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ORIGINAL ARTICLE

Maternal diet in early and late pregnancy in relation to weight gain

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Objective: To identify dietary factors related to the risk of gaining weight outside recommendations for pregnancy weight gain and birth outcome.
Design: An observational study with free-living conditions.
Subjects: Four hundred and ninety five healthy pregnant Icelandic women.
Methods: The dietary intake of the women was estimated with a semiquantitative food frequency questionnaire covering food intake together with lifestyle factors for the previous 3 months. Questionnaires were filled out at between 11 and 15 weeks and between 34 and 37 weeks gestation. Comparison of birth outcome between the three weight gain groups was made with ANOVA and Bonferroni *post hoc* tests. Dietary factors related to at least optimal and excessive weight gain during pregnancy were represented with logistic regression controlling for potential confounding.
Results: Of the women, 26% gained suboptimal and 34% excessive weight during pregnancy. Women in late pregnancy with at least optimal, compared with women with suboptimal, weight gain were eating more (OR = 3.32, confidence interval (CI) = 1.81–6.09, $P<0.001$) and drinking more milk (OR = 3.10, CI = 1.57–6.13, $P=0.001$). The same dietary factors were related to excessive, compared with optimal, weight gain. Furthermore, eating more sweets early in pregnancy increased the risk of gaining excessive weight (OR = 2.52, CI = 1.10–5.77, $P=0.029$). Women with a body mass index of 25.0–29.9 kg/m^2 before pregnancy were most likely to gain excessive weight (OR = 7.37, CI 4.13–13.14, $P<0.001$). Women gaining suboptimal weight gave birth to lighter children ($P<0.001$) and had shorter gestation ($P=0.008$) than women gaining optimal or excessive weight.
Conclusion: Women who are overweight before pregnancy should get special attention regarding lifestyle modifications affecting consequent weight gain during pregnancy. They are most likely to gain excessive weight and therefore most likely to suffer pregnancy and delivery complications and struggle with increasing overweight and obesity after giving birth.
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Keywords: pregnancy; maternal weight gain; energy intake; milk; sweets; birth outcome

Introduction

Weight gain during pregnancy is one of the main factors related to birth outcome,[1,2] with birth weight being highly correlated to maternal weight gain.[3,4] Studies have identified factors influencing gestational weight gain such as prepregnancy body mass index (BMI), height, age, parity, smoking, duration of gestation and fetal sex.[5–9] Few studies have investigated nutritional factors related to weight gain during pregnancy as well as the consequent birth size parameters,[10,11] and some have focused on dietary factors related to birth outcome only.[12–15] Total energy intake (EI) has been related to maternal weight gain, but with regard to the association of the macronutrients with maternal weight gain and birth outcome, data are inconclusive or scarce.[11,16–18]

Adequate weight gain is important for optimal perinatal outcome, but high weight gain in pregnancy has been related to gestational complications (i.e., hypertension, diabetes and pre-eclampsia), complications in delivery[1,4,19–21] and macrosomia[22] and low weight gain to retarded fetal growth and preterm birth.[19] With increasing rates of obesity in the world,[23] especially among women,[24–26] it is a commonly held notion that excessive pregnancy weight gain contributes to the increased rates of obesity in women.[3,27–30]

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Maternal weight gain during pregnancy correlates to birth weight[3,4] and higher birth weight has been related to better health in infancy and adult life.[31,32] Therefore, it is important that the upper limit of the recommendations on weight gain in pregnancy not be set too low. Recommendations for weight gain should preferably be population specific and adjusted to the women's prepregnant weight and, as stated in the guidelines from the Institute of Medicine (IOM), derived from the observed weight gains of women delivering full-term, healthy infants without complications. Icelandic women tend to be tall[33] and give birth to infants at the upper end of the scale for birth size worldwide.[3,34] The Icelandic recommendations for gestational weight gain for women of normal weight before pregnancy, 12–18 kg, are based on gestational outcome, minimal risk of complications in pregnancy or delivery and postpartum weight retention.[3,4,35]

Identification of the dietary factors along with other factors influencing gestational weight gain and birth outcome is of utmost importance for practitioners to guide their clients through an optimal pregnancy and prevent even further increase in the obesity epidemic. The relationship of special food items and weight gain during pregnancy or the changes in food consumption and consequent weight gain have not been studied. With this in mind, the aim of our present study was to investigate the association of maternal dietary intake in early and late pregnancy and anthropometric factors with excessive or suboptimal gestational weight gain as well as pregnancy outcomes.

Methods

Subjects

In this observational study, the participants were randomly selected, pregnant Caucasian women, attending a routine first visit at the Center of Prenatal Care in Reykjavik, Iceland, from 1999 to 2001. Of the 549 women enrolled in the research group, 495 (90%) women giving birth to full-term babies completed the study. The 54 women were excluded because they had a miscarriage or stillbirth ($n=17$), twins or triplets ($n=5$), a preterm birth ($\leqslant 259$ days) ($n=17$), personal data could not be found or they moved abroad before giving birth ($n=8$), or variables to be used in this study were missing ($n=7$). Only 406 mothers were included in Table 3 and Figures 2a and b as 89 women did not fill out their food frequency questionnaire (FFQ) and lifestyle questionnaires at the second time point, and therefore information on their dietary habits in late pregnancy was lacking. Regarding all the other variables included in the regression model, there was no significant difference between the 89 women excluded and the women included in the regression model. The National Bioethics Committee of Iceland and the Icelandic Data Protection Commission approved the study. All women gave informed consent for participation in the study.

Measurements

A semiquantitative FFQ covering food intake for the last 3 months and a questionnaire on several lifestyle factors was mailed to the participants 2 weeks before their first visit to the clinic at between 11 and 15 weeks of gestation (early pregnancy) and again 2 weeks before a visit at between 34 and 37 weeks of gestation (late pregnancy). The women were asked to complete the questionnaires at home and bring them to the clinic visits or return them by mail. The semiquantitative FFQ was developed at the Icelandic Nutrition Council to assess the entire diet over the previous 3-month period. FFQs were scanned and food and nutrient intake calculated, using the Icelandic Nutrition Database (ISGEM) and a nutrient and food calculating program (ICEFOOD). The FFQ has been validated using biomarkers for nutrient intake.[36,37] We also took any possible underreport into consideration and compared estimated EI with calculated basal metabolic rate (BMR).[37]

The lifestyle questionnaire also included multiple-choice questions on changes in eating patterns in early and late pregnancy, compared with usual intake before pregnancy. These were questions on whether they had no changes in eating pattern, ate more, ate less, tried to eat healthier, ate more sweets, ate more fruit and vegetables, drank more milk or disliked food that they used to like.

Weight gain from the initial visit at 11–15 weeks gestation until the last weighing before delivery was calculated to estimate the pregnancy weight gain. The pregnancy weight gain was divided into groups of suboptimal, optimal and excessive weight gain, according to recommendations that are based on Icelandic studies on maternal weight gain.[3,4,38] Optimal weight gain is considered to be 12.1–18.0 kg for prepregnantly normal-weight women and 7.1–12.0 kg for overweight women.[35]

Gestational length was estimated from an early ultrasound scan. Data on birth outcome (gestational age at birth, birth weight, birth length, head circumference and placental weight) were collected from maternity records at the Department of Obstetrics and Gynaecology, Landspitali – University Hospital in Reykjavik, Iceland.

Statistical analysis

The data are described by values of mean and standard deviation (s.d.) as well as percentages. Comparison of maternal characteristics, birth outcome and dietary intake of macronutrients between the three weight gain groups was made with ANOVA and Bonferroni *post hoc* tests. The χ^2 test was used to detect differences in binary and categorized variables across weight gain groups. The *T*-test or Mann–Whitney test, depending on the distribution of the data, was used to compare the answers to the questions about changes in eating patterns in pregnancy with the results from the FFQ. Two separate binary logistic regression models were designed for representing factors related to (1) at least optimal maternal weight gain and (2) excessive weight gain

during pregnancy.[39] The odds of gaining at least optimal or excessive weight during pregnancy was calculated with 95% confidence intervals (95% CI), adjusting for gestational length, maternal age and smoking. Stepwise backward elimination was used for selecting dietary factors and other possible sources of confounding, after comparing the differences between the three weight gain groups (i.e., suboptimal, optimal or excessive weight gain) with ANOVA. The level of significance was set at $P=0.05$, and two-tailed *P*-values were used. All statistical analyses were performed using the SPSS program (SPSS 11.0 for Windows, SPSS Inc., Chicago, IL, USA).

Results

The percentage of optimal, suboptimal and excessive maternal weight gain during pregnancy, for normal-weight and overweight women in the beginning of pregnancy, as well as all the women together, is presented in Table 1. Whereas 11% of the overweight women gained less than 7 kg, only 2% of the normal-weight women gained so little weight. However, 14% of the overweight women gained more than 18 kg, compared to 20% of the normal-weight women (data not shown).

In Table 2, maternal characteristics for the three weight gain categories are presented for normal-weight and overweight women, as well as all women together. Of the normal-weight women, women gaining excessive weight were significantly younger and tended to be slightly taller than women gaining less weight, although the difference was not significant. For overweight women, the mean maternal height was the same in all weight gain groups, but their weight at the first prenatal visit was significantly different across groups, with women gaining excessive weight being the lightest. The ratio of EI in late pregnancy to the estimated BMR (EI:BMR) was higher across weight gain groups.

Birth size parameters for infants born to women of normal weight before pregnancy are presented in Figure 1. Women gaining suboptimal weight gave birth to lighter babies than women gaining optimal or excessive weight (3591 ± 447 versus 3764 ± 436 and 3872 ± 471 g, respectively, $P<0.001$). Their babies were also shorter (51.4 ± 1.8 versus 52.0 ± 2.1 and 52.6 ± 2.0 cm, respectively, $P<0.001$), with smaller head circumference (35.3 ± 1.3 versus 35.8 ± 1.3 and 35.8 ± 1.4, respectively, $P=0.006$) and less placental weight (683 ± 135 versus 739 ± 147 and 749 ± 149 g, respectively, $P=0.007$). Their gestational length was shorter (280 ± 8 versus 281 ± 8 and 284 ± 7, respectively, $P=0.008$), but birth size parameters were also significantly greater/higher when adjusted for gestational length (data not shown). Within the group of overweight women, there was only a significant difference in babies' birth weight between women gaining suboptimal versus excessive weight (3594 ± 443 versus 3918 ± 526, respectively, $P=0.029$), whereas other factors of birth outcome were not affected (data not shown).

Figures2a and b show both the absolute intake and percentage of energy from macronutrients in late pregnancy among women who were overweight before pregnancy. There was no significant difference across weight gain groups for normal-weight women (data not shown), but overweight women showed significantly higher EI with increasing weight gain (6739 ± 2278 versus 7741 ± 2609 and 9137 ± 4315, respectively, $P=0.017$). They ate more fat and carbohydrates, but there was not a significant difference in protein intake in absolute amounts (Figure 2a). Furthermore,

Table 1 Percentage of women gaining suboptimal, optimal and excessive weight during pregnancy, for normal-weight, overweight and all women together

	%
BMI <25 kg/m^2 at first visit ($n=301$)	
Suboptimal ($\leqslant$12.0 kg)	36
Optimal (12.1–18.0 kg)	44
Excessive ($>$18.0 kg)	20
BMI $\geqslant 25$ kg/m^2 at first visit ($n=194$)	
Suboptimal ($\leqslant$7.0 kg)	11
Optimal (7.1–12.0 kg)	34
Excessive ($>$12.0 kg)	55
All pregnant women ($n=495$)	
Suboptimal	26
Optimal	40
Excessive	34

BMI = body mass index (kg/m^2)

Table 2 Maternal characteristics

	Weight gain			
	Suboptimal	*Optimal*	*Excessive*	P-*value*
BMI <25 kg/m^2 at first visit ($n=301$)				
Age (years)	28.8 (5.0)*	27.9 (5.2)$^+$	26.1 (5.1)*$^+$	0.003
Weight at first visit (kg)	61 (7)	62 (7)	64 (5)	0.117
Height (cm)	167 (5)	168 (6)	169 (5)	0.057
EI:BMR[a]	1.51 (0.54)	1.44 (0.44)	1.51 (0.54)	0.541
BMI $\geqslant 25$ kg/m^2 at first visit ($n=194$)				
Age (years)	28.2 (3.9)	28.9 (5.0)	28.3 (4.5)	0.712
Weight at first visit (kg)	90 (17)*$^+$	83 (10)*	80 (9)$^+$	<0.001
Height (cm)	168 (6)	168 (7)	168 (6)	0.701
EI:BMR[a]	1.08 (0.37)*	1.24 (0.42)$^+$	1.45 (0.73)*$^+$	0.034
All pregnant women ($n=495$)				
Age (years)	28.7 (4.8)	28.3 (5.1)	27.5 (4.8)	0.101
Weight at first visit (kg)	66 (14)*	69 (13)$^+$	74 (11)*$^+$	<0.001
Height (cm)	167 (5)	168 (6)	168 (6)	0.094
EI:BMR[a]	1.45 (0.54)	1.37 (0.44)	1.47 (0.66)	0.235

Values are mean$\pm$s.d. [a]EI (late pregnancy)/estimated BMRate. *$^+$Significant difference between the signed groups, calculated with ANOVA and Bonferroni *post hoc* test.

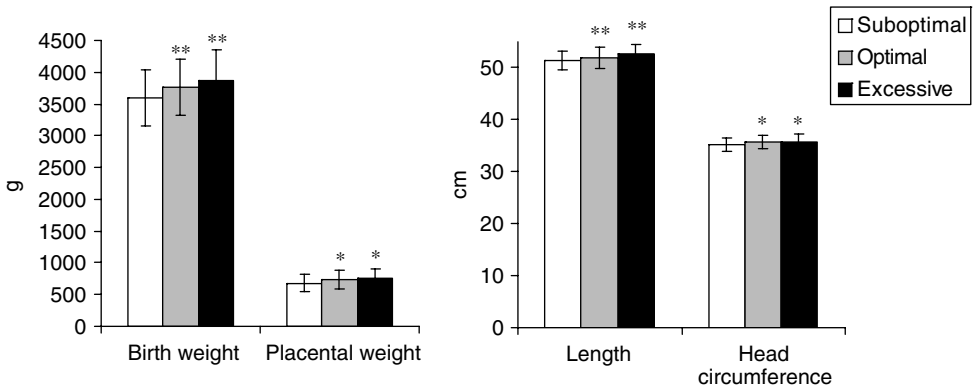

Figure 1 Birth size parameters of infants born to women of normal weight before pregnancy who gained suboptimal, optimal or excessive weight during pregnancy. Signed groups are significantly different from the first group (suboptimal weight gain), *$P<0.01$, **$P<0.001$.

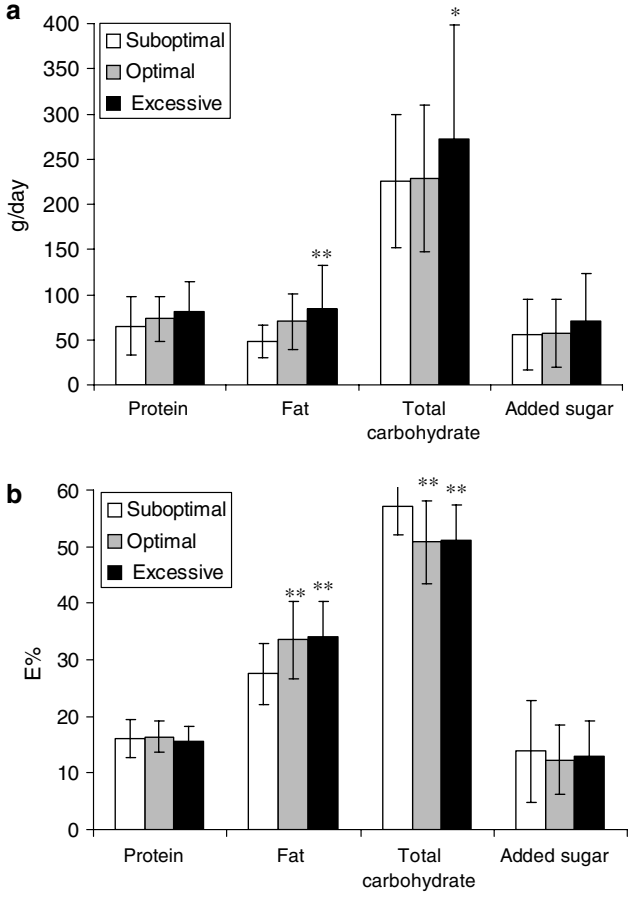

Figure 2 (**a**) Macronutrient intake among overweight women late in pregnancy. Absolute intake (g/day). (**b**) Macronutrient intake among overweight women late in pregnancy. Energy percent (E%). Signed groups are significantly different from the first group (suboptimal weight gain), *$P<0.05$, **$P<0.01$.

there was a difference in the distribution of macronutrients between the groups (Figure 2b). Compared with women gaining suboptimal weight, the diet of overweight women gaining excessive weight had higher energy percentage (E%) from fat (34.1 ± 6.2 versus 27.5 ± 5.4 E%, respectively, $P=0.002$) and lower E% from carbohydrates (51.1 ± 6.2 versus 57.1 ± 5.1 E%, respectively, $P=0.005$).

We also considered changes in macronutrient intake during pregnancy (difference between reported intake late and early in pregnancy) across weight gain groups (data not shown). Only women with excessive weight gain increased their EI (453 ± 2813 kJ/day, $P=0.010$) with progressing pregnancy from the first visit at 11–15 weeks of gestation to weeks 34–37. During this pregnancy period, overweight women with excessive weight gain increased their E% from fat (1.2 ± 6.3 E%) and decreased the E% from carbohydrate (-0.7 ± 6.4 E%). In comparison, for suboptimal weight gain, the changes in E% were in the opposite direction, -3.9 ± 5.7 E% from fat ($P=0.015$) and 4.5 ± 7.6 E% from carbohydrate ($P=0.030$). Furthermore, overweight women gaining excessive weight decreased their fiber intake per 10 MJ, whereas such intake increased for the overweight women gaining suboptimal weight (-1.4 ± 5.8 versus 3.4 ± 7.5 g/10 MJ, respectively, $P=0.019$). Absolute EI in late pregnancy correlated with maternal weight gain ($r=0.112$, $P=0.024$), as did changes in EI ($r=0.140$, $P=0.005$), but EI in early pregnancy did not correlate with weight gain from first visit to late pregnancy (data not shown).

In Table 3, a logistic regression model for factors related to maternal weight gain during pregnancy is presented. Changes in dietary pattern and anthropometric data are presented in the model, but gestational length, maternal age and smoking during pregnancy were adjusted for. First, women gaining suboptimal weight were compared with all other women. Second, women gaining optimal and suboptimal weight were compared with women gaining excessive weight. The first model showed that women with at least an optimal weight gain as compared to women with suboptimal weight gain were eating more in late pregnancy (OR = 3.32, 95% CI = 1.81–6.09, $P<0.001$) and drinking more milk late in pregnancy (OR = 3.10, 95% CI = 1.57–6.13, $P=0.001$). Height was also a significant factor in the

Table 3 Logistic regression models for factors related to at least optimal and excessive weight gain during pregnancy[a]

	At least optimal weight gain, $R^2 = 29.9\%$		*Excessive weight gain, $R^2 = 33.8\%$*	
	Adjusted OR[b] (95% CI)	P-*value*	*Adjusted OR[b] (95% CI)*	P-*value*
Eat more – early in pregnancy	1.00 (0.55–1.84)	1.000	1.60 (0.91–2.79)	0.101
More sweets – early in pregnancy	2.78 (0.84–9.27)	0.096	2.52 (1.10–5.77)	0.029
Eat more – late in pregnancy	3.32 (1.81–6.09)	<0.001	2.04 (1.17–3.58)	0.012
Drink more milk – late in pregnancy	3.10 (1.57–6.13)	0.001	1.82 (1.08–3.06)	0.024
Height (cm)	1.05 (1.00–1.10)	0.040	1.03 (0.99–1.08)	0.153
BMI category (kg/m^2)		<0.001		<0.001
<20	0.50 (0.21–1.19)	0.117	0.20 (0.05–0.72)	0.014
20.0–24.9 (reference)	1.00		1.00	
25.0–29.9	10.19 (4.29–24.23)	<0.001	7.37 (4.13–13.14)	<0.001
⩾30.0	3.34 (1.37–8.34)	0.008	3.63 (1.73–7.64)	0.001

[a]Stepwise backwards elimination was used for selecting the variables included in the models. [b]Adjustments were made for maternal age, gestational length and smoking.

model, increasing the odds of gaining at least optimal weight by 5% for each centimeter (95% CI = 1.00–1.10, $P = 0.040$). Compared with the reference group (BMI = 20.0–24.9), women with a BMI of 25.0–29.9 kg/m^2 were more than 10 times more likely to gain at least optimal weight (95% CI = 4.29–24.23, $P < 0.001$) and obese women (BMI30.0 kg/m^2) three times more likely to do so (95% CI = 1.37–8.34, $P = 0.008$). As with the first model, the second model, describing the odds of gaining excessive weight during pregnancy, showed a strong relationship between higher weight gain and eating more in late pregnancy (OR = 2.04, 95% CI = 1.17–3.58, $P = 0.012$) and higher weight gain and drinking more milk late in pregnancy (OR 1.82, 95% CI = 1.08–3.06, $P = 0.024$). Height did not have an impact on the OR of excessive weight gain. However, eating more sweets early in pregnancy significantly increased the OR of gaining excessive weight (OR = 2.52, 95% CI = 1.10–5.77, $P = 0.029$). Compared with the reference group (BMI = 20.0–24.9 kg/m^2), women with a BMI of 25.0–29.9 kg/m^2 were more than seven times more likely to gain excessive weight (95% CI = 4.13–13.14, $P < 0.001$). Women with BMI < 20.0 kg/m^2 were five times less likely to gain excessive weight, compared with the reference group (95% CI 0.05–0.72, $P = 0.014$).

Discussion

The percentage of women gaining optimal weight during pregnancy was 40%. Excessive weight gain was a common problem among women who were overweight at the beginning of pregnancy, with 55% gaining excessive weight and 14% gaining more than 18 kg. However, suboptimal weight gain was more common for normal-weight women, as 36% of them gained less than 12 kg. There was no significant difference in maternal dietary intake in early pregnancy, but in late pregnancy total EI was higher, with more total protein and fat consumed among women gaining excessive weight, whereas women gaining suboptimal or optimal weight were either stable or minimally decreased their EI as pregnancy progressed. Overweight women contributed the most to this higher EI. However, overweight women gaining suboptimal weight had the least E% from fat and the highest E% from carbohydrate, compared with others.

Special attention should be drawn to the large group of women who are overweight or obese at the beginning of pregnancy, which was 39% in the present study. Being overweight or obese at the start of pregnancy may pose serious complications for mother and child during pregnancy and labor.[21,22] Similar to the results of the present study, 30–40% of women in Sweden and the United States gain weight within the recommendations of IOM, whereas 20% gain too little weight and 40% excessive weight.[7,9,19,40] Of the normal-weight women in our study, women gaining excessive weight were younger than those gaining less weight, and they also tended to be taller and heavier. Caulfield *et al*.[7] also found women gaining more weight than recommended to be taller and heavier, but in contrast to our results they also found them to be older.

In contrast to the normal-weight women in our study, overweight women gaining excessive weight during pregnancy were at first visit lighter than the women gaining suboptimal weight. They also reported eating more (higher EI:BMR) than women gaining less weight, which could not be seen for the normal-weight women. The FFQ used has been evaluated with respect to under-reporting in non-pregnant women,[37] and under-reporters have been found to have a higher BMI than others. In our study, there was no difference in under-reporting across weight gain groups, and we therefore decided not to consider under-reporting in our calculations.

In agreement with other studies,[19] gestational length was shorter and birth weight, length, head circumference and placental weight, with and without adjustment for gestational length, were all lower in the group with suboptimal weight gain, and there was even a trend for a lower ponderal

index, that is, the newborns being thinner (data not shown). Little is known about the maternal influences leading to thinness at birth, but low EI and low weight gain in pregnancy have been implicated.[41]

There was no significant difference in maternal macronutrient intake between the weight gain groups in early pregnancy, but in late pregnancy there were significant differences across weight gain groups for all women and overweight women in particular. Total EI was highest in the group gaining excessive weight, and the total amounts of protein, fat and carbohydrate contributed to this weight gain. E% from macronutrients was associated with weight gain in overweight women only. Women gaining suboptimal weight had a significantly lower E% from fat and higher E% from carbohydrate than women gaining optimal or excessive weight. This is largely in agreement with the findings of Lagiou *et al*.[11] In their study, increased maternal weight gain by the end of the second trimester of pregnancy was associated with higher total EI as well as a higher proportion of protein and lipids of animal origin and lower proportion of carbohydrates. There have also been earlier studies indicating that maternal protein intake is positively associated with pregnancy weight gain.[17,18] The Icelandic diet is generally high in protein, or 18 E% on average,[42] and in our study, no difference was found in protein intake (E%) across the weight gain groups. Maternal weight gain during pregnancy and birth weight are high in Iceland[3,4,13,34] and the possibility cannot be precluded that this may partly be explained by high protein intake. However, within this population, no such conclusions can be drawn, as the percentage of energy from protein intake is quite homogeneous.

We were interested in looking not only at maternal dietary intake but also changes in consumption during pregnancy. Women gaining excessive weight were observed to significantly increase their total EI and amount of macronutrients in late as opposed to beginning of pregnancy. There have been many reports indicating that reduction in maternal EI is associated with reduced pregnancy weight gain and birth weight,[10,12,16] but to our knowledge no studies have looked into the changes in dietary habits during pregnancy that may lead to a gestational weight gain above recommended levels. Within the group of overweight women, the E% from macronutrients changed significantly from early to late pregnancy. Women gaining suboptimal weight decreased the E% from fat, and increased the E% from carbohydrate as well as fiber content per 10 MJ, whereas women gaining excessive weight did just the opposite. These results may indicate that overweight women gaining excessive weight tend to increase their consumption of high-fat food when pregnancy progresses, while those gaining suboptimal weight may choose low-fat food in an attempt to minimize weight gain. Thus, sound advice on good nutrition is required for both groups of women.

Few studies have tested the influence of changes in food group consumption in pregnancy on subsequent body weight changes. Increased milk or dairy consumption has been linked to both weight loss[43] and weight gain.[44] Increased consumption of sweets[44] or sugar-sweetened beverages[45] has also been linked to weight gain in women. Associations between changes in the consumption of these food items or the total amount eaten and changes in weight during pregnancy were tested in the present study. Eating more than usual and increasing sweets consumption were positively associated with maternal weight gain during pregnancy, as was milk consumption. We also tested the association between maternal weight gain and other energy-providing drinks, that is, total calorie-containing drinks, juices and soft drinks, but without observing any strong association. High intake of milk has been found to have a positive effect on growth in children, and some compounds in the milk, possibly calcium, seem to stimulate IGF-I.[46] We measured the total maternal weight gain and are therefore not able to distinguish between increase in fat mass and lean body mass. The average daily dairy consumption late in pregnancy was about 700 g for the women increasing their milk intake, compared with approximately 500 g for the others ($P<0.001$), and their EI was approximately 400 kJ higher. If we only examined the changes in daily dairy consumption for the women reporting an increased milk consumption in late pregnancy, women gaining optimal weight increased their daily intake of dairy products by about 100 g/day, but women gaining excessive weight increased it twofold, or by about 200 g/day. Increased milk consumption during pregnancy may be overemphasized in recommendations for pregnant women. Some studies have shown a relationship between birth size and maternal intake of dairy protein[41,47] or milk consumption,[12] which we did not find in the present study. We also investigated if dairy protein or dairy fat influenced maternal weight gain, but milk as whole was a stronger predictor.

It is important to note the independent differences in OR across the prepregnancy BMI groups. Whereas underweight women are half as likely to gain optimal weight and fivefold less likely to gain excessive weight, overweight women are most likely to gain excessive weight (OR = 7.37; 95% CI = 4.13–13.14, $P<0.001$). An inverse association between BMI and gestational weight gain has been observed when weight gain is considered in absolute values or kilograms rather than relative to recommendations based on prepregnant weight or weight early in pregnancy.[16] Such inverse association is also seen in the present data, but the recommended weight gain is lower for overweight and obese women than for normal-weight or underweight women. Overweight women have a high risk of gaining excessive weight and therefore need special attention in the prenatal clinics.

In the logistic regression, we used the results from the lifestyle questionnaires as these were more strongly related to gestational weight gain than dietary intake from the FFQ. The lifestyle questionnaires contain dichotomous variables about changes in eating patterns in early and late pregnancy,

compared with usual intake before pregnancy. The yes/no answers preclude any skewness by under-reporting, which is an advantage. Furthermore, changes in consumption according to the lifestyle questionnaires correlated well with changes between the two FFQs. In addition to the confounding factors included in the logistic regression model, we considered factors that others have related to gestational weight gain, including parity, education, marital status, work, physical activity and fetal sex.[5–9,11] Parity was the only one of these factors that was different across weight gain groups, but as age was highly correlated with parity, and age was a stronger predictor of gestational weight gain we only included age as confounding.

In this observational prospective study, possible mechanisms of the associations found were not investigated. Some underlying mechanisms besides EI could affect maternal weight gain, such as fetal and parental genetic factors or even environmental factors.

It is necessary to give women guidelines regarding weight gain during pregnancy, and they need to be advised about lifestyle modifications affecting consequent weight gain. Previous studies on Icelandic women show that most women who are normal weight before pregnancy do not have problems with postpartum overweight, irrespective of gestational weight gain in pregnancy,[3] but they may suffer pregnancy or delivery complications when weight gain is excessive.[4] Therefore, special attention should be given to women who are overweight before pregnancy. They are most likely to gain excessive weight during pregnancy and therefore most likely to suffer pregnancy and delivery complications and struggle with increasing overweight and obesity after giving birth.

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