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Nutritional and clinical associations of food cravings in pregnancy

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Abstract

Background: Cravings in pregnancy are considered to alter dietary intake; however, the nutritional consequences are unknown. The present study aimed to investigate the prevalence of food cravings in pregnancy, and their contribution, as a potentially modifiable determinant of weight gain and the development of obesity in pregnancy.
Methods: Healthy pregnant women were participants in the Belfast cohort of the Hyperglycaemia and Adverse Pregnancy Outcome study (HAPO), a prospective observational study examining maternal glycaemia and pregnancy outcome. Diet was assessed at an average of 29 weeks of gestation using a self-administered validated food frequency questionnaire over the previous 2 weeks that included questions on food cravings experienced at any time during pregnancy. Clinical measurements collected included, height, weight, blood glucose and neonatal outcomes. Mean daily nutrient intakes were analysed with appropriate software.
Results: Food cravings were reported by 39% (n = 635) of women, with sweet foods, fruit and dairy products most frequently consumed. Those who craved foods had a higher mean (SD) energy intake [9721 (3016) kJ] (P = 0.002) even when under-reporters were removed [10131 (2875) kJ] (P = 0.008). However, no differences were found in nutrient or food intake between groups when adjusted for energy. Similarly, no differences were observed between groups and glycaemic control, anthropometric measurements or offspring outcome measures.
Conclusions: Cravings commonly occur in pregnancy and contributed to a small increase in energy intake; however, this did not impact on overall dietary intake, nor was it associated with excessive gestational weight gain, maternal glycaemia or offspring outcome measurements.

Introduction

Food cravings and aversions are commonly reported in pregnancy [(1–5)] Both food cravings and aversions can serve as motivators for increasing and/or decreasing the intake of certain foods [(6)]; however, food cravings have been reported as being associated with weight and eating-related pathology [(7)] and are generally reported for foods that provide energy, whereas aversions are more often associated with a response to nausea and vomiting and are therefore likely to be associated with the avoidance of foods and restriction [(1)]. No evidence exists to suggest that food cravings and aversions are associated [(1)] with each other. The present study therefore aimed to investigate the contribution of food cravings in pregnancy as a potentially modifiable determinant of weight gain and the development of obesity in pregnancy.

The aetiology of food cravings is unknown, although it has been suggested that the physical and hormonal changes that occur during pregnancy may play a role in

their development. Anecdotal evidence suggests that an increased requirement for energy or other nutrients [3,8–10] may result in physiological changes in taste and olfactory sensitivity [3,11,12], which may therefore trigger the consumption of specific foods [9], thus altering the nutritional content of the diet [9]. However, studies documenting these relationships are relatively archaic and sparse. Additionally, anecdotal reports have suggested that the physiological changes occurring during pregnancy may lead to cravings for sugar to meet the increased energy requirements [13]. However, more recently, Belzer *et al.* [2] proposed that the physiological changes occurred in relation to insulin resistance and glucose intolerance in women with mild gestational diabetes mellitus leading to the existence of sweet cravings and an increased preference for sweet foods.

It is therefore more likely that food cravings contribute to the development of overweight and obesity and, given the rise in prevalence of excess gestational weight gain, food cravings may therefore be a potentially modifiable determinant for energy intake (EI) and nutrient quality in pregnancy [7]. Changes in food intake resulting from cravings may intentionally modify a pregnant woman's diet by the selection of specific foods to improve well-being, although the consequences of any such dietary changes are not well publicised. It is well known that overconsumption of energy dense foods may lead to excessive gestational weight gain, which is an established risk factor for future obesity in both mother and offspring [14,15]. Thus, avoiding excessive gestational weight gain could be an effective approach for preventing postpartum weight retention and chronic diseases such as obesity and diabetes. Understanding the associations between food cravings and EI is therefore of clinical importance. The present study aimed to assess the prevalence and types of foods craved in pregnancy and, in addition, to compare the anthropometric, clinical characteristics and dietary intakes of women with and without food cravings utilising data from a large cohort of pregnant women participating in the Belfast centre of the Hyperglycaemic and Adverse Pregnancy Outcome (HAPO) Study.

Materials and methods

Subjects and recruitment

Pregnant women without diabetes attending antenatal clinics at Royal Jubilee Maternity Hospital, Belfast Northern Ireland, were recruited to a prospective observational study examining maternal glycaemia (short of diabetes) and adverse pregnancy outcome (HAPO Study) [16] between January 2001 and June 2006. Eligible women were over 18 years of age and all were recruited before 31 weeks of gestation. Specific exclusion criteria are shown in Table 1. Informed consent was provided by all of the subjects who participated and ethical approval was obtained from The Northern Ireland Regional Ethics Committee. Data from the HAPO study were used in this analysis [16]. Lifestyle information was collected at recruitment and included questions on age, weight (recorded at booking appointment), time in education, previous children, smoking and alcohol habits. Anthropometric and biochemical information was collected at approximately 28 weeks of gestation and included weight, height, fasting and random blood glucose. Offspring data were collected at birth and included sex, weight, length and head circumference. This analysis was undertaken on those women who participated and completed dietary information in one centre of this observational study and therefore no power calculation was undertaken.

Dietary evaluation

Pregnant women completed a semi-quantitative validated FFQ during the first routine study visit between 24 and 32 weeks of gestation (as close to 28 weeks as possible), where they also underwent metabolic investigation and a 75-g oral glucose tolerance test. The FFQ used was first developed and evaluated by Rogers, Emmett and the ALSPAC Study team [17] in Southwest England for the ALSPAC study. The ALSPAC FFQ included questions about the weekly frequencies of consumption of 43 food groups and food items covering all the main foods consumed in UK, with the following options for response: never/rarely, once in 2 weeks, 1–3 times a week,

Table 1 Criteria for exclusion in the Hyperglycaemia and Adverse Pregnancy Outcome study (HAPO) study

Age <18 years
Planning to deliver at another hospital or location [16]
Date of last menstrual period uncertain and no ultrasonographic estimation for between 6 and 24 weeks of gestational age available
Unable to complete oral glucose tolerance test within 32 weeks of gestation
Known multiple pregnancy
Conception by means of gonadotrophin ovulation induction or *in vitro* fertilisation
Glucose testing before recruitment or a diagnosis of diabetes during the current pregnancy
Diagnosis of diabetes before the current pregnancy and requiring treatment with medication
Participation in another study that could interfere with the HAPO study
Infection with the human immunodeficiency virus or hepatitis B or C virus
Previous participation in the HAPO study
Inability to converse in language used in field centre

4–6 times a week, once a day, and more than once a day. Women were asked to record their usual intake of foods consumed over the previous 2 weeks. More detailed information on the daily consumption of basic foods (e.g. bread, fats, oils, milk, coffee, tea, sugar and drinks) were also collected as part of ALSPAC FFQ. The list was revised by including foods frequently eaten in Northern Ireland (e.g. soda bread, wheaten bread and pancakes) following a pilot of this FFQ on a separate cohort of 500 women of childbearing age. The revised FFQ included 72 quantitative and qualitative questions of which 48 were concerned with the frequency of consumption of breakfast cereals, meats, poultry and fish, fruits and vegetables and sweet foods. Questions were also asked regarding frequency of meals and supplements taken. Portion sizes were estimated based on Food Standards Agency [18] publication, when not specified in the FFQ. Estimated EI values calculated from the FFQ were validated against those obtained from a 7-day food record with significant positive correlations observed for nutrients (range for nutrients $r = 0.31$–0.69; A. Hill, unpublished data, 2013). As part of the questionnaire, women were asked to describe subjectively any food cravings experienced at any stage during the current pregnancy. There were no prompts or suggested foods listed. Women were asked to record all foods, drinks and nonfood items craved. Instructions for completion of the FFQ were given by trained personnel who probed subjects for inaccurate or omitted responses. These were then reviewed by an experienced dietitian. Each participant was given a unique identification number, which was then used to collect anthropometry, background and lifestyle information, as described in detail elsewhere [16].

Analysis of food frequency questionnaire

Mean nutrient intakes of each participant were calculated from the food frequency questionnaire (FFQ) using the nutritional software package Q-Builder (Questionnaire Design System), version 2.0 (Tinuviel Software, Anglesey, UK). Q-Builder comprises questionnaire design software that incorporates nutritional analysis using standard food portion sizes [18] and UK food composition tables [19]. Information collected from the FFQ on the frequency with which foods were consumed is converted by Q-Builder into foods and weights that generate a mean daily nutrient intake. The estimated daily intake was calculated by multiplying the weekly frequencies of consumption of a food by the nutrient content of a standard portion. Each one of the frequency options of the questionnaire allocated was mapped as: never or rarely = 0, once in 2 weeks = 0.5, one to three times a week = 2, four to six times a week = 5, daily = 7, and more than once a day = 14.

Food cravings

There is no standard procedure for categorising food cravings; therefore, these foods were grouped based on food group. Food cravings were assigned to one group based on the major ingredient; for example, chocolate ice cream was coded as ice cream but not as chocolate: sweet breakfast cereals were coded with all other cereals as starchy carbohydrate and not as sugary foods. Some foods were easy to categorise in this way, whereas others were less obvious. For example, prawn crackers were classed with crisps and olives were classed with fruit.

Under-reporting

The level of under-reporting of EI was determined: basal metabolic rate (BMR) was computed using published equations based on age, pre-pregnancy weight and height [20], and an increment of 1.1 MJ for the third trimester of pregnancy and estimated physical activity level [21] was added. Goldberg's method was used to predict levels of under-reporting using the ratio of EI (EI reported) to estimated BMR (BMR estimated) [22]. A ratio of ≤1.2 may indicate under-reporting and a ratio of ≤0.9 is a sign of definite under-reporting [22]. Analysis was run both with and without under-reporters. Subjects were divided into three groups 'definite under-reporters' if the EI : BMR ratio was ≤0.9; 'potential under-reporters' if the ratio was >0.9–≤1.2 and 'normal reporters' >1.2.[23]

Statistical analysis

Data were analysed using SPSS [24] (SPSS Inc., Chicago, IL, USA). Descriptive statistics (mean, mode, range and SD) were calculated for continuous variables and frequencies calculated for categorical variables. Differences in categorical variables in women who experienced cravings and those who did not were assessed using chi-squared analysis. Differences in the incidence and type of craving were investigated in relation to maternal glycaemic control, nutrient intakes and continuous socio-demographic variables using independent samples *t*-test and analysis of variance. Multiple regression analysis was conducted to explore the relationship between cravings, EI, education, smoking and weight gain and other potential cofounders. $P < 0.05$ was considered statistically significant.

Results

Subject characteristics

Of the 1639, almost exclusively Caucasian (98%) women, 39% ($n = 635$) reported experiencing craving (assessed at

approximately 29 weeks of gestation) at least one food during pregnancy. The craving and noncraving groups were comparable with respect to age, gestational age at interview and marital status (Table 2). However, compared to women who reported no cravings, those who reported experiencing food cravings had fewer years of formal education ($P = 0.04$), were more likely to be smokers ($P = 0.05$) have previous children ($P = 0.002$), and were less likely to be employed ($P = 0.001$), However, after adjustment for these nondietary covariates, this was no longer significant and no differences were observed between cravers and non cravers.

Frequency and type of food craving

The most commonly craved foods (calculated as a percentage of the total number) were sweet foods, especially chocolate (35%), fruit and fruit juices (13%), and dairy foods (8%) (Table 3). Most (60%) subjects reported craving only one food; 27% reporting two foods; and 13% reporting three or more foods. Although many cravings were general (e.g. something sweet), others were more specific (e.g. chocolate ice cream, mint chocolate bar, pear ice lolly, green apples). Others were for unusual food combinations (e.g. pickled onions and marmalade sandwiches, chicken burgers with salt and vinegar crisps). Nonfood cravings (Pica) (e.g. ice, coal, cigarette butts) were reported infrequently (1.5%).

Anthropometric associations with food cravings

Groups were comparable in relation to mean body mass index, height and gestational age at the time of measurement. Women who craved foods were found to gain, on average, more weight overall during pregnancy ($P = 0.043$); however, when the rate of weight gain was calculated per week for each women based on IOM guidelines [25], no differences were observed between groups (Table 2). Similarly, no differences in weight gain were observed between groups when BMI categories were investigated. Weight gain throughout pregnancy was comparable between groups with respect to age, years of education and marital status. However, of those who craved foods, nonsmokers gained on average 1.7 kg more weight than smokers ($P = 0.001$), those with no previous children gained 1.3 kgs more than those with children ($P = 0.004$) and those who were employed gained 1.3 kg more than those who were unemployed ($P = 0.008$). However, after adjustment for these nondietary covariates this was no longer statistically significant.

Clinical associations of cravings in pregnancy

No differences were observed between groups in measurements of glycosylated haemoglobin (HbA1c), fasting, and 1- and 2-h blood glucose measurements at 29 weeks of gestation (mean 29.0wks ± 1.24). Similarly no differ-

Table 2 Characteristics of women with ($n = 635$) and without food cravings ($n = 1004$)

	Cravings	No cravings	*P** value
Age at interview (years) (SD)	29.7 (5.5)	29.7 (5.5)	NS
Gestational age at interview	28.9 (1.2)	28.9 (1.2)	NS
Years in education (years)	14.7 (2.9)	15.1 (2.8)	0.037
Smoking at interview†	165 (26%)	218 (22%)	0.05
Employed at interview‡	453 (72%)	785 (78%)	0.001
Previous children§	347 (55%)	477 (48%)	0.002
BMI (kg/m²) <16 weeks gest (mean 12.1 weeks ± 2.3)	25.8 (4.9)	25.5 (4.9)	NS
Weight (kg) <16 weeks gest (mean 12.1 weeks ± 2.3)	68.5 (14)	67.5 (13)	NS
Weight (kg) 29 weeks	75.8 (14)	74.9 (13)	NS
Height (m) 29 weeks	163 (6.3)	163 (6.3)	NS
BMI (kg/m²) 29 weeks	28.5 (4.9)	28.3 (4.8)	NS
Weight gain <16 weeks – 3rd trimester (mean 32.8 weeks ± 4.5)	9.6 (5.4)	8.9 (5.5)	NS
Rate of weight gain (kg week^{-1})	0.5 (0.2)	0.4 (0.2)	NS
Fasting blood glucose 29 weeks (OGTT) mmol L^{-1}	5.2 (1)	5.2 (1)	NS
HbA1c 29 weeks	4.8 (0.4)	4.8 (0.3)	NS
Neonatal birthweight	3.5 (0.6)	3.5 (0.5)	NS
Birthweight SDS	−0.1 (0.9)	−0.1 (0.9)	NS
Birth length SDS	0.2 (1.1)	0.1 (1.2)	NS
Head circumference SDS	0.3 (1)	0.2 (1)	NS
Female child √	310 (49%)	474 (48%)	NS

Data are the mean (SD) or n (%) of subjects *t-test for independent samples or chi-squared tests †With cravings, $n = 633$, and without cravings, $n = 998$. ‡With cravings, $n = 633$, and without cravings, $n = 997$. §With cravings, $n = 631$, and without cravings, $n = 1003$. ¶With cravings, $n = 633$, and without cravings, $n = 988$. BMI, body mass index; HbA1c, glycosylated haemoglobin; NS, not significant; OGTT, oral glucose tolerance test; SDS, Standard deviation score.

Table 3 Most common types of foods craved by pregnant women (overlapping percentage)

Food group	Foods included	Percentage of cravings in category
Number of women craving (%)		39% (n = 635)
Total number of foods craved		1024
Of those who reported craving foods (%)		
Sweet	Chocolate, sweets, ice-cream, desserts	34.7
Fruit	Fruit, juices	12.7
Dairy	Milk, yoghurt, cheese, cream	8.1
Protein	Meat, poultry, fish	7.6
Carbohydrate	Cereal, bread, pasta, potatoes	7.3
Salty snacks	Crisps, corn snacks, peanuts	6.7
Pickled foods	Beetroot, pickles	5.1
Fast food	Pizza, Chinese, Indian, fish and chips	4.5
Vegetables	All vegetables and salads	4.1
More food	Sandwiches, larger portions	3.6
Spicy	Curry, chilli, spices	3.3
Pica	Nonfoods items; ice, coal	1.5
Miscellaneous	Alcohol, tea, coffee	0.8

ences were observed between groups in the duration of gestation, method of delivery, sex of offspring, birthweight, head circumference or length at delivery (Table 2).

Nutritional associations of cravings in pregnancy

Misreporting of energy intake

Mean EI : BMR of all subjects was 1.42 ± 0.512. The Goldberg's cut-off of ≤1.2 revealed that 36.5% (n = 587) women may be under-reporting EI. Of those who had cravings, 10.5% (n = 172) were classified as definite under-reporters with a Goldberg's ratio of <0.9, 26% (n = 415) potential under-reporters Goldberg's ratio 0.9 to ≤1.2 and 63.5% (n = 1023) normal reporters Goldberg's ratio >1.2. Women with cravings had a higher mean EI : BMR ratio than those without cravings (P = 0.006) (Table 3) and also less women who craved foods (8.3%) were classified as under-reporters than those who did not crave foods (12.2%) (P = 0.019).

Reported energy, nutrient and fibre intakes

Table 4 presents mean intakes of energy, fibre, macronutrients and selected micronutrients of the total group and also excluding those identified as 'definite' under-reporters (10.5%). Women reporting a food craving had significantly higher mean EI [9721 (3016) kJ] compared to those who did not experience food cravings [9256 (2786) kJ] (P = 0.002), which showed a similar trend when under-reporters were excluded (P = 0.008) (Table 4).

No differences were observed in the mean daily intake of macronutrients, fibre and selected micronutrients when adjusted for energy between groups (Table 4).

Overweight and obese women with cravings reported consuming significantly less energy than normal weight women compared to women without cravings (Table 5).

Types of foods craved

A slightly higher proportion of women with cravings reported consuming more green vegetables and also yoghurts each week. However, there were no differences in the number of portions eaten each week between groups and other types of foods, including the most frequently reported foods craved (e.g. fruits, vegetables and sweet foods). Similarly, when only those who reported craving sweet foods (most commonly craved food) were investigated, there were no differences observed between groups in the number of portions of foods eaten. (Table 6). Similarly, no energy or nutrient differences were observed between those who experienced the most commonly craved foods (sweet foods 35% of cravers) and those who did not crave any foods.

Discussion

The present study reports the food craving habits of 1639 almost exclusively Caucasian (98%) pregnant women assessed at an average of 29 weeks of gestation in relation to nutritional and clinical characteristics. Almost 40% (n = 635) of women experienced food cravings during pregnancy with sweet foods, chocolate particularly chocolate being most commonly craved. However, there were no differences observed between groups in body mass index, gestational weight gain or measures of glycaemia.

A key finding that emerged in the present study was that women who craved foods had a significantly higher overall EI (465 kJ, P = 0.002) even when under-reporters were excluded (10.5%) (386 kJ, P = 0.008). However, no differences were observed in nutrient intakes between groups when adjusted for energy and, similarly, no evidence was found to suggest that cravings contributed towards increased consumption of a particular food or food group.

The small increase in EI identified in the present study may have resulted from an increase in food intake as a result of food craving; however, this difference in EI was

Table 4 Mean intakes of energy, macronutrients and selected micronutrients in pregnancy split by craving status

	Total sample (n = 1639)			Total sample excluding under-reporters (Goldberg's ratio >0.91) (n = 1438)		
	Cravings (SD)	No cravings (SD)	P* value	Cravings (SD)	No cravings (SD)	P* value
Energy (kJ)	9721 (3016)	9256 (2786)	0.002	10131 (2875)	9745 (2558)	0.008
Protein (% TE)	15.5 (2.7)	15.7 (2.7)	NS	15.3 (2.7)	15.5 (2.6)	NS
Fat (% TE)	32.7 (5.8)	32.5 (5.9)	NS	33.0 (5.8)	32.9 (5.9)	NS
SFA (% TE)	13.5 (3.7)	13.4 (3.9)	NS	13.7 (3.8)	13.6 (3.9)	NS
MUFA (% TE)	10.9 (1.9)	10.8 (1.9)	NS	10.9 (1.9)	10.9 (1.9)	NS
PUFA (% TE)	4.7 (1.3)	4.7 (1.3)	NS	4.7 (1.4)	4.7 (1.3)	NS
Carbohydrate (% TE)	52.1 (5.7)	52.9 (5.6)	NS	51.9 (5.8)	51.7 (5.5)	NS
Sugars (% TE)	22.5 (5.4)	21.9 (5.2)	NS	22.5 (5.4)	21.9 (5)	NS
Vitamin C (mg)	144 (78.4)	132 (75.3)	NS	148 (79)	137 (76)	NS
Calcium (mg)	1218 (337)	1169 (326)	NS	1258 (324)	1218 (308)	NS
Vitamin D (μg)	3.5 (2.6)	3.2 (2.3)	NS	3.6 (2.7)	3.3 (2.3)	NS
Iron (mg)	12.6 (3.97)	11.9 (3.4)	NS	13 (3.9)	12.4 (3.2)	NS
Fibre (g)	17 (5.5)	16 (5.1)	NS	17.4 (5)	16.7 (4.9)	NS
Dietary GI	55.9 (3.03)	55.9 (4.1)	NS	55.8 (3)	55.9 (4.1)	NS
Dietary GL	177 (54.3)	168 (48.9)	NS	184 (52)	176 (46)	NS
EI : BMR ratio	1.46 (0.54)	1.39 (0.49)	0.006	1.5 (0.5)	1.48 (0.5)	0.034

Data are the mean (SD) or n (%). *t-test for independent samples. BMR, basal metabolic rate; EI, energy intake; GI, glycaemic index; GL, glycaemic load; MUFA, monounsaturated fatty acids; NS, not significant; PUFA polyunsaturated fatty acids; SFA saturated fatty acids; TE, total energy.

Table 5 Weight change, energy intake (EI) and EI : basal metabolic ratio (BMR) of those with and without cravings by body mass index (BMI) category (≤16 weeks)

	Underweight (BMI < 18.5 kg m^{-2})			Normal weight (BMI 18.5-24.9 kg m^{-2})			Overweight (BMI 25.0-29.9 kg m^{-2})			Obese (BMI ≥30.0 kg m^{-2})			
	n	Mean (kg)	SD	n	Mean (kg)	SD	n	Mean (kg)	SD	n	Mean (kg)	SD	P
Mean weight change <16 weeks until end (28–41 weeks)													
Cravings	10	10.2	(5.4)	280	10.2*	(5.0)	180	9.5	(5.3)	91	7.3*	(5.6)	<0.0001
No cravings	15	11.5	(4.4)	477	9.8	(4.1)	257	8.9*	(4.8)	142	6.7*	(5.2)	<0.0001
Mean EI (kJ)													
Cravings	10	14452**	(7227)	280	10019**	(2999)	180	9671	(2665)	91	8853**	(2538)	<0.001
No cravings	15	11009	(3145)	477	9567	(3015)	257	8827**	(2378)	142	8900**	(2355)	<0.001
Mean EI : BMR ratio													
Cravings	10	2.37	(1.26)	278	1.54	(0.51)	175	1.44	(0.48)	89	1.3	(0.55)	<0.001
No cravings	15	1.76	(0.55)	475	1.44	(0.48)	254	1.31	(0.44)	140	1.3	(0.52)	<0.001

*Significant difference between mean weight change and BMI category by analysis of variance (ANOVA) ($P < 0.05$).
**Significant difference between mean EI (kJ) and BMI category by ANOVA ($P < 0.05$).
***Significant difference between EI : BMR ratio and BMI category by ANOVA ($P < 0.05$).

relatively small and therefore it is unlikely to be of clinical significance (Table 4). It is more plausible that the small increase in EI found in the present study may be a result of biases associated with conducting dietary surveys, most notably the use of FFQs in assessing dietary intake and mis-reporting of EI. To what extent mis-reporting of EI accounts for the discrepancy is unclear. In the present study, average daily EI was assessed from a FFQ that was designed to assess habitual intake and subsequently the calculated EI : EE may be underestimated. Therefore, it is not possible to state conclusively that subjects classed as normal reporters (63.5%) with a Goldberg's ratio >1.2 cut-off level determined for under-reporting were actually achieving their energy and/or nutrient requirements and bias may still be present within the sample. It must also be acknowledged that

Table 6 Mean number of portions of foods eaten each week split by craving status

Food	Cravings Mean (SD)	No cravings Mean (SD)	*P* value*
Green vegetables	2.8 (2.2)	2.5 (2.0)	0.027
All vegetables	9.5 (5.4)	8.7 (5.1)	NS
Fresh fruit	8.6 (5.7)	8.0 (5.7)	NS
All fruit and vegetables†	2.27 (1.8)	2.04 (1.8)	NS
Potatoes	3.6 (2.1)	3.2 (1.9)	NS
Breakfast cereals (all types)	6.1 (4.1)	5.6 (3.7)	NS
Chicken (all types)	1.9 (1.6)	1.8 (1.5)	NS
Meat (all types red meat)	2.0 (91.8)	2.0 (1.7)	NS
Yoghurt	2.3 (2.5)	2.1 (2.4)	0.023
Takeaway meals	1.5 (0.6)	1.4 (0.5)	NS
Chocolate bars	3.0 (2.8)	2.7 (2.6)	NS
Crisps	2.6 (2.6)	2.6 (2.5)	NS
Biscuits	5.2 (4.4)	5.0 (4.1)	NS

*Mann–Whitney *U*-test for nonparametric continuous variables. †Per day. NS, not significant.

under-reporting is widely associated with overweight and obesity [26,27], which was confirmed in the present study because overweight and obese women had, on average, a lower EI : BMR ratio (Table 5). However, of note, non-cravers were found to be more likely to under-report EI ($P = 0.006$) than cravers, which remained even after excluding under-reporters ($P = 0.034$), irrespective of BMI category. This being the case, it may be that cravers are more likely to report food intake including cravings more accurately. It could therefore be speculated that cravers taking part in the study may have an enhanced awareness of recalling and recording food intake more accurately.

Food cravings in pregnancy have been reported to contribute towards an increase in calcium and EI values [28], influence food consumption patterns [9] and/or lead to an increased dietary intake [13] of that food.

The present study did not find any evidence to support previous research suggesting that cravings for sweets, desserts and chocolates result in a general increase in consumption of sugary foods and beverages and overall EI [2,9,13]. Similarly, the present study did not find any evidence to suggest that craving any specific food contributed to an increased overall consumption of that food and therefore no association was identified between food cravings and dietary quality that was consistent with one prior study [29]. The underlying reasons as to why food cravings do not appear to influence dietary intake in the present study are unknown; however, several factors may play contributory roles. It is possible that those who completed the questionnaire later in pregnancy (range 24–31 weeks of gestation; SD 1.3) may have provided the least reliable reports because food cravings typically arise late in the first trimester, peak in frequency and intensity during the second trimester, and then diminish as pregnancy progresses [1,2,13]. Second, because this FFQ assessed habitual food intakes over a 2-week period, at an average of 29 weeks of gestation (range 24–32 weeks; SD 1.3), it is possible that any effect on dietary intake arose earlier in pregnancy. Third, diet was assessed at only one time point (approximately 29 weeks of gestation), which, ideally and in future studies, should be completed in each trimester.

The most commonly craved foods identified were sweet foods (35%) particularly chocolate, and other high energy sugary and fatty foods. Cravings were also frequently reported for nutrient dense foods such as fruit (13%), dairy foods (8%), meats (7.5%) and starchy foods (7.3%), although this was less often, which is a finding broadly consistent with previous studies [1,3,4,9,13,30–33]. It is possible that the pattern of types of foods craved during pregnancy vary because evidence suggests that the preference for sweet foods peaks in intensity during the second trimester [34] and, for savoury foods, the preference is strongest during the first trimester [2]. Therefore, it could be speculated that women experiencing food cravings had a heightened awareness of their food intake and so may have been able to recall their dietary intake more completely.

Excess gestational weight gain is associated with adverse maternal and neonatal health outcomes, which include, for example, an increased risk of gestational diabetes mellitus, hypertension and pre-eclampsia [25]. Excess gestational weight gain is also a strong predictor of macrosomia [35] and the development of overweight and obesity in offspring [36], which highlights the potential impact of nutritional influences encountered during early life on future health. Therefore, identifying risk factors for excessive weight gain in pregnancy is a potentially modifiable determinant for future health. A lack of evidence exists regarding the potential influence of food cravings as a risk factor in the development of excessive gestational weight gain. However, King [28] suggested that cravings in pregnancy increase EI, which has been attributed to excessive gestational weight gain [28], and preliminary evidence in overweight African-American women identified cravings as a significant predictor of excess gestational weight gain [37]. However, the present study found no significant differences in gestational weight gain between groups when rate of weight gain per week (kg) was calculated using IOM guidelines [25] (Table 2). Therefore, the present study provides no evidence to suggest that women who crave foods gain more weight in pregnancy than those who do not crave foods.

Similarly, the present study did not identify any association between the type of food craved and measures of glycaemia and/or the development of gestational diabetes

mellitus. Recent evidence from women with known gestational diabetes mellitus (GDM) shows they have a higher taste preference for moderately sweetened dairy drinks compared to healthy non-GDM women [2,38], which would suggest that women with higher blood sugar levels prefer the taste of sweet foods. However, this was not shown in the present study, where no differences between blood sugar levels were observed (assessed during an oral glucose tolerance test) between those women who craved sweet foods and those who did not. However, because women in the present study were not known to have diabetes before pregnancy (mean fasting blood sugar was 4.6 mmol L^{-1}: range 3.5–8.3; SD 0.37 as documented during the oral glucose tolerance test), the range may have been too narrow to detect any differences between groups and, in addition, the number of women identified as GDM in the present study was small (4% using IADPSG criteria) [39] and may have contributed to no differences being observed. Finally, assessing diet in each trimester would allow a more complete assessment of how cravings may be associated with food intake throughout pregnancy.

In conclusion, the present study of 1639 almost exclusively Caucasian women in Northern Ireland provides evidence that cravings commonly occur in pregnancy, with sweet foods being most frequently reported. However, no conclusive evidence was found to suggest that cravings increase the consumption of any specific food, contribute to an increased EI or influence gestational weight gain. These findings therefore provide no evidence to suggest that food cravings in pregnancy alter dietary intake or have an impact on changes in EI or nutritional quality in the later stages of pregnancy.

Conflict of interests, source of funding and authorship

The authors declare that they have no conflicts of interest.

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DRM is PI for the Belfast HAPO study. AJH carried out statistical tests and drafted the manuscript with contributions from VC and DRM. VC analysed the dietary data. All authors critically reviewed the manuscript and approved the final version submitted for publication.

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