Taiwanese Journal of Obstetrics & Gynecology 58 (2019) 196–200

Contents lists available at ScienceDirect

Taiwanese Journal of Obstetrics & Gynecology

journal homepage: www.tjog-online.com

Original Article

Total gestational weight change and rate of change in pregnant Taiwanese women

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A R T I C L E I N F O

Article history:
Accepted 17 August 2018

Keywords:
Body mass index
Hierarchical linear modeling
Pregnancy
Gestational weight gain
Body weight

A B S T R A C T

Objective: The purpose of this study was to estimate and compare total gestational weight gain (GWG) and the trimester-specific mean rate of GWG based on pre-pregnancy body mass index (BMI) as recommended by the Institute of Medicine (IOM).

Materials and methods: The medical records of 470 participants who had received antenatal care at medical teaching hospitals in northern Taiwan and who delivered after 37 weeks of pregnancy were analyzed.

Results: The mean total GWG was 13.84 (SD = 4.33) kg, and nearly 60% of women had not complied with the current IOM recommendations for total GWG. The best-fit model for the mean GWG rate revealed that all groups had a GWG rate of zero in the 1st trimester and had an equivalent mean GWG rate in the 3rd trimester. Women tended to have excessive weekly GWG in the 2nd and 3rd trimesters, and women with a higher pre-pregnancy BMI were more likely to have excessive weekly GWG in the 2nd and 3rd trimesters. Moreover, the plurality of normal-weight (30.4%), overweight (75.8%) and obese (62.5%) women experienced excessive weekly weight gain during the 2nd and 3rd trimesters. Few women met the recommended 2009 IOM weekly weight-gain guidelines in the 2nd trimester, but more met them in the 3rd trimester.

Conclusion: These findings indicate that most pregnant Taiwanese women currently exceed the total and weekly GWG recommendations of the IOM. More specifically, weekly GWG in excess of the IOM recommendations is common among normal-weight, overweight and obese women.

Introduction

Gestational weight gain (GWG) has important health implications for both the mother and the child [1–3]. The GWG recommendations that follow the Institute of Medicine (IOM) guidelines are 12.5–18 kg for underweight women (BMI<19.8), 11.5–16 kg for women of normal weight (BMI 19.8–25.9), 7–11 kg for overweight women (BMI 26–29), and 7 kg for obese women (BMI≧30) [4]. The 2009 IOM also suggests a pre-pregnancy BMI-specific weekly GWG rate for the 2nd and 3rd trimesters of 0.44–0.58 kg/week for underweight women, 0.35–0.50 kg/week for women of normal weight, 0.23–0.33 kg/week for overweight women and 0.17–0.27 kg/week for obese women.

Several studies have demonstrated that GWG that exceeds IOM recommendations increases the health risks for mothers and fetuses [3,5,6]. Chmitorz et al. found that based on trimester-specific guidelines, excessive GWG can be predicted for overweight and obese mothers, whereas inadequate GWG can be predicted for mothers who are underweight or of normal weight [7]. Huang et al. found that the rate of GWG in the 2nd and 3rd trimesters was independently associated with premature births, although GWG also varied based on the pre-pregnancy BMI and the trimester [8]. Therefore, the pre-pregnancy BMI and trimester-specific rate of GWG are associated with and are important determinants of

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https://doi.org/10.1016/j.tjog.2019.01.005

maternal and fetal health. However, neither total GWG nor weekly GWG is discussed with women as an important indicator to monitor and control their GWG during pregnancy. Many studies calculate only the total GWG to predict impacts on maternal and neonatal health [3,5] but do not include measurements of weekly GWG [8]. Therefore, we do not clearly understand the changes in weekly GWG for weight control across trimesters by pre-pregnancy categories. To our knowledge, no studies have examined the changing trends in weekly GWG in the 2nd to 3rd trimesters according to pre-pregnancy BMI.

Thus, the objective of this study was to estimate the total GWG and the mean rate of GWG as assessed by trimester-specific and pre-pregnancy BMI and in relation to the IOM's recommendations. Using pre-pregnancy BMI, we estimated the changes in the total GWG and mean rate of GWG from the 2nd to 3rd trimesters.

Methods

Study participants

The participants were recruited in the postpartum unit of a hospital in the Taipei area. A total of 533 pregnant women agreed to participate in this study. Women were included if they met the following inclusion criteria: had delivered singleton healthy infants, could read and write Chinese, were at ≥37 weeks gestation, and had not experienced any perinatal complications. The final sample included 470 women (88.0%) who met the inclusion criteria. Of these, 353 (75.1%) were in the normal-weight group, 56 (11.9%) were in the underweight group, 49 (10.4%) were in the overweight group, and 12 (2.6%) were in the obese group.

Data collection

The data were collected between October 2010 and January 2011. Participants who met the inclusion criteria and voluntarily accepted the invitation to participate in the study received an explanation of the study and signed a consent form. This study was approved by the institutional review board of Taipei's Far Eastern Hospital (no. 099064-F). We collected primary and secondary data through questionnaires and medical records. The primary data included demographic variables (pre-pregnancy body weight, height, age, level of education and occupation) and perinatal variables (para and abortion history), which were reported by the participants. Secondary data, such as gestational age and gestational body weight, were obtained through medical records. The mean number of prenatal checkups and services per woman in our sample was 9.25 (SD = 2.44; minimum = 3; maximum = 14).

Data analysis

Changes in body weight were evaluated using multi-group growth models *via* hierarchical linear modeling (HLM). We analyzed the body-weight changes for the four groups over the three trimesters based on BMI using HLM to create a two-level hierarchical model in which repeated individual weight measures were nested [9]. The Level 1 model for individual weight changes focused on individuals by examining each participant's degree of weight change via repeated weight assessments over time. The Level 1 equation was specified as a function of trimester time. The Level 2 equations contained random coefficients to estimate the average body-weight changes and the trimester-specific mean GWG (as a slope). Random effects were used to estimate the individual differences in GWG over all three trimesters. Based on the above model settings, HLM could estimate the individual slopes for three trimesters. Following the recommendations of the IOM, we classified the women into "inadequate," "adequate" and "excessive" groups.

Descriptive analyses of demographic variables, perinatal variables and body-weight data were performed using the SPSS 22.0 software package (SPSS Inc., Chicago, IL, USA). An SPSS mixed-module was used to conduct HLM. Model fit was determined, and comparisons were made by examining fit indices with Information Criteria (IC) (i.e., the Bayesian information criterion (BIC) [10] and the Consistent Akaike's Information Criterion (CAIC) [11]) as well as the deviance chi-square difference test [12]. Lower BIC and CAIC indicate a better model fit. The three trimesters and four pre-pregnancy BMI groups were included in the HLM. The outcome variables were body weights and estimated growth models for these four groups. The level of significance was set at 5%.

Results

Participants' characteristics

The mean age of the participants in this study was 31 years (SD = 4.05). Most of the women had completed a university degree and a graduate degree (76%), 288 (61.3%) had a full-time job, 60% were primipara, and most (75.1%) had a normal pre-pregnancy BMI (Table 1). Most had never had an abortion (98.7%), and 75.1% were of normal weight.

Total GWG and the trimester-specific mean rate of GWG

The mean total GWG was 13.84 kg (SD = 4.33), as shown in Table 2. Based on pre-pregnancy BMI, both underweight women and women of normal weight gained weight appropriately during gestation. However, overweight and obese women gained 12.06 kg (SD = 4.13) and 12.19 kg (SD = 4.59), respectively, which were well above the recommended levels (Table 2).

We used multi-group growth models via HLM to estimate the changes in the rate of GWG over all three trimesters for all four groups of women. Table 3 presents the mean rate of GWG in the 2nd and 3rd trimesters by pre-pregnancy BMI. Based on the current guidelines, both the underweight (0.52 kg/week and 0.49 kg/week) and normal-weight (0.49 kg/week and 0.49 kg/week) groups were within the recommended ranges in the 2nd and 3rd trimesters. However, both the overweight (0.42 kg/week and 0.48 kg/week) and obese (0.35 kg/week and 0.48 kg/week) groups exceeded the mean GWG range in the 2nd and 3rd trimesters. Moreover, the underweight, normal-weight, overweight and obese groups

Table 1
Demographic data.

Variables	N	%
Educational level		
High school or less	113	24.0
College/university	320	68.1
Graduate school	37	7.9
Work status		
Full-time	288	61.3
None or part-time	182	38.7
Para		
Primipara	282	60.0
Multipara	188	40.0
Abortion history		
Yes	6	1.3
No	464	98.7
Pre-pregnancy BMI		
Underweight (<18.5)	56	11.9
Normal weight (18.5–24.9)	353	75.1
Overweight (25–29.9)	49	10.4
Obese (≥30)	12	2.6

Table 2
Differences between the IOM recommendations and total gestational weight gain in our cohort by BMI categories.

Pre-pregnancy BMI (kg/m^2)	Participants			BMI-specific IOM standard
	n (%)	Mean (SD)	Range	Range (kg)
Underweight	56 (11.9)	14.88 (4.23)	5.8–30.40	12.5–18.0
Normal weight	353 (75.1)	13.98 (4.29)	3.2–32.20	11.5–16.0
Overweight	49 (10.4)	12.06 (4.13)	3.2–20.20	7.0–11.5
Obese	12 (2.6)	12.19 (4.59)	6.5–21.00	5.0–9.0
Total	470 (100.0)	13.84 (4.33)	3.2–32.2.0	

Table 3
Differences between the IOM recommendations and the rate of weekly GWG by BMI category in the 2nd and 3rd trimesters (estimated via multi-group HLM).

Pre-pregnancy BMI (kg/m^2)	2nd trimester	3rd trimester	BMI-specific IOM standard	
	Mean (SE)	Mean (SE)	Mean (kg/week)	Range (kg/week)
Underweight	0.52 (0.03)	0.49 (0.02)	0.51	0.44–0.58
Normal weight	0.49 (0.01)	0.49 (0.01)	0.42	0.35–0.50
Overweight	0.42 (0.03)	0.48 (0.03)	0.28	0.23–0.33
Obese	0.35 (0.06)	0.48 (0.05)	0.22	0.17–0.27

exceeded the mean GWG rates recommended by the IOM, while in the 3rd trimester, the underweight group met the IOM's recommended mean rate (0.51 kg/week).

Pre-pregnancy BMI and relation to the IOM's recommendations

Table 4 presents the percentage of women with inadequate, adequate, or excessive total and weekly gestational weight gain according to the IOM guidelines. Nearly 60% of all women had either inadequate or excessive total GWG according to the current guidelines. Approximately 40.9% of the women had adequate IOM-recommended GWG; 51.8% of the underweight women and 39.7% of the normal-weight women exhibited adequate GWG. However, 51% of the overweight women and 66.7% of the obese women gained weight in excess of the recommended levels.

Approximately 45% of all women exceeded the IOM-recommended GWG rate in the 2nd trimester, and 50.5% exceeded it in the 3rd trimester. Moreover, a plurality of all normal-weight, overweight and obese women exhibited excessive weekly weight gain in both the 2nd and 3rd trimesters. The weight gain rate increased with increasing BMI and with the trimester for all four BMI categories. The adequate weight gain rate decreased by trimester, with calculated rates of 6.8%, 34.8%, 8.7%, and 0% for the four BMI categories.

The best-fit model for the mean GWG rate

We compared the HLM-generated growth models for the pre-pregnancy BMI groups and selected the one with the best fit. The best-fit model for the mean GWG rate revealed that all groups had a GWG rate of zero in the 1st trimester and an identical mean GWG rate in the 3rd trimester. However, in the 2nd trimester, all the groups exhibited different mean GWG rates, and the CAIC and BIC had smaller values: 14187.443 and 14167.443, respectively ($\chi^2 = 6.18$, $p = 0.52$).

The changing of trimester-specific GWG

Table 5 presents the changing trends, by pre-pregnancy BMI, from the 2nd trimester (inadequate, adequate and excessive GWG) to the 3rd trimester. Nearly one-third of all groups exhibited excessive weekly weight gain from the 2nd to the 3rd trimester. Furthermore, most of the normal-weight (30.4%), overweight (75.8%) and obese (62.5%) women exhibited excessive weekly GWG during the 2nd trimester and again during the 3rd trimester. However, few women met the recommended 2009 IOM weekly weight gain guidelines in the 2nd trimester and in the 3rd trimester were underweight (7.8%), normal weight (12.3%), overweight (6.1%) or obese (0%).

Table 4
Percentage of women with inadequate, adequate, or excessive total and weekly gestational weight gain according to the IOM guidelines.

Trimester	Pre-pregnancy BMI	Sample size	Inadequate	Adequate	Excessive
Total	Underweight	56	30.4	51.8	17.9
	Normal weight	353	33.1	39.7	27.2
	Overweight	49	10.2	38.8	51.0
	Obese	12	0.0	33.3	66.7
	Total	470	29.6	40.9	29.6
2	Underweight	50	24.0%	52.0%	24.0%
	Normal weight	242	12.8%	42.6%	44.6%
	Overweight	34	5.9%	20.6%	73.5%
	Obese	8	0%	37.5%	76.5%
	Total	334[a]	13.5%	41.6%	44.9%
3	Underweight	56	37.5%	26.8%	35.7%
	Normal weight	351	18.2%	34.8%	47.0%
	Overweight	46	6.5%	8.7%	84.8%
	Obese	12	8.3%	0%	91.7%
	Total	465[b]	19.1%	30.3%	50.5%

Note: Participants have only one data point of body weight in each of the 2nd and 3rd trimesters, but more than two data points of body weight should be used to estimate the mean rate of GWG.
[a] A total of 43 participants had one data point of body weight and 93 participants had no data point of body weight in the 2nd trimester.
[b] A total of 5 participants had one data point of body weight in the 3rd trimester.

Table 5
The percentage of women with inadequate, adequate, or excessive weekly gestational weight gain according to the IOM guidelines for the 2nd and 3rd trimesters (n = 360).

2nd trimester	3rd trimester			
	Inadequate n (%)	Adequate n (%)	Excessive n (%)	All n (%)
All				
Inadequate	18 (5.4)	12 (3.6)	13 (3.9)	43 (12.8)
Adequate	44 (13.1)	36 (10.7)	46 (13.7)	126 (37.5)
Excessive	16 (4.8)	39 (11.6)	112 (33.3)	167 (49.7)
Underweight				
Inadequate	6 (11.8)	2 (3.9)	2 (3.9)	10 (9.6)
Adequate	12 (23.5)	4 (7.8)	7 (13.7)	23 (45.1)
Excessive	4 (7.8)	6 (11.8)	8 (15.7)	18 (35.3)
Normal weight				
Inadequate	11 (4.5)	10 (4.7)	10 (4.1)	31 (12.7)
Adequate	30 (12.3)	30 (12.3)	35 (14.3)	95 (38.9)
Excessive	11 (4.5)	33 (13.5)	74 (30.4)	118 (48.4)
Overweight				
Inadequate	1 (3.0)	0 (0)	1 (3.0)	2 (6.1)
Adequate	1 (3.0)	2 (6.1)	2 (6.1)	5 (15.2)
Excessive	1 (3.0)	0 (0)	25 (75.8)	26 (78.8)
Obese				
Inadequate	0 (0)	0 (0)	0 (0)	0 (0)
Adequate	1 (12.5)	0 (0)	2 (25.0)	3 (37.5)
Excessive	0 (0)	0 (0)	5 (62.5)	5 (62.5)

Discussion

The purpose of this study was to estimate and compare the total GWG and trimester-specific mean rate of GWG based on pre-pregnancy BMI as recommended by the IOM. Our study found that the mean total GWG was 13.84 kg, which met the ideal range of recommended gain in Taiwan of 10–14 kg [13]. However, approximately 60% (29.6% inadequate and 29.6% excessive GWG) of the women did not comply with the current guidelines for total GWG. Our study also found that women who had a higher pre-pregnancy BMI tended to exhibit more excessive weekly GWG in the 2nd and 3rd trimesters and increasing GWG with each trimester compared to the women who had a lower pre-pregnancy BMI. The weight gain rate among pregnant women with lower BMI is associated with a lower risk of adverse outcomes [14], but an excessive weight gain rate among women with higher pre-pregnancy BMI is associated with increased adverse outcomes [3]. Our findings clearly show that more than two-thirds of obese and overweight women gained above the IOM recommendations, and being overweight or obese increased their risk of excessive GWG, consistent with a previous study [7]. Although overweight and obese women needed to gain comparatively little weight to achieve an adequate rate of GWG, it was still difficult for these women to meet the IOM recommendations.

Our study also indicated that few (10.7%) Taiwanese pregnant women could maintain adequate weekly GWG during the 2nd and 3rd trimesters. Moreover, more than one-third of women exhibited excessive weekly weight gain from the 2nd trimester to the 3rd trimester. Specifically, weekly GWG in excess of the IOM recommendations was common among normal-weight (30.4%), overweight (75.8%) and obese women (62.5%). Therefore, not only did obese and overweight women show excessive weekly and total GWG, but normal-weight women also exhibited excessive weekly weight gain in both the 2nd and 3rd trimesters. This finding is inconsistent with previous studies that reported that being normal weight increases the risk for inadequate GWG [7]. Normal weight was the most common BMI category among our group of women who exhibited excessive weekly GWG, and we found that this excessive weekly GWG may be a common phenomenon among pregnant Taiwanese women. Therefore, excessive total and weekly gestational weight control is a prenatal health problem for Taiwanese pregnant women. Several studies have demonstrated that GWG that exceeds IOM guidelines in pregnancy is strongly associated with both short- and long-term maternal/child morbidity [1,5,6].

Our study found that many Taiwanese pregnant women tend to gain more than the recommended IOM weight gain guidelines of the total and weekly GWG and may not manage their weight well. The reason may lie in cultural differences among Taiwanese pregnant women, who may not be aware that GWG is a maternal and neonatal health problem. Cultural differences among women may have an effect on GWG. For example, there may be very different Taiwanese cultural beliefs regarding pregnancy. A traditional Taiwanese folk belief encourages women to “nourish the fetus.” Therefore, Taiwanese women think they should eat an excessive amount of food to feed their fetus: “One person eats for two (people).” Women are told that they should “eat for two” to have healthy fetal growth [15]. For women with normal pre-pregnancy weight, the American College of Obstetricians and Gynecologists recommends an extra 300 calories per day to achieve the recommended GWG [16]; even less is needed for women who are overweight or obese prior to pregnancy. Moreover, in traditional Taiwanese culture, pregnant women are seen as very vulnerable, needing to be protected, and requiring large amounts of rest [17]. Pregnant women in this culture thus tend to be as inactive as possible during pregnancy while also eating more, a pattern that tends to lead to greater GWG. Overcoming these conventional beliefs is challenging but necessary. Women should be cautioned against “eating for two” and large caloric increases. To more effectively promote the proper level of GWG, health providers should be aware of local social customs and cultural norms regarding pregnancy and motherhood. They should effectively counsel pregnant women with regard to not only the proper diet but also their patterns of physical activity or exercise to control or prevent excessive GWG.

During each prenatal checkup, women must measure their current body weight. However, pregnant women may not know their pre-pregnancy BMI categories or know the recommended weight gain during pregnancy. Pre-pregnancy BMI is an important determinant of GWG. Thus, it is very important to periodically measure the body weight of pregnant women to carefully monitor total and weekly GWG. Previous studies have found that only 32% of overweight and 23% of obese women knew their pre-pregnancy BMI [18], and at least two-thirds of them did not know the recommended amount of weight they should gain during pregnancy [19]. Health providers should calculate a woman's pre-pregnancy BMI at her first prenatal visit, at which time they may also educate her regarding the importance of appropriate total and weekly GWG goals. When health providers engage in practical counseling for pregnant women, it may be helpful to use weekly or trimester-based measurements of their GWG than total GWG measurements. Knowledge of weekly GWG could allow women to monitor their process of gaining weight and help them set short-term weight-gain goals across three trimesters and a long-term total GWG goal. Thus, education, counseling, and monitoring of weekly GWG should continue throughout pregnancy and should be undertaken within the context of these women's local cultures.

Limitations and strengths

To our knowledge, this is the first study to use specifically examine the distribution of the rate of GWG by BMI in the 2nd and 3rd trimesters as well as the amount of change in the weekly GWG from the 2nd to the 3rd trimesters. We assessed the individual percentages as inadequate, appropriate or excessive in terms of the BMI-specific IOM recommendations. Our results are consistent with the IOM recommendations that weekly weight gain should be zero in the first trimester, that GWG should occur at an equal rate regardless of pre-pregnancy BMI in the 3rd trimester, and that the rate of GWG may vary according to pre-pregnancy BMI in the 2nd trimester. Thus, if there is zero mean weight gain in the 1st trimester and an equal rate of GWG in the 3rd trimester, the GWG slope will vary in the 2nd trimester at a specific rate. This clear and predictable pattern could be used as a basis for developing trimester-specific GWG recommendations for women. However, a large-scale, population-based study with postpartum follow-up will be needed to establish weight-change patterns during and after pregnancy.

Despite its strengths, this study also has some limitations that must be considered when interpreting the results. First, our study used weights and heights that were self-reported by the women at their first prenatal visit in their 1st trimester to approximate pre-pregnancy BMI. However, self-reported weight may lead to a misclassification of GWG [20]. Furthermore, many women experiencing unplanned pregnancies lack preconception care, and a professional measurement of their pre-pregnancy weight is therefore unavailable to them [21]. In fact, it is common for normal-weight, overweight and obese women to underreport their weight and therefore overestimate their GWG [22]. However, self-reported pre-pregnancy data can usually be closely correlated with pre-pregnancy BMI using both self-reported and measured weights [22]. The second limitation of our study is that our analyses were restricted to pregnancies that resulted in full-term singleton infants. Thus, our findings might not be applicable to all pregnancies.

Conclusions

We compared the total GWG and trimester-specific rates of GWG based on pre-pregnancy BMI with the IOM recommendations. Our study found that women who had a higher pre-pregnancy BMI tended to have more excessive weekly GWG in the 2nd and 3rd trimesters than did women who had a lower pre-pregnancy BMI. More specifically, GWG in excess of the IOM recommendations was common among overweight and obese women. We also found that many Taiwanese women did not follow and did not fit the IOM recommendations. Both their weekly GWG during the 2nd and 3rd trimesters and their total GWG were excessive. More specifically, based on their pre-pregnancy BMI, GWG in excess of the IOM recommendations was common among normal-weight, overweight and obese women. In fact, even the normal-weight women exhibited excessive weekly GWG. We have found that this phenomenon may be common among pregnant Taiwanese women. Therefore, it is very important to periodically measure the body weight of pregnant women to closely monitor their total and weekly GWG. In the context of practical counseling for pregnant women, recommendations for weekly or trimester-based GWG may be more helpful than recommendations for weekly and total GWG.

Conflict of interest

None.

Acknowledgments

This study was supported by a Cooperative Hospital-University Research Grant from the Oriental Institute of Technology and the Far Eastern Memorial Hospital in Taiwan (RD1000079). The authors are grateful to all of the research project participants.

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