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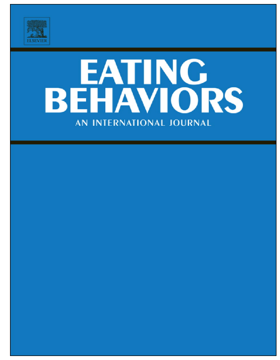

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Intuitive eating is associated with weight and glucose control during pregnancy and in the early postpartum period in women with gestational diabetes mellitus: A clinical cohort study

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Abstract

Introduction: High pre-pregnancy weight and body mass index (BMI) increase the risk of gestational diabetes mellitus (GDM) and diabetes after pregnancy. To tackle weight and metabolic health problems, there is a need to investigate novel lifestyle approaches. Outside of pregnancy, higher adherence to intuitive eating (IE) is associated with lower BMI and improved glycemic control. This study investigated the association between IE and metabolic health during pregnancy and in the early postpartum period among women with GDM.

Methods: Two-hundred and fourteen consecutive women aged ≥18, diagnosed with GDM between 2015 and 2017 and completed the "Eating for Physical rather than Emotional Reasons (EPR)" and "Reliance on Hunger and Satiety cues (RHSC) subscales" of the French Intuitive Eating Scale-2 (IES-2) questionnaire at the first GDM clinic visit were included in this study.

Results: Participants' mean age was 33.32±5.20 years. Their weight and BMI before pregnancy were 68.18±14.83kg and 25.30±5.19kg/m^2 respectively. After adjusting for confounding variables, the cross-sectional analyses showed that the two subscales of IES-2 at the first GDM visit were associated with lower weight and BMI before pregnancy, and lower weight at the first GDM visit (β=-0.181 to -0.215, all p≤ 0.008). In addition, the EPR subscale was associated with HbA1c and fasting plasma glucose at the first GDM visit (β=-0.170 and to -0.196; all p≤ 0.016). In the longitudinal analyses, both subscales of IES-2 at first GDM visit were associated with lower weight at the end of pregnancy, BMI and fasting plasma glucose at 6-8 weeks postpartum (β=-0.143 to -0.218, all P≤ 0.040) after adjusting for confounders.

Conclusions*:* Increase adherence to IE could represent a novel approach to weight and glucose control during and after pregnancy in women with GDM.

Keywords: Intuitive eating; Gestational diabetes mellitus; Body mass index; Glycemic control; Pregnancy; Postpartum

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Author contribution

DYQ, JG, LG, AH and JP designed the study. DYQ, JG, CH, LG were involved in data collection. DYQ extracted the data, performed all the analyses and wrote the draft manuscript. DYQ, JG and JP interpreted the data. JG, LG, AH and JP reviewed the manuscript. All authors revised and accepted the manuscript for submission. JP had the idea of the cohort and co-supervised all the work with AH.

Conflict of interest

None

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1. Introduction

Gestational diabetes mellitus (GDM) refers to any degree of glucose intolerance that is diagnosed in the second or third trimester of pregnancy but does not fulfil the criteria of overt diabetes prior to gestation (1). The negative maternal consequences of GDM are well documented (2,3). Pre-pregnancy BMI and weight gain during pregnancy also increase the risk for complications, such as cesarean delivery and maternal postpartum weight retention (4). Although pre-pregnancy overweight or obesity increase the risk of GDM (5), excess weight gain in women with GDM may increase the risk of developing diabetes in the postpartum period (5,6).

The cornerstone of GDM treatment requires nutrition/diet and exercise intervention to achieve weight and glucose control and also to reduce the need for medical therapy (7). Regarding nutrition, several diets, such as low glycemic index (GI) diet, total energy restriction diet, low carbohydrate diet, and ethnic or traditional diets, such as the Mediterranean diets, have been used to manage weight and glycemic control in women with GDM (8). Although lifestyle interventions (diet and physical activity) led to a lower postpartum weight gain according to a recent Cochrane review (9), the review found no differences regarding postpartum glucose tolerance, postnatal weight retention or return to pre-pregnancy weight in women with GDM between those who had a lifestyle intervention and the control group (9). This evidence suggests that, research should focus on interventions targeting specific lifestyle aspects to address the long-term outcomes of GDM. BMI and weight are independent risk factors of GDM and of the development of diabetes after pregnancy. Therefore, additional methods that improve or maintain weight and promote healthier eating options during pregnancy and in the postpartum period need to be explored especially in women with GDM.

Research suggests that, adaptive eating behaviors that encourage people to recognize and respond to their internal signs of hunger and satiety prevent emotional eating and dietary restriction (10–12), and may lead to lower weight and BMI (13). One such adaptive eating behavior is intuitive eating (IE). IE is characterized by eating in response to physiological hunger and satiety cues rather than external and/or emotional cues (14,15). IE is a more sustainable long-term eating behavior than dieting and is known to be associated with lower levels of cholesterol and cardiovascular risk. It is also inversely associated with disordered eating behavior and leads to body shape satisfaction, lower weight and glucose maintenance (16,17).

Outside of pregnancy, evidence suggests that IE is associated with lower BMI (18–20), weight loss (21,22) and glycemic control in the general population (23,24). In the postpartum period, higher IE practices were associated with lower weight compared to those who engaged in fewer IE practices (25). Even though IE is associated with long-term weight maintenance or weight loss (26), no study has investigated the potential benefit of IE in pregnancy, although the IE questionnaire has been validated in samples of pregnant women (27). Considering that, IE is correlated with BMI, weight and glycemic control as indicated above, we hypothesize that, higher adherence to IE may be beneficial for weight and glycemic control in women with GDM during and after pregnancy. The objective of this study therefore was to investigate the cross-sectional and longitudinal associations between IE and BMI, weight and glycemic control, both during pregnancy and in the early postpartum period among women with GDM.

2. Methods

2.1 Participant consent and recruitment

Pregnant women diagnosed with GDM according to the International Association of the Diabetes and Pregnancy Study Groups (IADPSG) and American Diabetes Association (ADA) guidelines (28,29) were invited to participate in the study at the diabetes in pregnancy clinic, where patients from both the University Hospital, Lausanne (CHUV) antenatal care clinic and obstetricians in private practice are referred. This study is part of an ongoing cohort of women with GDM at the Lausanne University Hospital. Women who agreed to participate in the study signed a consent form. The Human Research Ethics Committee of the Canton de Vaud approved the study protocol (326/15).

2.2 Inclusion criteria and exclusion criteria

Women ≥18 years, with GDM diagnosis and were followed in our clinic between 2015 and 2017, who understood French or English, consented to the cohort, and completed the French IE questionnaire at their first GDM visit, were included in this study.

Out of the cohort population of 1000 participants that were followed in our clinic, we excluded those who did not complete an IE questionnaire at the first GDM visit (N=533) and those who did not attend postpartum visit (N=32). Out of the eligible cohort population of 435 participants, we then excluded those who did not sign an informed consent (N= 145). Participants with known type 1 diabetes (N= 7), known type 2 diabetes (N= 9), GDM diagnosed at ≤13 weeks (N= 11), diabetes diagnosed during pregnancy at ≤20 weeks (N= 19), normal (i.e. negative) HGPO results (N= 7), with glucose intolerance but no GDM (N= 2), and those participating in a form of an active lifestyle randomized controlled trial (RCT) intervention (N= 21) were also excluded. Overall, 214 women were included in the final analysis.

2.3 Data collection

2.3.1 Assessment of Intuitive eating (IE)

We assessed IE with the French Intuitive Eating Scale-2 (IES-2); an 18-item validated self-report questionnaire that assesses individuals' tendency to follow their physiological, hunger and satiety cues in determining when, what and how much to eat. The French IES-2 contains 3 subscales. These are (1) the Eating for physical rather than emotional reasons (EPR, 8 items) subscale; that assesses how much eating is affected by emotional responses, (2) the Reliance on hunger and satiety cues (RHSC, 6 items) subscale; that evaluates the extent to which individuals are aware and able to trust internal signals rather than relying on external rules/cues, and (3) the Unconditional permission to eat (UPE, 4 items) when hungry subscale that assesses whether an individual purposefully tries to ignore hunger and satiety signals (27). The English IES-2 (23-item questionnaire), however, consists of 4 subscales. These are (1) the Eating for physical rather than emotional reasons (EPR, 8 items) subscale; (2) the Reliance on hunger and satiety cues (RHSC, 6 items) subscale, (3) the Unconditional permission to eat (UPE, 4 items) when hungry subscale and 4) the Body-Food Choice Congruence (BFC-C, 5 items) subscale (13,15). The French IES-2, just like the English version, has demonstrated good psychometric properties in samples of pregnant women (27). In an earlier study, the IES-2 indicated a good internal reliability among the subscales. The Cronbach's alphas (α) for the two subscales were 0.92 and 0.87 for EPR and RHSC respectively (25). The IES-2 measures interoceptive abilities. These abilities determine when and how much to eat, and help to accurately perceive and respect one's hunger and satiety cues. Thus, higher IE scores are related to emotional, psychological, and physical well-being (30). It is also important to note that the conceptualization of IE as interoceptive comprises of sensing the physiological condition of the body as well as the representation of the internal state (31).

For the purpose of our study, we removed the UPE subscale (4 items) from the French IES-2. This is because women involved in this study had in general one pre-partum diet visit with a registered dietician during pregnancy and one post-partum visit after pregnancy. We believe that discussions during diet counselling could significantly influence participants' responses to the UPE subscale such as *"I try to avoid certain foods high in fat, carbohydrates, or calories". "If I am craving for a certain food, I allow myself to have it". "I have forbidden foods that I don't allow myself to eat". "I allow myself to eat what food I desire at any moment". "I do NOT follow eating rules or dieting plans that dictate what, when, and/or how much to eat"*. This is because during the one-hour dietary counseling, participants' were advised on the carbohydrate content of their foods and to avoid or limit certain foods in order to improve their eating habits and glycemic profile.

In our hospital, 85% of women with gestational diabetes, see a dietician. In the general clinic population, reasons for not being able to see a dietician included appointment-scheduling problems or participants' visited the GDM clinic at an advanced stage of their pregnancy, leaving no time to schedule a dietary counseling session. Before the pre-partum and postpartum dietary counseling, glycemic control variables, weight, and BMI were measured.

We therefore gave the two subscales, i.e., the EPR and RHSC subscales of the French IES-2 and its English translated version produced by our team (with the same 14 items; EPR has 8 items and RHSC has 6 items); to participants who speak French and English respectively. Women completed the EPR and RHSC subscales of the IES-2 questionnaire during the first GDM visit by responding to a 5-point Likert scale response ranging from one (1) 'strongly disagree' to five (5) 'strongly agree' to each item in both subscales. We then calculated the EPR and RHSC subscale scores as recommended; by dividing the total scores obtained from the sum of 1-5 from each item by the total number of items in each subscale (EPR by 8 and RHSC by 6), leading to a possible subscale score between one and five. Higher scores indicated greater levels of IE. Higher score of the EPR subscale reflects eating as an answer to hunger and lower score meant eating to cope with emotional distress whereas higher score of the RHSC subscale signifies trust in internal cues and lower score reflects less ability to regulate food intake.

2.3.2 Anthropometric measures

We measured height and weight of participants' during the first GDM visit. When available, weight before pregnancy was obtained from patients' medical charts and records. Otherwise this was self-reported. During the first GDM visit, body weight was measured to the nearest 0.1kg in women wearing light clothes and no shoes with an electronic scale (Seca®), height was measured to the nearest 0.1 cm with a Seca® height scale. The electronic scales were regularly calibrated. We also measured participants' weight at the end of pregnancy, and at the 6-8 weeks postpartum visit. We calculated gestational weight gain as the difference between weight at the end of pregnancy and weight before pregnancy. We also calculated the difference between weight at 6-8 weeks postpartum and weight at the first GDM visit. We expressed BMI as the ratio of weight in kilograms to the square of height in meters (kg/m^2).

2.3.3 Assessment of glycemic control variables

Participants underwent a 75g oral glucose tolerance test (oGTT) during pregnancy at 24-32 weeks of gestation, unless an initial fasting glucose was ≥ 5.1 mmol/L. Women were diagnosed of GDM if one of the following criteria were met: fasting glucose ≥ 5.1 mmol/L, 1-hr glucose ≥ 10.0 mmol/L, or 2-hr glucose ≥ 8.5 mmol/L using the IAPDSG guidelines (28). At the first GDM visit, HbA1c was measured using a chemical photometric method (conjugation with boronate; Afinion®). At 6-8 weeks postpartum, an oGTT was performed to measure fasting glucose, 2-hr glucose and HbA1c using a High Performance Liquid Chromatography method (HPLC). Both methods are traceable to the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) Reference Method for Measurement of HbA1c (32).

2.3.4 Measurement of covariates and other variables

Potential covariates were age and gestational age at the first GDM visit (model 2) and weight when the outcome was fasting glucose or HbA1c (model 3). For descriptive analyses, the following parameters that were recorded at the first GDM visit were used: Socio-demographic characteristics, including age, education level, nationality, employment status, family history of type-2 diabetes, history of GDM, gravida and parity, habits (smoking and alcohol status during pregnancy), and medical treatment during pregnancy (either metformin or insulin). Age was analyzed as a continuous variable. We grouped education level into four categories. These were compulsory school achieved; general and vocational training levels; high school; and university education. Nationality consisted of Switzerland; Europe and North America; Africa; Asia and Western pacific; and Latin America. Employment status was categorized as student; employed; housewife/at home; and unemployed. We categorized family history of type-2 diabetes, history of GDM, smoking and alcohol intake during pregnancy as either 'yes' or 'no'.

2.4 Statistical analysis

All analyses were conducted using the SPSS software version 25 (32). All descriptive variables were presented as either means (±standard deviation) or in percentages (%) where appropriate. Both predictor (EPR and RHSC subscales of the IES-2 questionnaire) and outcome (BMI, weight and glycemic control including fasting glucose, 1hr glucose, 2hr glucose and HbA1c at the different time points) variables were normally distributed. The correlation between the two subscales of IES-2 questionnaire was low-to moderate (r=0.35, P<0.01). We conducted a linear regression analysis to determine the cross-sectional and longitudinal associations between the two subscales of IES-2 at the first GDM visit with BMI, weight, fasting glucose, 1hr glucose, 2hr glucose and HbA1c during pregnancy (cross-sectional analysis), at the end of pregnancy and at 6-8 weeks postpartum, respectively (longitudinal analysis). We made use of three models in the regression analyses. Model 1 consisted of unadjusted regression estimates. In model 2, we adjusted for socio-demographic characteristics that showed significance with at least one of metabolic health outcome variables (BMI, weight, fasting glucose, 1h or 2h glucose, HbA1c) at either the first GDM visit or at 6-8 weeks postpartum. Thus, this was tested for age, gestational age, education level, nationality, employment status, family history of type-2 diabetes, history of GDM, smoking and alcohol intake during pregnancy, gravida, parity, and medical treatment during pregnancy. Of these potential confounder variables, age, gestational age, smoking during pregnancy, parity, and medical treatment during pregnancy showed significance with one of the metabolic health outcome variables and were thus included in Model 2 as confounder variables. We did not adjust for medical treatment in our cross-sectional analysis. This is because women had not started medical treatment during the first GDM visit. (Table 3), as this had no effect on the association between IE and metabolic health at the first GDM visit. However, we adjusted for this in our longitudinal analyses. When the outcome was glycemic control, we added a third model: model 3, where we adjusted for weight at the respective time points (at the first GDM visit and at 6-8 weeks postpartum). All analyses were conducted separately for both subscales of the IES-2 questionnaire. All statistical significances were two sided and accepted at $p < 0.05$.

3. Results

Table 1 shows the socio-demographic characteristics of the participants (N=214). The mean age of participants was 33.3 ± 5.2 years and the mean gestational age at first GDM visit was 27.4 ± 3.4 weeks. A third (32.2 %) of the participants were university graduates, and 41%

were of Swiss nationality. Few women had a history of previous GDM (5.2%) and majority had a family history of type-2 diabetes (60.7%). 44% of the women had no medical treatment for GDM during pregnancy.

The mean weight before and during pregnancy, variables regarding glycemic control and the scores of the two subscales of the IES-2 at the first GDM visit are shown in Table 2. Mean weight and BMI before pregnancy were 68.2 ± 14.8kg and 25.3 ± 5.2kg/m^2 respectively. Mean weight and HbA1c at first GDM visit were 79.2 ± 14.9kg and 5.4 ± 0.4% respectively. The mean score of the EPR subscale at first GDM visit was 3.8 ± 0.9, whereas the mean score of the RHSC subscale was 3.5 ± 0.9.

Table 3 shows the cross-sectional associations between the two scales of IES-2 with BMI, weight and glycemic control at the first GDM visit. Cross-sectional analyses showed that both subscales of IES-2 at the first GDM visit were associated with lower weight and BMI before pregnancy, weight, fasting glucose and HbA1c at the first GDM visit (β= -0.171 to -0.222, all $p \leq 0.01$), however the RHSC subscale was not significantly associated with HbA1c at the first GDM visit. After adjusting for confounders including age, gestational age, smoking, and parity (model 2), the associations between the two subscales of IES-2 with weight and BMI before pregnancy and weight at first GDM visit remained unchanged. The association between the EPR subscale with fasting glucose and HbA1c also remained largely unchanged, except that the association between the RHSC subscale with fasting glucose was attenuated ($p=0.095$), albeit with a similar beta-coefficient. When fasting glucose or HbA1c was the outcome, we adjusted for weight at first GDM visit as a potential confounder (model 3). The relationship between the EPR subscale with fasting glucose and HbA1c were attenuated (both $p \leq 0.07$), while the relationship between the RHSC subscale and fasting glucose remained insignificant ($p=0.261$). This shows that weight partly mediates the relationship between IE and fasting glucose in our sample.

Table 4 shows the longitudinal associations between IES-2 at the first GDM visit with BMI, weight and glycemic control at the end of pregnancy and at 6-8 weeks postpartum visit. Both subscales of IES-2 at first GDM visit were associated with lower weight at the end of pregnancy, weight, BMI and fasting glucose at 6-8 weeks postpartum (β=-0.139 to -0.242, all $P \leq 0.046$) (model 1). None of the IES-2 subscales was related to change in weight at the end of pregnancy and change in weight at 6-8 weeks postpartum and weight at first GDM visit. After adjusting for confounders including age, gestational age, smoking, parity, and medical treatment during pregnancy (model 2), the significant associations between the two subscales of IES-2 with weight at the end of pregnancy, weight, BMI and fasting glucose at 6-8 weeks postpartum remained unchanged (all $p \leq 0.004$). However, there was an attenuation of the association between RHSC subscale and weight at 6-8 weeks postpartum ($p=0.057$), albeit with a similar beta-coefficient. When fasting glucose and HbA1c were the outcome variables, we adjusted for weight at 6-8 weeks postpartum visit (model 3) as a potential confounder. Thus, the inverse association between the EPR subscale and fasting glucose at 6-8 weeks postpartum remained unchanged ($p= 0.038$), whereas the association between the RHSC subscale and fasting glucose at 6-8 weeks postpartum was attenuated ($p \leq 0.059$).

4. Discussion

We investigated the relationship between the two subscales of IES-2 with weight and glucose control during pregnancy and in the early postpartum period in women diagnosed with GDM. To the best of our knowledge, this has not been previously studied in a general pregnant population or in women with GDM. In this prospective cohort of women followed in a clinical setting, we found that, the two subscales of IES-2 (“Eating for physical rather than emotional reasons” and “Reliance on hunger and satiety cues” subscales) during pregnancy were associated with lower BMI and weight before pregnancy, weight, fasting glucose and/or

HbA1c during pregnancy and in the early postpartum period. The relationship between intuitive eating and fasting glucose was partly mediated by weight.

Although certain lifestyle interventions such as low GI diets can lead to a decrease in weight gain and postprandial glucose among women with GDM (9,33), the effect size of their impact on weight and their influence on fasting glucose and HbA1c remains controversial (9,33,34). As opposed to those previous studies that focused on macronutrient contents of foods, type of carbohydrates, portion sizes and eating frequency, IE represents an interesting and different approach that has never been studied in pregnancy in general and in women with GDM in particular (33,34). To fill this gap during pregnancy, where feelings and cues of hunger and satiety are distinct from out of pregnancy-states, and in women with GDM where increased weight gain during pregnancy and weight retention in the postpartum period can lead to recurrent GDM, obesity and future development of diabetes, this study evaluated the associations between IE with weight and glucose control during and after pregnancy in an observational design.

Results of our cross-sectional analyses showed that the two subscales of IES-2 at the first GDM visit were associated with lower weight and BMI before pregnancy and weight at the first GDM visit. These associations may exist due to the following reasons. First, the EPR subscale of the IES-2 measures the extent to which individuals use food to satisfy hunger rather than to cope with negative emotional states, such as anxiety, depression, boredom, or loneliness, that can lead to overeating, weight gain, and an eventual increase in BMI (35). The RHSC subscale, on the other hand, uses one's innate ability to respond to satiety cues by determining when, what, and how much to eat. Eating intuitively therefore may lead to improved hunger and satiety cues, less cognitive control, and increased response to physiological signals. Improvement in cognitive control and response to physiological cues may in turn lead to lower weight and BMI (36).

The association between the EPR subscale with fasting glucose and HbA1c independent of adjustment for confounders in our cross-sectional analyses indicates that eating habits driven by emotions and cravings during pregnancy may lead to higher glycemic values (10). This may be explained by the following mechanisms: frequent snacking and reduced time without food intake might impact on increased hepatic insulin resistance and subsequent increased overnight glucose production, which may lead to increased fasting glucose levels (37). On the other hand, higher adherence to the EPR subscale prevents disordered eating behaviors and thus may lead to lower fasting glucose and HbA1c levels (38). In contrast, the lack of association between the RHSC subscale with HbA1c and with fasting glucose after adjustments indicates that when it comes to pregnancy, elements of RHSC that assesses the degree of awareness of internal hunger and satiety signals may be overshadowed by the potential importance of eating for physical rather than emotional reasons. This could be the reason why the adherence to the RHSC subscale was comparatively lower than the EPR subscale in our sample. One of the possible reasons why IE was not related to the one and two-hour glucose levels was that during the oGTT, a fixed amount of 75 g of glucose was given regardless of any signs of IE. In addition, the oGTT test overrides all internal stimuli.

As explained above, the associations between the two subscales of IES-2 with lower weight at the end of pregnancy and lower weight and BMI at 6-8 weeks postpartum in the longitudinal analyses could indicate that the sustained adherence to IE over a period of time may improve emotional states and disordered eating behaviors, as well as help to increase one’s ability to innately recognize hunger and satiety cues. This could be beneficial in lowering cognitive restraint that usually lead to weight gain and higher BMI. In this context of a clinical setting, women with GDM were followed by either a nurse or a physician and likely had a pre-partum and postpartum dietary counseling sessions with a dietician. During the postpartum dietary counselling, the general goal was for women to return to their weight before pregnancy within one year after delivery. This is because gestational weight retention is a known risk factor for recurrent GDM and type-2 diabetes. Therefore, the sustained practice of IE and the desire to lose postpartum weight itself may account for the observed association regarding weight and BMI outcomes in our longitudinal analyses. The lack of associations between IE with weight gain (at the end of pregnancy) and weight retention at 6-8 weeks postpartum visit remains unclear, however, factors such as little variation and short time periods between these time points may be reasons for the lack of association.

The lack of associations between the two subscales of IES-2 with HbA1c in our longitudinal analyses can be explained by the following reasons: in the postpartum period, eating habits, such as frequent overeating (especially excess animal fat intake), may influence glucose level and can impact on HbA1c (39). Similarly, medical treatment may also have an impact in the longitudinal analyses, as it lower fasting and postprandial glucose levels and may confound our findings. We therefore adjusted for medical treatment in our longitudinal analysis. In our study, the majority (52.5%) of our participants' received medical treatment during pregnancy either in the form insulin or insulin and metformin. The possible impact of iron deficiency anemia (40) and the changes in insulin sensitivity in the early weeks after delivery may be implicated in the lack of longitudinal associations between the two subscales of IES-2 and HbA1c. Other factors, such as breastfeeding in the postpartum period also act to reduce glucose levels and may affect HbA1c levels (41).

Our results corroborate the findings of a cross-sectional review outside of pregnancy which indicated that IE was positively related with improved dietary intake and/or healthy eating behaviors that are drivers for weight loss and maintenance (24). The results of our study are also consistent with a study among postpartum women where the higher practice or adherence to IE was associated with accelerated rates of postpartum weight loss (25). Several attempts by weight loss programs that mainly consists of lifestyle intervention to address postpartum weight retention have been inconsistent (42). Difficulties in adhering to specific structured diet and physical activity recommendations have been named as the possible reason. Following a more IE approach to food consumption may encourage postpartum weight loss without the required diet restrictions, calorie counting and exercise regimes, all of which are features of traditional weight loss programs. IE could offer an alternative approach that may be rewarding and less exhausting for new mothers who have busy lives, limited available time and new to parenting (25). Regarding glycemic control, the findings of this study are in line with those of Wheeler and colleagues who showed that, higher adherence to the EPR subscale was associated with lower HbA1c in a cross-sectional study (43) and with a review in which IE led to improvements in metabolic health indicators, including fasting glucose (24). Our results have important clinical implications and suggests that IE could represent a novel approach for weight and glycemic control in women diagnosed with GDM. Future epidemiologic/intervention studies should investigate the long-term and sustained effect of IE during pregnancy and in the postpartum period among women with GDM.

This study has several strengths. It is the first to investigate the relationship between IE with BMI, weight and glycemic control in women with GDM in a real-life clinical setting. We used a well-developed and validated tool to measure IE during pregnancy. However, the results of this study must be interpreted with the following limitations. Other factors, such as dietary counseling with a dietician and use of medication during pregnancy, which can influence both weight and glycemic control, may account for the observed relationships in our longitudinal analysis, even though we adjusted for medication use during pregnancy in our analyses. We believe that visiting a dietician did not impact on our cross-sectional results because we measured weight, BMI and glucose control variables at the first GDM visit before the appointment with a dietician was scheduled. Even for the longitudinal results, the impact was probably not major, as we measured the outcome variables only at 6-8 weeks postpartum. In this context, we do not believe that one hour of consultation with the dietician during pregnancy that focused on the carbohydrate content of foods would influence our outcomes in a major way, considering that, many habits changes in the postpartum period. Missing data of some socio-demographic characteristics is a possible limitation because these variables were potential confounders in our analyses. The lack of a total IES-2 score in our analyses may be a source of limitation as it would have been interesting to see the overall effect of IES-2 on our outcomes would have been interesting. Other limitations such as a relatively small sample size limit our ability to generalize our findings. We obtained weight before pregnancy from patients' medical chart when available, otherwise we relied on self-reported pre-pregnancy weight which may be a limitation. In addition, several psychosocial and behavioral factors including family support, willingness and change in attitudes following GDM diagnosis were not investigated could influence weight changes especially in the postpartum period. ~~Despite these limitations, we believe our results are reliable and provide significant and baseline information on the associations between IE and measures of metabolic health during and after pregnancy in women diagnosed with GDM.~~ Further research that utilizes IE as an intervention for weight retention and glucose control in a larger population during pregnancy and in the postpartum period is needed to determine the causality of these associations found in women with GDM.

5. Conclusions

In this prospective cohort of women with GDM, cross-sectional analyses showed that the two subscales of IES-2 at the first GDM visit were associated with lower weight and BMI before pregnancy and weight at first GDM visit after adjusting for confounders. The EPR subscale was also associated with lower HbA1c and fasting glucose at the first GDM visit. In the longitudinal analyses, both subscales of IES-2 at first GDM visit were associated with lower weight at the end of pregnancy, BMI and fasting plasma glucose at 6-8 weeks postpartum after adjusting for confounders. The EPR subscale was also associated with weight at 6-8 weeks postpartum. None of the IES-2 subscales was associated with weight changes at the end of pregnancy and at 6-8 weeks postpartum. These results suggests that practicing IE may be beneficial and could represent an interesting approach to weight and glucose management during and after pregnancy in women with GDM. In addition, higher adherence to IE may reduce the risk of developing diabetes in the postpartum period in women with GDM.

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Tables and captions

[Table 1] **Socio-demographic characteristics of study participants**

Variable	Mean	SD	Frequency	Percent (%)
Age (year) N= 214)	33.32	5.20		
Gestational age at the first GDM visit (weeks) (N= 214)	27.43	3.36		
Educational level (N=164)				
Compulsory school achieved[1]			28	13.1
CFC[2]			40	18.7
High school			27	12.6
University			69	32.2
Ethnic origin (N=212)				
Switzerland			88	41.1
Europe + North America			80	37.4
Africa			25	11.7
Asia + western pacific			15	7.0
Latin America			4	1.9
Employment status (N=186)				
Student			5	2.3
Employed			137	64.0
Unemployed			22	10.3
At home/housewife			22	10.3
Family history of Type-2 Diabetes (N= 214)				
1st degree[3]			71	33.2
2nd degree[4]			59	27.5
No			84	39.2
History of GDM (N= 214)				
Yes			11	5.2
No			203	94.8
Smoking status during pregnancy (N= 214)				
Yes			45	21.0
No			169	79.0
Alcohol intake during pregnancy (N= 214)				
Yes			14	6.5
No			200	93.5
Gravida (N= 214)				
1			89	41.6
2			68	31.8
≥3			57	26.6
Parity (N= 214)				
0			116	54.2
1			70	32.7
2			22	10.3
≥3			6	2.8
Medical treatment during pregnancy (N=207)				
None			95	44.4
Metformin			7	3.4
Insulin and Metformin			105	49.1

[1]Includes 1 patient who did not complete compulsory school
[2]CFC means general and vocational education
[3]1st degree means 1 degree of relationship of the participant (at least 50% of genetic link, which included mother, father, brother, sister, daughter, son)
[4]Second degree means 2nd degree of kinship of the participant (at least 25% of genetic link that included grandparents, grandchildren, nephews, niece, half-brother, half-sister)
All results are frequency and percentage unless otherwise stated

[Table 2] **Mean distribution of study variables at first GDM visit or before pregnancy**

Variable	**N**	**Mean**	**SD**
Weight before pregnancy (kg) (self-reported)	213	68.18	14.83
BMI before pregnancy (kg/m^2)	213	25.30	5.19
Weight at first GDM visit (kg) (measured)	211	79.16	14.87
∆Weight before pregnancy and at First GDM visit (kg)	210	10.92	4.58
HbA1c at First GDM visit (%)	211	5.36	0.39
Fasting glucose at first GDM visit (mmol/l)	206	5.08	0.79
1hr glucose at first GDM visit (mmol/l)	163	9.73	1.70
2hr glucose at first GDM visit (mmol/l)	164	7.87	1.74
EPR at first GDM visit	214	3.88	0.93
RHSC at first GDM visit	214	3.54	0.90

GDM means gestational diabetes mellitus
HbA1c means glycated hemoglobin
BMI means body mass index
EPR means Eating for Physical Rather than Emotional Reasons subscale of the Intuitive Eating scale2 (IES-2). Higher scores means higher adherence to the EPR subscale
RHSC means Reliance on Hunger and Satiety Cues subscale of the Intuitive Eating scale2 (IES-2). Higher scores means higher adherence to the RHSC subscale
The differences in Frequency of Fasting glucose, 1hr and 2hr glucose is because GDM was diagnosed with a 75-G oral glucose-tolerance test unless an initial fasting glucose was ≥5.1 mmol/L.

[Table 3] **Cross-sectional associations between the two subscales of intuitive eating scale-2 and weight, BMI and glycemic control at first GDM visit**

	Model 1				Model 2				Model 3			
Variable	**regression coefficient**	**95% CI**		**P-value**	**regression coefficient**	**95% CI**		**P-value**	**regression coefficient**	**95% CI**		**P-value**
EPR												
Weight before pregnancy *(n=213)*	-0.203	-5.329	-1.107	**0.003**	-0.181	-5.002	-0.745	**0.008**	NA			
BMI before pregnancy (*n=213)*	-0.216	-1.936	-0.463	**0.002**	-0.194	-1.824	-0.332	**0.005**	NA			
Weight at first GDM visit (*n=211)*	-0.205	-5.355	-1.126	**0.003**	-0.191	-5.168	-0.871	**0.006**	NA			
HbA1c at first GDM visit *(n=211)*	-0.171	-0.126	-0.015	**0.013**	-0.170	-0.127	-0.013	**0.016**	-0.123	-0.106	0.004	0.070
Fasting glucose at first GDM visit *(n=206)*	-0.195	-0.278	-0.050	**0.005**	-0.196	-0.280	-0.049	**0.005**	-0.124	-0.213	0.007	0.066
1-hr glucose at first GDM visit *(n=163)*	0.122	-0.058	0.490	0.122	0.154	-0.009	0.556	0.058	0.112	-0.081	0.465	0.166
2-hr glucose at first GDM visit *(n=164)*	-0.030	-0.336	0.226	0.698	-0.033	-0.351	0.232	0.689	-0.065	-0.404	0.169	0.420
RHSC												
Weight before pregnancy *(n=213)*	-0.194	-5.394	-0.999	**0.005**	-0.181	-5.171	-0.800	**0.008**	NA			
BMI before pregnancy (*n=213)*	-0.222	-2.046	-0.518	**0.001**	-0.215	-2.007	-0.482	**0.002**	NA			
Weight at first GDM visit (*n=211)*	-0.190	-5.365	-0.934	**0.006**	-0.188	-5.331	-0.886	**0.006**	NA			
HbA1c at first GDM visit *(n=211)*	-0.061	-0.085	0.032	0.376	-0.061	-0.085	0.033	0.389	-0.004	-0.060	0.056	0.954
Fasting glucose at first GDM visit *(n=206)*	-0.148	-0.248	-0.010	**0.033**	-0.117	-0.222	0.018	0.095	-0.076	-0.182	0.050	0.261
1-hr glucose at first GDM visit *(n=163)*	0.072	-0.149	0.409	0.359	0.097	-0.108	0.459	0.224	0.043	-0.209	0.359	0.605
2-hr glucose at first GDM visit *(n=164)*	-0.072	-0.417	0.153	0.361	-0.068	-0.416	0.165	0.394	-0.124	-0.526	0.070	0.132

Gestational age at first GDM visit is 24-32 weeks
EPR means Eating for Physical Rather than Emotional Reasons subscale of the Intuitive Eating scale2 (IES-2). Higher scores means higher adherence to the EPR subscale
RHSC means Reliance on Hunger and Satiety Cues subscale of the Intuitive Eating scale2 (IES-2). Higher scores means higher adherence to the RHSC subscale
Model 1: Unadjusted regression estimates
Model 2: Adjusted for age, gestational age, smoking, and parity
Model 3: Adjusted for weight at first GDM visit

[Table 4] **Longitudinal associations between two subscales of intuitive eating scale-2 and weight, BMI and glycemic control at the end of pregnancy and in early postpartum (6-8 weeks)**

	Model 1				Model 2				Model 3			
Variable	**regression coefficient**	**95% CI**		**P-value**	**regression coefficient**	**95% CI**		**P-value**	**regression coefficient**	**95% CI**		**P-value**
EPR												
Weight at end of pregnancy (*n=198)*	-0.223	-5.450	-1.297	**0.002**	-0.212	-5.373	-1.063	**0.004**	NA			
Weight at 6-8 weeks postpartum (*n=207)*	-0.237	-5.700	-1.592	**0.001**	-0.219	-5.536	-1.267	**0.002**	NA			
BMI at 6-8 weeks postpartum *(n=205)*	-0.242	-2.003	-0.574	**0.000**	-0.226	-1.956	-0.474	**0.001**	NA			
Δweight first GDM visit and end of pregnancy (*n=192)*[1]	-0.007	-0.562	0.509	0.922	0.025	-0.452	0.642	0.732	NA			
Δweight first GDM visit and 6-8 weeks PP (*n=205)*[2]	-0.061	-1.137	0.438	0.382	-0.062	-1.154	0.448	0.386	NA			
HbA1c at 6-8 weeks postpartum(n=206)	-0.002	-0.053	0.051	0.978	-0.003	-0.056	0.054	0.968	0.017	-0.047	0.060	0.815
Fasting glucose 6-8 weeks postpartum (n=207)	-0.200	-0.159	-0.031	**0.004**	-0.191	-0.158	-0.026	**0.007**	-0.144	-0.132	-0.004	**0.038**
2-hr glucose 6-8 weeks postpartum (n=206)	-0.020	-0.261	0.194	0.775	-0.005	-0.253	0.235	0.943	-0.018	-0.264	0.205	0.806
RHSC												
Weight at end of pregnancy (*n=198)*	-0.193	-5.276	-0.868	**0.007**	-0.175	-5.059	-0.545	**0.015**	NA			
Weight at 6-8 weeks postpartum (*n=207)*	-0.139	-4.486	-0.040	**0.046**	-0.134	-4.435	0.065	0.057	NA			
BMI at 6-8 weeks postpartum *(n=205)*	-0.164	-1.691	-0.155	**0.019**	-0.165	-1.708	-0.156	**0.019**	NA			
Δ weight first GDM visit and end of pregnancy (*n=192)*	0.092	-0.200	0.926	0.205	0.102	-0.159	0.974	0.157	NA			
Δ weight first GDM visit and 6-8 weeks PP(*n=205)*	0.105	-0.198	1.467	0.135	0.064	-0.444	1.216	0.360	NA			
HbA1c at 6-8 weeks postpartum(n=206)	-0.074	-0.084	0.025	0.291	-0.072	-0.085	0.028	0.315	-0.065	-0.081	0.030	0.358
Fasting glucose 6-8 weeks postpartum (n=207)	-0.163	-0.151	-0.014	**0.019**	-0.140	-0.140	-0.002	**0.045**	-0.128	-0.131	0.003	0.059
2-hr glucose 6-8 weeks postpartum (n=206)	-0.025	-0.284	0.196	0.717	-0.006	-0.262	0.239	0.930	-0.024	-0.284	0.201	0.736

[1]Means the difference in weight at the end of pregnancy and at first GDM visit
[2]Means the difference between weight at the 6-8 weeks postpartum visit and first GDM visit
EPR means Eating for Physical Rather than Emotional Reasons subscale of the Intuitive Eating scale 2 (IES-2). Higher scores means higher adherence to the EPR subscale
RHSC means Reliance on Hunger and Satiety Cues subscale of the Intuitive Eating scale 2 (IES-2). Higher scores means higher adherence to the RHSC subscale
Model 1: Unadjusted regression estimates
Model 2: Adjusted for age, gestational age smoking, parity and medical treatment during pregnancy
Model 3: Adjusted for weight 6-8 weeks post-partum
PP means postpartum

Highlights

1. Intuitive eating is inversely associated with disordered and emotional eating
2. Intuitive eating was associated with lower weight and fasting glucose during pregnancy and at 6-8 weeks postpartum
3. Higher adherence to intuitive eating might reduce the risk of diabetes in the postpartum period in this population