



Effects of dietary restraint and weight gain attitudes on gestational weight gain



Emily Heery ^{a,*}, Patrick G. Wall ^a, Cecily C. Kelleher ^a, Fionnuala M. McAuliffe ^b

^a School of Public Health, Physiotherapy and Sports Science, Woodview House, University College Dublin, Belfield, Dublin, Ireland

^b UCD Obstetrics and Gynaecology, School of Medicine and Medical Science, University College Dublin, National Maternity Hospital, Dublin, Ireland

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ABSTRACT

The aim of this study was to examine the impact of dietary restraint and attitudes to weight gain on gestational weight gain. This is a prospective cohort study of 799 women recruited at their first antenatal care visit. They provided information on pre-pregnancy dietary restraint behaviours (weight cycling, dieting and restrained eating) and attitudes to weight gain during pregnancy at a mean of 15 weeks' gestation. We examined the relationship of these variables with absolute gestational weight gain and both insufficient and excessive gestational weight gain, as defined by the Institute of Medicine recommendations. Multivariable analysis revealed that restrained eating, weight cycling and dieting were associated with higher absolute weight gain, whilst weight cycling only was associated with excessive weight gain. There was no evidence that the relationships between the dietary restraint measures and the weight gain outcomes were mediated by pregnancy-associated change in food intake. Increased concern about weight gain during pregnancy was independently associated with higher absolute weight gain and excessive weight gain. These relationships were attenuated following adjustments for pregnancy-associated change in food intake. These findings suggest that in early pregnancy, both a history of fluctuations in body weight and worry about gestational weight gain, are indicators of high pregnancy weight gain. Concern about weight gain during pregnancy seems to partly arise from an awareness of increased food intake since becoming pregnant. Prenatal dietary counselling should include consideration of past dieting practices and attitudes to pregnancy weight gain.

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1. Introduction

Internationally, there is a lack of consensus on how much weight gain during pregnancy is optimal. There are no evidence-based weight gain recommendations for pregnancy in the UK; instead women are advised to eat healthily and to exercise (National Institute for Health and Clinical Excellence, 2010). In contrast, the US Institute of Medicine (IOM) provides recommendations for weight gain during pregnancy indexed to pre-pregnancy BMI: 12.5–18.0 kg for underweight women; 11.5–16.0 kg for normal weight women; 7.0–11.5 kg for overweight women and 5.0–9.0 kg for obese women (IOM, 2009). Under the IOM framework, excessive gestational weight gain (GWG) refers to weight gains above these

guidelines, whilst inadequate GWG refers to weight gain below these guidelines. The lack of international consensus makes it difficult for health providers to provide coherent advice to perinatal women at a time when they may need extra support, as their body image ideals may be changing, they often feel pressure to limit weight gain (Watson, Fuller-Tyszkiewicz, Broadbent, & Skouteris, 2015) and BMI is negatively associated with body image satisfaction (Shloim, Hetherington, Rudolf, & Feltbower, 2015; Watson et al., 2015).

High proportions of pregnant women are gaining weight outside the IOM's recommended range for their BMI category (Crozier et al., 2010; Deputy, Sharma, Kim, & Hinkle, 2015; Institute of Medicine, 2009; Johnson et al., 2015). Gestational weight gain outside the IOM's recommendations has been consistently associated with an array of negative maternal and child outcomes. For example, inadequate weight gain confers a greater risk for low birth weight and preterm birth, whilst excessive weight gain confers a greater risk for macrosomia, caesarean delivery, postpartum weight retention and childhood overweight (Nehring, Lehmann, & von

Abbreviations: IOM, Institute of Medicine; GWG, gestational weight gain; PWGAS, Pregnancy Weight-Gain Attitude scale.

* Corresponding author.

E-mail address: emily.heery@ucdconnect.ie (E. Heery).

Kries, 2013; Siega-Riz et al., 2009; Starling et al., 2015; Viswanathan et al., 2008). These adverse health outcomes have prompted researchers to identify potentially modifiable determinants of GWG (such as restrained eating and attitudes to weight gain) which may be amenable to intervention during the course of pregnancy.

Studies examining the relationship between attitudes to weight gain during pregnancy and actual GWG have yielded mixed results. Palmer, Jennings, and Massey (1985) developed the 18-item Pregnancy Weight-Gain Attitude scale (PWGAS), to measure women's attitude towards their own weight gain during pregnancy. They found that negative attitudes towards pregnancy weight gain were associated with lower actual weight gains. However, a study of 99 pregnant adolescents found that maternal weight gain was positively associated with 4 of the 18 items in the PWGAS, but not the total attitude score (Stevens-Simon, Nakashima, & Andrews, 1993).

Another study found no relationship between maternal weight gain attitudes at 20 weeks' gestation and actual GWG among 1000 pregnant women (Copper, DuBard, Goldenberg, & Oweis, 1995). The investigators observed that maternal attitudes to weight gain were strongly associated with pre-pregnancy BMI; thin women (defined as BMI less than 19.6 kg/m²) were more likely to have positive attitudes and obese women (defined as BMI greater than 26.6 kg/m²) were more likely to have negative attitudes. Similarly, three other studies found no association between total scores on the PWGAS and prenatal weight gain (Conway, Reddy, & Davies, 1999; Dipietro, Millet, Costigan, Gurewitsch, & Caulfield, 2003; Olson & Strawderman, 2003). Furthermore, Dipietro et al. (2003) conducted a factor analysis of the PWGAS and identified four constructs: Positive Pregnancy Body Image, Negative Pregnancy Body Image, Indifference towards Pregnancy Weight Gain and Weight Gain Restricting Behaviors. They found that women with inadequate GWG had the least negative body image attitudes, and that those with excessive GWG had the most negative body image attitudes.

Two studies did *not* use Palmer's scale to examine the impact of maternal weight gain attitudes on GWG. Swann et al. (2009) examined attitudes towards weight gain during pregnancy among 35,929 women enrolled in the prospective population-based Norwegian mother and child cohort study. They assessed worry about pregnancy weight gain using a single-item rather than a scale at about 18 weeks' gestation. In women without an eating disorder, worry about weight gain was associated with higher maternal weight gain, higher infant birth weight, an increased likelihood of having a large for gestational age baby and a decreased likelihood of having a small for gestational age baby. In addition, Strychar et al. (2000) developed their own scale to examine attitudes to pregnancy weight gain and found that women who were more concerned about their weight in early pregnancy (before 16 weeks) were more likely to gain an excessive amount of weight during pregnancy. They also observed that women in late pregnancy (30–36 weeks) who had a less favourable attitude towards their weight gain were more likely to have excessive GWG.

Prior research has also revealed that pregnancy can provide a temporary reprieve from weight and shape concerns, especially among those with a prior history of restrained eating or dieting (Clark & Ogden, 1999; Fairburn & Welch, 1990). Restrained eating refers to the conscious effort to restrict food intake to control body weight. On the basis of the *boundary model* of eating behaviour (Herman & Polivy, 1983), researchers have predicted that pregnancy would result in disinhibited eating among those with a history of restrained eating (Clark & Ogden, 1999). This is because many of the characteristics of pregnancy are similar to triggers of disinhibited eating in non-pregnant restrained eaters. For example, predictors of disinhibited eating among non-pregnant restrained eaters, including high calorie preloads (Herman & Mack, 1975),

emotional upheaval (Ruderman, 1985) and smoking abstinence (Ogden, 1994), may be reflective of common features of pregnancy such as food cravings, mood changes and giving up smoking. In support of the predictions of the boundary model, Conway et al. (1999) found that those classified as restrained eaters or weight cyclers prior to pregnancy were more likely to exceed the IOM guidelines for weight gain during pregnancy. Those with a history of restrained eating also had a significantly higher pre-pregnancy BMI, had more negative attitudes to prenatal weight gain and reported having used more weight control methods prior to pregnancy than non-restrained eaters. Similarly, Mumford, Siega-Riz, Herring, and Evenson (2008) found that women with history of restrained eating, dieting or weight cycling were more likely to exceed IOM recommendations. They also observed significant effect modification by pre-pregnancy BMI status, whereby restrained eaters and dieters in the normal weight, overweight and obese categories tended to gain in excess of recommendations, whilst the underweight women tended to gain less compared with women without restrained eating behaviours (Mumford et al., 2008).

The main objectives of the present study were to determine whether pre-pregnancy restrained eating behaviours and pregnancy attitudes to weight gain were associated with weight gains outside the IOM guidelines. On the basis of the research discussed above, it was hypothesized that a history of dietary restraint behaviours (restrained eating, weight cycling and dieting) would be associated with higher absolute GWG and weight gains in excess of the IOM guidelines. The role of pregnancy-associated change in food intake in mediating the hypothesized effects of restrained eating behaviours on GWG has not been examined previously. Thus, this research also explored whether pregnancy-associated change in food intake mediated the relationship between restrained eating behaviours and GWG. On basis of the predictions of the boundary model described above, it was expected that increased food intake would act as an intermediary in this relationship. Furthermore, following the above evidence, it was hypothesized that greater worry about pregnancy weight gain and greater worry about changes in body shape and size would be associated with higher total GWG and excessive GWG, respectively. Swann et al. (2009) recommended that the role of food intake in elucidating the relationship between attitudes to pregnancy weight gain and actual weight gain at delivery should be examined. Consequently, the role of changes in food intake since becoming pregnant in explaining the hypothesized relationship between worry about pregnancy weight gain and actual GWG was also examined.

2. Method

2.1. Procedure

This prospective cohort study was approved by the ethics committee of the National Maternity Hospital, Dublin and all participants provided written informed consent. Pregnant women attending their 'booking' appointment were consecutively recruited by a team of trained research assistants from the National Maternity Hospital over a 3-month period (March–May 2011). Before recruitment, it was estimated that a minimum analysis sample of 600 women was required based on power analysis for detection of significant differences in the weight gain outcomes (at 80% power and 5% significance level) and based on stability of estimates calculations for regression analyses. Thus, the goal was to recruit 1000 women to ensure that a final analysis sample of 600 women was achieved following all exclusions. Women were eligible for the study if they were 1) aged 18 years or above 2) able to give full informed consent and 3) expecting a singleton

pregnancy. Eligible women who consented to participate were given a self-completion questionnaire to obtain information about psychological status, health behaviours and socio-demographics. The questionnaire was completed at a mean of 15.4 (*SD* 3.9) weeks' gestation. Following pregnancy, biomedical data (including serial weight measurements) was obtained from the women's medical records.

2.2. Participants

Of 1229 women invited to participate in the research, 984 women agreed to participate and completed the study questionnaire, resulting in an 80% response rate. Seventy-eight women were excluded as they had gestational diabetes or diabetes mellitus, twins, a miscarriage, or changed hospital. Furthermore, 107 women were excluded due to insufficient maternal weight information. Of these, 92 women had > 10 weeks between the last recorded weight in pregnancy and delivery, 12 women's medical chart was unavailable and 2 women had a missing self-reported pre-pregnancy weight and a pre-pregnancy weight was not imputable. Following all exclusions, a final sample of 799 women was available for analysis.

The mean age of the sample was 31 years (range: 18–44 years). Slightly over half (53%) of the participants were nulliparous and 30% were foreign nationals. Almost half of the women (47%) had obtained a primary or postgraduate degree and 55% had private health insurance. Nearly two-thirds (64%) of the women were married and 79% were in paid employment. The mean BMI of the sample was 23.9 (range: 15.0–49.9) kg/m², which is normal weight. On the whole, the demographic characteristics described above were comparable with the National Maternity Hospital population in 2011.

Although, the cohort study was not designed to represent the Irish population, the key similarities and differences between the general population and the cohort study are outlined for contextual purposes. For instance, 24% of women who delivered live singleton infants in Ireland in 2011 were foreign nationals, versus 30% in the present study (National Perinatal Reporting System (NPRS), 2012). In addition, a lower proportion of women who delivered live singleton infants in Ireland in 2011 were nulliparous (40%) than in the cohort study (53%) (NPRS, 2012). In the 2010 Quarterly National Household Survey the proportion of Irish adults who reported having private health insurance (47%) was somewhat lower than the cohort study (55%) (Central Statistics Office (CSO), 2011).

There were also some similarities between the characteristics of the cohort study and the Irish population. For example, the percentage of women married in the present sample (64%) is similar to the percentage reported for singleton live births in the 2011 national perinatal statistics (65%) (NPRS, 2012). Additionally, the mean age of women giving birth in the cohort study (31 years) is similar to the mean age of all mothers giving birth in Ireland in 2011 (31.7 years) (NPRS, 2012).

2.3. Measures

2.3.1. Main outcomes

Three GWG measures were the primary outcomes of this research. First, total GWG was calculated by subtracting self-reported pre-pregnancy weight from the last measured weight before delivery. Then, the women's total pregnancy weight gain was compared against their expected weight gain based on the current IOM recommendations (Institute of Medicine, 2009) to create two categorical variables: (a) excessive weight gain vs. not excessive and (b) inadequate weight gain vs. not inadequate. The calculation of the categorical outcomes adjusted for the timing of

the last weight measurement before delivery and length of gestation.

The calculation of the categorical outcomes adjusted for the timing of the last weight measurement before delivery and length of gestation. The trimester-specific cut-offs recommended by the IOM (2009) were used to adjust the categorical outcomes.¹ If the participant's total GWG was within the upper and lower cut-offs of expected weight gain at the time of their last weight measurement in pregnancy, it was classified as adequate. Likewise, if the woman's total weight gain was above the upper cut-off of expected weight gain, it was classified as excessive and if it was below, it was deemed inadequate.

Pre-pregnancy BMI (as a continuous variable) was a secondary outcome of this research. Pre-pregnancy BMI was calculated using self-reported weight and measured height. At the first antenatal clinic visit, maternal height was measured to the nearest 0.1 cm using a wall-mounted stadiometer. To assess self-reported weight, the questionnaire included the following question: 'How much did you weigh (without clothes) just before you got pregnant?'

For 8% of the analysis sample, an imputed weight was used in lieu of the self-reported weight, because it was missing or considered biologically implausible. Pre-pregnancy weight was imputed by using the first weight measurement taken during antenatal care minus the weight gain recommended by the IOM (Institute of Medicine, 2009; Rasmussen et al., 2010) for the period between conception and the first weight measurement. A pre-pregnancy weight was not imputed in cases where pregnancy weight was measured after 18 weeks' gestation. A similar methodology for imputation of pre-pregnancy weight has been used previously (Laraia, Siega-Riz, & Gundersen, 2010; Siega-Riz, Adair, & Hobel, 1994).

2.3.2. Risk factors

Attitudes to pregnancy weight gain were assessed using the women's responses to two statements in the Prenatal Distress questionnaire (Yali & Lobel, 1999): (a) 'I find weight during pregnancy troubling' and (b) 'Overall, the changes in my body shape and size during pregnancy bother me'. The response categories for these statements were: 'not at all', 'a little', 'moderately', 'very much' and 'extremely'. The response categories 'very much' and

¹ For each woman, the lower and upper cut-offs of expected weight gain at the gestational age of the last weight measurement before delivery were calculated, using the following formulae:

Lower cut-off = lower cut-off of recommended first trimester weight gain + [(gestational age at last measured weight – 13 weeks) × lower cut-off rate of weight gain recommended for the second and third trimesters].

Upper cut-off = upper cut-off of recommended first trimester weight gain + [(gestational age at last measured weight – 13 weeks) × upper cut-off rate of weight gain recommended for the second and third trimesters].

The lower cut-off rate of recommended weight gain for the second and third trimesters was calculated for each BMI category by subtracting the lower cut-off of first trimester recommended weight gain from the lower cut-off of total recommended weight gain and then dividing the answer by 27 (the number of weeks in the second and third trimesters). Similarly, the upper cut-off rate of recommended weight gain for the second and third trimesters was calculated for each BMI category by subtracting the upper cut-off of first trimester recommended weight gain from the upper cut-off of total recommended weight gain and then dividing the answer by 27. The lower cut-offs recommended for first trimester weight gain were, 1, 1, 1 and 0.5 kg, and the upper cut-offs were, 3, 3, 3 and 2 kg, for underweight, normal weight, overweight and obese women, respectively (Institute of Medicine, 2009; Rasmussen et al., 2010). Furthermore, the lower cut-offs recommended for total weight gain were, 12.5, 11.5, 7 and 5 kg, and the upper cut-offs were, 18, 16, 11.5 and 9 kg, for underweight, normal weight, overweight and obese women, respectively (Institute of Medicine, 2009; Rasmussen et al., 2010). For example, the lower and upper cut-offs of expected total weight gain for an obese woman, whose last weight measurement was taken at 36 weeks' gestation, were calculated as follows: lower cut-off = 0.5 + [(36 – 13) × (5 – 0.5)/27] = 4.33 kg; upper cut-off = 2 + [(36 – 13) × (9 – 2)/27] = 7.96 kg.

'extremely' were combined, due to small numbers in the 'extremely' category. It was decided to use single-items (albeit from a well-validated scale) rather than a full scale such as PWGAS to assess attitudes to pregnancy weight gain, as a single-item measure assessing worry about weight gain was more effective previously at predicting GWG (Swann et al., 2009).

Restrained eating behaviours and attitudes prior to pregnancy were examined using the revised version of the Restraint Scale (Herman & Polivy, 1980). This scale has 10-items with 4–5 response categories and a possible range of scores between 0 and 35. A version of the Restraint Scale that was modified by Conway et al. (1999) to focus on the period prior to pregnancy was used. A total score for the Restraint Scale was calculated by summing the scores for all 10 questions. Two subscales have been identified within the Restraint Scale, namely Weight Cycling and Concern with Dieting (Ruderman, 1983). The Weight Cycling subscale was calculated by summing scores for questions 2, 3, 4 and 10, which focused on body weight fluctuations before pregnancy. The Concern with Dieting subscale was calculated by summing scores for questions 1, 5, 6, 7, 8 and 9, which focused on prior eating behaviours, including a history of dieting, lifestyle changes following a weight fluctuation of 5 lb (2.3 kg), preoccupation with food choices, guilt about overeating and private binge eating. Comparisons were made between women above and below the median score for the Restrained Eating, Weight Cycling and Concern with Dieting scales, as per the literature (Conway et al., 1999; Herman & Polivy, 1980; Mumford et al., 2008).

The Revised Restraint Scale and its two subscales have been criticised previously for not being unidimensional (van Strien, Breteler, & Ouwens, 2002). Nonetheless, the Revised Restraint Scale was chosen to measure restrained eating rather than the Three-Factor Eating Questionnaire [Eating Inventory] (Stunkard & Messick, 1985) or the Dutch Eating Behaviour Questionnaire (van Strien, Frijters, Bergers, & Defares, 1986) as it has been previously associated with GWG (as detailed above), whilst no evidence that the other scales were associated with pregnancy weight gain was identified (Kapadia et al., 2015). As the study aimed to extend the literature by examining if change in food intake mediated the relationship between restrained eating and GWG, it was considered important to choose a measure of restraint which had been previously related to absolute and excessive weight gain.

2.3.3. Potential covariates

The potential covariate measures were collected via a self-completion questionnaire at approximately 15 weeks' gestation and via an audit of the participants' medical records following delivery. The potential biological covariates were maternal age (18–24, 25–29, 30–34, 35+), parity (0, 1, 2+) and height (<157 cm, 157–170 cm, = 170 cm). In addition, pre-pregnancy BMI class (<18.5, 18.5–24.9, 25.0–29.9, ≥ 30 kg/m²) was examined as a potential covariate in the models of GWG. The potential socio-demographic covariates included nationality (Irish, foreign), marital status (married, single), educational attainment (<second level, completed second level, vocational/training course, degree/postgraduate), employment status (not employed, part-time employed, full-time employed), pregnancy intention (intended, unintended) and private health insurance status (yes, no). A number of psychological well-being variables, measured during pregnancy using validated instruments, were examined as possible covariates of the GWG outcomes. These included a categorical measure of depression status assessed using the Edinburgh Postpartum Depression Scale (EPDS) (Cox, Chapman, Murray, & Jones, 1996; Cox, Holden, & Sagovsky, 1987). Scores above 12 on the EPDS were used to identify probable antenatal depression (Cox & Holden, 2003). Tertile categories of perceived stress (Cohen,

Kamarck, & Mermelstein, 1983), pregnancy-specific distress (Yali & Lobel, 1999) and optimism (Scheier, Carver, & Bridges, 1994) were also examined as potential covariates. Furthermore, pregnancy smoking status (non-smoker, former, current smoker) was examined as a possible covariate of the GWG outcomes and pre-pregnancy smoking status (current smoker, non-smoker) was examined as a possible covariate of pre-pregnancy BMI.

The researchers were also interested in examining the dietary mechanisms underlying the potential relationships of the dietary restraint and attitudes to weight gain variables with the GWG outcomes. A measure of change in the amount of food eaten since becoming pregnant was examined as a potential mediator of the relationship between the dietary restraint variables and the GWG outcomes. In addition, the potential role of pregnancy-associated change in food intake in explaining (or partly explaining) the association between the attitudes to weight gain variables and actual weight gain during pregnancy was examined. Change in food intake was examined using a single questionnaire item: 'How has the amount of food you eat now changed compared with times when you were not pregnant?' The five response categories were 'a lot less food now', 'a little less food now', 'about the same', 'a little more food now' and 'a lot more food now'. This is a modified version of an item with four response categories used originally by Olson and Strawderman (2003) which we altered to include a fifth category: 'about the same'. Both the original item and the modified one were strongly associated with GWG in prior research (Olson & Strawderman, 2003; citation removed for peer review). Indeed, the modified item was a better predictor of GWG than an energy intake measure derived from a 149-item food frequency questionnaire (citation removed for peer review).

2.4. Statistical analysis

Univariable analyses using chi-square tests were conducted to examine the relationship between self-reported change in food intake since becoming pregnant and each of the dietary restraint and attitudes to weight gain variables. In addition, linear regression was used to examine the univariable associations between pre-pregnancy BMI score and each of the weight gain attitudes and dietary restraint variables. Multivariable linear regression models were then used to separately investigate the relationship between maternal pre-pregnancy BMI and each of the risk factors, whilst controlling for other factors.

Next, linear regression was used to examine the univariable associations between total GWG in kilograms and each of the dietary restraint and attitudes to weight gain variables. Multivariable linear regression models were then used to separately investigate the relationship between total weight gain and each of the risk factors, whilst controlling for selected covariates. Additionally, the crude odds of both excessive and inadequate GWG were estimated for each of the restrained eating and attitudes to weight gain predictors using binary logistic regression models. Multivariable models were then used to examine the relationship of each of the independent variables with both excessive and inadequate weight gain, whilst adjusting for covariates.

The potential mechanisms by which the dietary restraint variables may be related to the GWG outcomes were explored using the steps recommended by Baron and Kenny (1986) for examining potential mediation. The food intake measure was chosen as this has been previously shown to be a significant predictor of each of the GWG outcomes in this cohort (citation removed for peer review). For the multivariable analysis of each GWG outcome by each dietary restraint risk factor, an additional model that included food intake as a potential mediator was only tested, if the risk factor, the outcome and the food intake variables were all correlated with

each other. If an additional model that included food intake was tested, non-trivial attenuation of effect estimates was considered to indicate mediation (Baron & Kenny, 1986).

The dietary mechanisms by which attitudes to weight gain during pregnancy may be related to GWG were also examined. For the multivariable analysis of each GWG outcome by each weight gain attitudes risk factor, a further model that added the food intake measure was only tested, if the risk factor, the outcome and the food intake variables were all significantly related to each other. If an additional model that included food intake was tested, non-trivial attenuation of effect estimates was considered to indicate that change in food intake since becoming pregnant accounts (or partly accounts) for the relationship between attitudes to weight gain and GWG. As the change in food intake variable was only examined for the period between conception and the questionnaire administration at around 15 weeks' gestation, this analysis *cannot* be used to infer that food intake was an intermediary in the relationship between pregnancy weight gain attitudes and actual GWG. Instead, this analysis was conducted to examine whether change in food intake could be an antecedent of the women's weight gain attitudes.

Only factors that were independently associated with the outcomes were included as covariates in the multivariable models. The linear regression models of GWG also controlled for gestation at delivery and the number of weeks between the last measured weight and delivery. The logistic regression models were not adjusted for these two variables, as the calculation of the weight gain adequacy outcomes adjusted for gestational age at the time of the last measured weight. Due to the high correlations among the attitudes to weight gain and dietary restraint variables, each of the independent variables was modelled separately, whilst adjusting for the selected covariates.

3. Results

As shown in Table 1, about one-third (34%) of the women were at least moderately worried about weight gain during pregnancy and 28% of the women were at least moderately worried about changes in body shape and size during pregnancy. A further 38% were 'a little' worried about weight gain during pregnancy and a further 36% were 'a little' worried about changes in body shape and size during pregnancy. Chi square tests showed that increased food intake since becoming pregnant was associated with greater worry about weight gain during pregnancy, $\chi^2(12, N = 796) = 33.69, p = 0.001$, and greater worry about changes in body shape and size during pregnancy, $\chi^2(12, N = 796) = 23.86, p = 0.021$. Chi square tests also showed that change in food intake since becoming pregnant was not associated with restrained eating $\chi^2(4, N = 750) = 1.32, p = 0.859$, weight cycling, $\chi^2(4, N = 757) = 3.32, p = 0.505$, or dieting, $\chi^2(4, N = 778) = 2.23, p = 0.693$.

Descriptive statistics and regression coefficients for pre-pregnancy BMI scores by the dietary restraint and attitudes to weight gain variables are displayed in Table 2. The crude and adjusted analyses showed that greater worry about weight gain during pregnancy was associated with higher pre-pregnancy BMI scores. The estimated relationship between worry about weight gain and BMI scores is presented in Fig. 1. Meanwhile, the unadjusted analyses showed that greater worry about changes in body shape and size during pregnancy was not associated with pre-pregnancy BMI scores. Following adjustment for other factors however, it was observed that mothers who were 'very much/extremely' worried about changes in body shape and size during pregnancy had a significantly higher pre-pregnancy BMI. Furthermore, in both the crude and adjusted models, restrained eaters, weight cyclers and dieters had significantly higher pre-pregnancy BMI scores than non-restrained eaters, non-cyclers and non-

Table 1
Descriptive and univariable analysis of GWG by pre-pregnancy dietary restraint and Attitudes towards weight gain during pregnancy (N = 799).

Variable	n	Sample (%)	Total GWG (kg) ^a	Inadequate GWG (%) ^b	Adequate GWG (%)	Excessive GWG (%) ^c
Worried about weight gain during pregnancy						
Very much/extremely	97	12.2	17.0*	7.2	20.6	72.2*
Moderately	175	21.9	17.2*	6.9*	23.4	69.7*
A little	306	38.3	15.4	9.5	29.1	61.4
Not at all ^d	220	27.6	14.9	14.5	31.8	53.6
Missing	1					
Worried about changes in body shape and size during pregnancy						
Very much/extremely	86	10.8	17.1*	9.3	20.9	69.8*
Moderately	135	16.9	16.5*	7.4	27.4	65.2*
A little	287	36.0	16.1*	9.4	24.0	66.6*
Not at all ^d	290	36.3	14.9	12.1	33.1	54.8
Missing	1					
Pre-pregnancy restrained eating status						
Restrained eater	401	53.3	16.3*	7.2*	25.2	67.6*
Non-restrained eater ^d	351	46.7	15.5	12.3	30.2	57.5
Missing	47					
Pre-pregnancy dieting status						
Dieter	388	49.7	16.3*	8.0	25.3	66.8*
Non-dieter ^d	392	50.3	15.5	11.2	30.4	58.4
Missing	19					
Pre-pregnancy weight cycling status						
Cycler	377	49.7	16.3	6.4*	22.8	70.8*
Non-cycler ^d	382	50.3	15.5	12.8	31.9	55.2
Missing	40					

Note. GWG = gestational weight gain.

* $p < 0.05$.

^a Univariable analyses of total GWG in kilograms were conducted using linear regression.

^b Univariable analyses of excessive GWG (vs. not excessive) were conducted using logistic regression.

^c Univariable analyses of inadequate GWG (vs. not inadequate) were conducted using logistic regression.

^d Reference category for univariable analysis.

Table 2
Descriptive statistics and crude and adjusted linear regression coefficients for BMI scores by pre-pregnancy dietary restraint and Attitudes towards weight gain during pregnancy variables (N = 799).

Variable	n	Mean BMI kg/m ² (SD)	Crude B [95% CI]	p	Adjusted B [95% CI] ^a	p
Worried about weight gain during pregnancy						
Very much/extremely	97	25.79 (4.58)	2.94 [1.85, 4.03]	<0.001	2.62 [1.55, 3.68]	<0.001
Moderately	175	24.21 (4.59)	1.36 [0.45, 2.27]	0.003	1.61 [0.73, 2.48]	<0.001
A little	306	23.97 (4.90)	1.12 [0.33, 1.92]	0.005	1.13 [0.37, 1.89]	0.004
Not at all	220	22.85 (4.03)	[reference]		[reference]	
Worried about changes in body shape and size during pregnancy						
Very much/extremely	86	24.14 (4.14)	0.58 [-0.54, 1.70]	0.307	0.79 [0.07, 1.52]	0.033
Moderately	135	24.31 (4.62)	0.76 [-0.19, 1.70]	0.119	0.85 [-0.06, 1.77]	0.067
A little	287	24.08 (4.58)	0.52 [-0.24, 1.28]	0.178	0.36 [-0.74, 1.46]	0.524
Not at all	290	23.56 (4.84)	[reference]		[reference]	
Pre-pregnancy restrained eating status						
Restrained eater	401	25.59 (5.11)	3.50 [2.90, 4.12]	<0.001	3.49 [2.91, 4.07]	<0.001
Non-restrained eater	351	22.09 (3.08)	[reference]		[reference]	
Pre-pregnancy dieting status						
Dieter	388	25.27 (5.07)	2.70 [2.07, 3.32]	<0.001	2.74 [2.14, 3.33]	<0.001
Non-dieter	392	22.57 (3.70)	[reference]		[reference]	
Pre-pregnancy weight cycling status						
Cycler	377	25.95 (5.11)	3.92 [3.32, 4.52]	<0.001	3.80 [3.23, 4.37]	<0.001
Non-cycler	382	22.02 (3.03)	[reference]		[reference]	

Note. P values <0.05 are in boldface. CI = confidence interval. SD = standard deviation.

^a Adjusted for parity, age, education, nationality, height, and health insurance status.

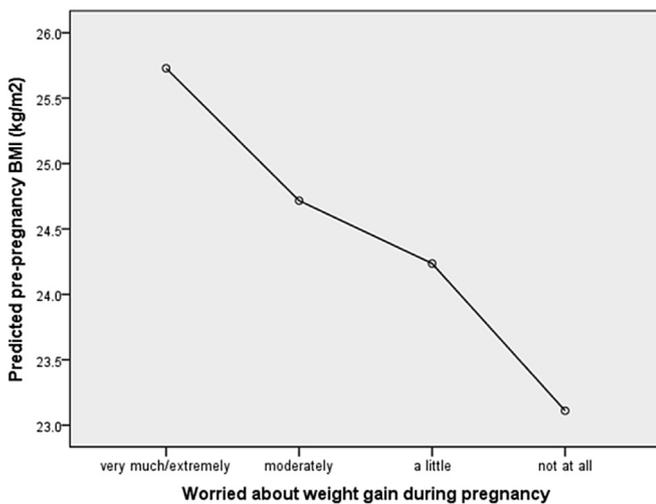


Fig. 1. Predicted pre-pregnancy BMI scores as a function of worry about weight gain during pregnancy (in linear regression model adjusted for parity, age, education, nationality, height, and health insurance).

dieters respectively. Furthermore, weight cycling was the strongest independent predictor of pre-pregnancy BMI; weight cyclers had about four points higher BMI scores than non-cyclers.

Univariable analyses of the GWG outcomes by pre-pregnancy dietary restraint and pregnancy attitudes towards weight gain variables are presented in Table 1. The univariable analysis showed that greater worry about weight gain during pregnancy was significantly associated with higher total weight gain and higher odds of excessive weight gain. Similarly, greater worry about changes in body shape and size during pregnancy was significantly associated with higher absolute weight gain and higher odds of exceeding the IOM guidelines.

In addition, a history of restrained eating, dieting, or weight cycling were each significantly associated with higher total weight gain and increased odds of gaining more weight than recommended. Finally, restrained eating, weight cycling and being 'moderately' worried about weight gain during pregnancy, were each protective against inadequate weight gain.

Table 3 shows the adjusted models of total GWG by pre-pregnancy dietary restraint and attitudes towards weight gain during pregnancy. Greater worry about weight gain during pregnancy and greater worry about changes in body shape and size during pregnancy were independently associated with higher total weight gains. The estimated relationship between worry about weight gain and total weight gain is presented in Fig. 2. In addition, restrained eaters, dieters and weight cyclers had higher absolute weight gains than non-restrained eaters, non-dieters and non-cyclers respectively.

Table 4 shows the adjusted models of excessive weight gain by pre-pregnancy dietary restraint and attitudes to weight gain variables. Greater worry about weight gain during pregnancy and greater worry about changes in body shape and size during pregnancy were each independently associated with elevated odds of excessive weight gain. A history of weight cycling was independently associated with higher odds of exceeding the IOM recommendations, however past restrained eating and dieting were not significantly associated with exceeding recommendations.

The multiple regression models (data not shown) of inadequate weight gain by pre-pregnancy dietary restraint and attitudes towards weight gain during pregnancy variables showed that being 'moderately' troubled by weight gain during pregnancy was protective against insufficient weight gain, although the variable as whole was not significant ($p = 0.094$). Additionally, worry about changes in body shape and size during pregnancy was not associated with inadequate weight gain. Furthermore, restrained eating and weight cycling, were each significantly associated with lower odds of inadequate weight gain, whilst pre-pregnancy dieting was not associated with inadequate weight gain.

Next, pregnancy-associated change in food intake was examined as a potential intermediary in the pathway between the dietary restraint behaviours and the GWG outcomes. As reported above, all three of the dietary restraint scales were not associated with changes in food intake since becoming pregnant. No additional multivariable models looking for mediation were therefore tested, as the initial analyses indicated that food intake could not be an intermediary in the pathway between the dietary restraint variables and GWG.

Subsequently, the role of pregnancy-associated change in food intake in accounting for the relationship between attitudes towards

Table 3

Multivariable linear regression models of total GWG in kilograms by pre-pregnancy dietary restraint and Attitudes towards weight gain during pregnancy variables (N = 799).

Variable	Models of total GWG <i>without</i> adjustment for change in food intake ^a		Models of total GWG <i>with</i> adjustment for change in food intake ^b	
	B [95% CI]	p	B [95% CI]	p
Worried about weight gain during pregnancy				
Very much/extremely	3.15 [1.90, 4.41]	<0.001	2.65 [1.38, 3.92]	<0.001
Moderately	2.36 [1.33, 3.39]	<0.001	1.97 [0.94, 3.00]	<0.001
A little	0.78 [-0.11, 1.67]	0.086	0.67 [-0.21, 1.56]	0.136
Not at all	[reference]		[reference]	
Worried about changes in body shape and size during pregnancy				
Very much/extremely	2.62 [1.33, 3.92]	<0.001	2.13 [0.84, 3.42]	0.001
Moderately	1.86 [0.79, 2.92]	0.001	1.50 [0.43, 2.56]	0.006
A little	1.17 [0.32, 2.02]	0.007	1.08 [0.24, 1.92]	0.012
Not at all	[reference]		[reference]	
Pre-pregnancy restrained eating status				
Restrained eater	1.49 [0.70, 2.29]	<0.001		
Non-restrained eater	[reference]			
Pre-pregnancy dieting status				
Dieter	1.42 [0.66, 2.18]	<0.001		
Non-dieter	[reference]			
Pre-pregnancy weight cycling status				
Cycler	1.84 [1.03, 2.66]	<0.001		
Non-cycler	[reference]			

Note. P values <0.05 are in boldface. GWG = gestational weight gain; CI = confidence interval.

^a Models adjusted for parity, nationality, pre-pregnancy BMI class, height, depressive symptoms, health insurance status, length of gestation (weeks) and length of time (weeks) between the last measured weight in pregnancy and delivery.

^b Models also adjusted for change in amount of food eaten since becoming pregnant.

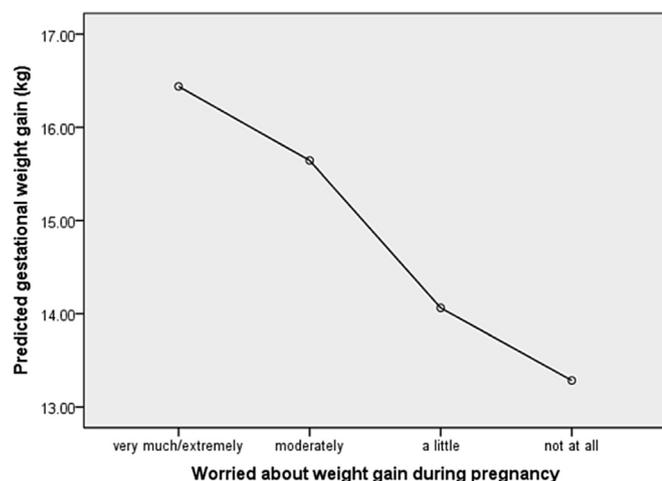


Fig. 2. Predicted total gestational weight gain as a function of worry about weight gain during early pregnancy (in linear regression model adjusted for parity, nationality, pre-pregnancy BMI class, height, depressive symptoms, health insurance, length of gestation (weeks) and length of time (weeks) between the last measured weight in pregnancy and delivery).

pregnancy weight gain and the GWG outcomes was examined. As shown in previous analyses, the initial criteria for adding food intake into additional multivariable models predicting total weight gain were met. The variables, total weight gain, change in food intake and worry about weight gain during pregnancy, were all significantly correlated with each other. Furthermore, the variables, total weight gain, change in food intake and worry about changes in body shape and size, were each significantly related to each other. As a result, further models that included food intake as a covariate were tested. Compared to the significant effects of maternal weight gain attitudes in the models unadjusted for food intake, the effects in the models adjusted for food intake were attenuated, but remained significant. This suggested that increased food intake partly accounted for the positive relationship between worry about

weight gain during pregnancy and total weight gain at delivery. It also partly accounted for the relationship between worry about changes in body shape and size during pregnancy and total weight gain.

Likewise, the conditions for adding food intake into additional multivariable models examining the effect of maternal weight gain attitudes on excessive weight gain were met. Excessive weight gain, food intake and concern about weight gain during pregnancy were all significantly associated with each other. In addition, the variables, excessive weight gain, change in food intake and concern about changes in body shape and size during pregnancy, were all significantly correlated with each other. As a consequence, additional models that included food intake as a covariate were tested. Following the inclusion of food intake, the concern about weight gain and concern about changes in body shape and size effects were attenuated and some were no longer significant. For example, following adjustment for food intake, being 'moderately' worried about changes in body shape and size during pregnancy no longer significantly predicted excessive weight gain ($p = 0.083$). Finally, as the attitudes towards weight gain during pregnancy variables were not significant predictors of inadequate weight gain, the role of food intake in accounting for these relationships was not tested.

4. Discussion

The purpose of this research was to examine the influence of dietary restraint behaviours and attitudes to maternal weight gain on GWG. In support of our hypotheses, this research showed that at approximately 15 weeks' gestation, increasing levels of concern about weight gain and increasing levels of concern about changes in body shape and size were independently associated with higher total weight gain and higher odds of excessive weight gain. These effect estimates were attenuated following adjustments for changes in food intake since becoming pregnant, although most of the effects remained statistically significant. This suggests that women's concerns about weight gain and changes in body shape and size during pregnancy may partly arise from recognition of increased food intake since becoming pregnant.

Table 4
Multivariable logistic regression models of excessive weight gain by pre-pregnancy dietary restraint and Attitudes towards weight gain during pregnancy variables (N = 799).

Variable	Models of excessive GWG <i>without</i> adjustment for change in food intake ^a		Models of excessive GWG <i>with</i> adjustment for change in food intake ^b	
	OR [95% CI]	<i>p</i>	OR [95% CI]	<i>p</i>
Worried about weight gain during pregnancy		0.016		0.057
Very much/extremely	2.25 [1.29, 3.92]	0.004	2.08 [1.17, 3.70]	0.012
Moderately	1.70 [1.09, 2.64]	0.019	1.56 [0.99, 2.45]	0.054
A little	1.30 [0.90, 1.88]	0.166	1.29 [0.89, 1.88]	0.184
Not at all	[reference]		[reference]	
Worried about changes in body shape and size during pregnancy		0.012		0.036
Very much/extremely	2.27 [1.29, 3.97]	0.004	2.05 [1.16, 3.64]	0.014
Moderately	1.60 [1.02, 2.51]	0.042	1.51 [0.95, 2.40]	0.083
A little	1.50 [1.05, 2.14]	0.026	1.48 [1.03, 2.12]	0.034
Not at all	[reference]		[reference]	
Pre-pregnancy restrained eating status		0.147		
Restrained eater	1.28 [0.92, 1.78]			
Non-restrained eater	[reference]			
Pre-pregnancy dieting status		0.085		
Dieter	1.32 [0.96, 1.82]			
Non-dieter	[reference]			
Pre-pregnancy weight cycling status		0.003		
Cycler	1.68 [1.19, 2.37]			
Non-cycler	[reference]			

Note. *P* values <0.05 are in boldface. GWG = gestational weight gain; CI = confidence interval. OR = odds ratio.

^a Models adjusted for parity, nationality, BMI class, height and depressive symptoms.

^b Models also adjusted for change in amount food eaten since becoming pregnant.

Taken together, these findings are consistent with a Norwegian cohort study of 35,929 pregnant women which showed that greater worry about weight gain during pregnancy was associated with higher absolute GWG (Swann et al., 2009). The findings are also consistent with research by Strychar et al. (2000) which showed that greater concern about prenatal weight gain was associated with exceeding the IOM weight gain guidelines. However, to our knowledge, this is the first study to demonstrate that greater worry about changes in body shape and size during pregnancy is associated with higher absolute GWG and increased odds of excessive weight gain. Furthermore, a unique finding of this research is that increased food intake may partially predicate the relationship between attitudes to maternal weight gain and both absolute weight gain and excessive weight gain. It also the first time that concern about weight gain has been associated with excessive weight gain in a large sample, using an item to measure weight gain concerns taken from a well-validated questionnaire on pregnancy-specific distress, thereby strengthening the evidence of a relationship.

The higher pre-pregnancy BMI among restrained eaters is compatible with other studies in pregnant women (Conway et al., 1999; Laraia, Siega-Riz, Dole, & London, 2009). Furthermore, the finding that restrained eating, weight cycling and dieting were each independently associated with higher absolute weight gains was consistent with our hypotheses and prior research on this topic (Conway et al., 1999; Mumford et al., 2008). Additionally, the observation that a history of weight cycling was associated with exceeding the IOM guidelines was compatible with our predictions and other relevant research (Mumford et al., 2008). However, the finding that pre-pregnancy restrained eating or dieting were *not* independently associated with excessive GWG did not support our hypotheses and contrasts with prior research which found that these behaviours were independently associated with higher weight gain adequacy ratios during pregnancy among normal weight, overweight and obese women (Mumford et al., 2008). It should be noted however that restrained eating and dieting were both significantly associated with excessive GWG in the univariable analysis.

On the basis of the boundary model of eating behaviour, it was

expected that restrained eaters would be more likely to report increased food intake since becoming pregnant than non-restrained eaters. However this prediction was not borne out by the findings. Nevertheless, the finding that women with a history of dieting, weight cycling, or restrained eating had a higher pre-pregnancy BMI and higher GWG compared to those without a history of these behaviours was supportive of the boundary model. Over half (54%) of the mothers in this research reported eating more food since becoming pregnant. This finding is compatible with previous research by Clark and Ogen (1999) which found that compared to the months prior to pregnancy, pregnant women rated themselves as less restrained in their eating behaviours and nearly half stated that they were eating more. They also found that pregnant women were less dissatisfied with their body shape and had less difficulty controlling their eating than non-pregnant women. The investigators concluded that pregnancy 'both legitimises increased food intake and removes any previous intention to eat less' (p. 18). Thus, a possible interpretation of the present findings is that both restrained and non-restrained eaters consumed more food since becoming pregnant, but that restrained eaters also continued to engage in periods of disinhibited overeating and therefore gained more weight than the non-restrained eaters. However, when answering the question about changes in food intake since becoming pregnant, the restrained eaters did not take account of their periods of overeating.

This study also revealed that a history of dietary restraint behaviours and greater worry about weight gain during pregnancy were positively correlated with pre-pregnancy BMI. Indeed, this is the first study, to our knowledge, to identify a link between pre-pregnancy BMI and worry about weight gain in early pregnancy. However, dietary restraint and concerns about weight gain were also associated with GWG, irrespective of BMI which suggests that the impact of weight concerns and dietary restraint on weight gain during pregnancy is not confined to overweight women.

This research had a number of strengths including a relatively large sample size, a prospective design and the inclusion of multiple extraneous variables. A limitation was that self-reported pre-pregnancy weight was used to calculate BMI and weight gain which

can lead to underestimation of BMI and overestimation of GWG, as pre-pregnancy weight is generally underestimated, particularly among high BMI women (Stevens-Simon, McAnarney, & Coulter, 1986; Stevens-Simon, Roghmann, & McAnarney, 1992; Yu & Nagey, 1992). Nonetheless, self-reported pre-pregnancy weight has been shown to correlate highly with clinically measured pre-pregnancy weight indicating that the ranking of individuals is well-preserved (Oken, Taveras, Kleinman, Rich-Edwards, & Gillman, 2007; Stevens-Simon et al., 1986). Moreover, the reliability of the outcome measures was enhanced by replacing self-reported pre-pregnancy weights that were deemed biologically implausible with pre-pregnancy weights imputed from the first measured weight in pregnancy.

Another potential limitation is that the Restraint Scale measures restrained eating and disinhibited eating rather than just restraint per se (Stice, Ozer, & Kees, 1997; Williamson et al., 2007). It has been suggested however that the behaviour of restrained eating followed by periods of disinhibition may be precisely what causes weight gain (Laraia et al., 2009). This suggests that the multi-dimensional nature of the Restraint Scale may make it a better predictor of GWG than 'purer' measures of restraint contained in the Eating Inventory and the Dutch Eating Behaviour Questionnaire. Future research with pregnant women should include an eating behaviour questionnaire (e.g., the Eating Inventory) which measures disinhibition separately from restraint. This would enable a better understanding of which eating styles are most predictive of GWG.

A further limitation was that the food intake measure (although retrospective in nature) was administered at the same time as the attitudes to GWG measures and thus it cannot be conclusively established that increased food intake played a causal role in women's attitudes to weight gain. However, it seems plausible that those who found that they had already gained a substantial amount of weight by the end of the first trimester were the most worried about their weight and continued to gain the most weight. This interpretation is consistent with literature which suggests that early pregnancy gains are associated with weight gain at delivery and postpartum weight retention (Kleinman et al., 2007). Future research should include serial measures of food intake and maternal weight throughout pregnancy to help to clarify whether those women who were most worried about weight gain, had higher weight gains due to early pregnancy weight gain only, or if they continued to eat more than necessary throughout pregnancy.

5. Conclusions

This research identified a number of psychological predictors of excessive weight gain during pregnancy—concerns about weight gain, concerns about changes in body shape and size and a history of weight cycling. Furthermore, this research suggests that increased food intake during early pregnancy may be a precursor to the relationship between concern about weight gain and excessive GWG. Both the Restraint Scale and the two items used in this research to measure attitudes to weight gain could potentially be used to identify women who might be at risk of unhealthy eating habits and excessive GWG. These short measures could be used by health professionals at early antenatal care visits, or by research personnel administering lifestyle interventions during pregnancy, to obtain information about women's past eating behaviours and current concerns about weight gain. This information may help to target those women needing extra guidance regarding healthy eating habits during pregnancy, and thus help to prevent excessive weight gain and consequent adverse pregnancy outcomes (Chung et al., 2013; Gaillard et al., 2013; Nohr et al., 2009).

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