or used simple statistical models such as multiple regression or MANOVA, which have lower statistical power for detecting the relationship between variables under study (17). The use of more advanced statistical models enabled us to study the longitudinal trend of gestational weight gain and the effect of its potential indicators more properly.

Conclusion

According to the results of this study, the mean weight gain of the sampled women during pregnancy was about 12.3 Kg, which was within the normal limits recommended by the World Health Organization and the Institute of Medicine. However, our findings showed that about 51% of women were not in the normal range. As the weight gain has a undeniable impact on maternal and children's health, it is necessary for physicians and other people working in this field to become more familiar with this trend and pay a special heed to the cases who are not within the normal range or those who are exposed to the risk of the indicators of abnormal weight gain.

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Conflicts of Interest

None declared.

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