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Mental health after childbirth and the impact on postpartum weight retention & body composition. Data from the INTER-ACT randomized controlled trial

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What is already known about this subject?

- The prevalence of maternal overweight and obesity is high and rising.
- A relationship between maternal weight and mental health has been shown.

What this study adds?

- Nearly half of women with a history of excessive gestational weight gain report mental health problems during the first year after childbirth, with increased anxiety and deterioration of quality of life.
- Poor mental health 6 weeks after childbirth predicts increased fat accumulation in the first year postpartum, in women with a history of excessive gestational weight gain.

Abstract

Objective:

To study the evolution of maternal mental health during the first year after childbirth in women with previous excessive gestational weight gain, and the relationship with postpartum weight retention and body composition.

Methods:

Anthropometric and mental health data of 505 women of the INTER-ACT RCT control group were collected and assessed using descriptive statistics and mixed model analyses.

Results:

At 6 weeks postpartum 28% of women reported depressive symptoms, 46% anxiety, 47% low sense of coherence and 48% low quality of life. From 6 weeks to 12 months postpartum there was a monthly increase (+0.38, P=0.003) in anxiety and a monthly decrease (-0.39, P=0.008) in quality of life. High levels of depressive symptoms at 6 weeks postpartum predicted higher body fat (+0.9%, P=0.01) and higher waist circumference (+1.3cm, P=0.02) the first year postpartum. High sense of coherence at 6 weeks postpartum predicted lower body fat (-0.8%, P=0.01) the first year postpartum.

Conclusions:

In women with a history of excessive gestational weight gain, the first year after childbirth is characterized by a high prevalence of mental health problems in which levels of anxiety and quality of life deteriorate over time. Moreover, high levels of depressive symptoms and low sense of coherence in the first weeks postpartum predict unfavorable body composition outcomes in the year after childbirth.

Introduction

In Europe more than one in three women start pregnancy with excessive weight or obesity (1, 2). These women are at increased risk for excessive gestational weight gain (GWG) (3) and therefore postpartum weight retention (PPWR) (4). Globally, 50 to 75% of women are not returning to pre-pregnancy weight 12 months after childbirth (5, 6), and this may lead to long-term weight retention and associated cardiovascular and metabolic risks (5, 7). Body composition (i.e., fat- and muscle mass, visceral fat) is a strong marker for women's global metabolic health, but data on the evolution of maternal body composition after childbirth are scarce (4).

Women with pre-pregnancy overweight or obesity, whether or not in combination with excessive GWG, are at increased risk for postpartum depressive symptoms compared to their counterparts with a normal weight at the start of pregnancy (8, 9). Women with excessive GWG showed higher levels of maternal anxiety two days after childbirth compared to women with adequate GWG (10). Bliddal (2015) (11) showed that women with more than 2 BMI units PPWR at 6 months after childbirth had an increased risk for depression and anxiety from 6 months after childbirth onwards. In addition, prenatal mental health status, as well as biological, social and behavioural factors appear to be predictive for poor mental health during the postpartum period (12, 13).

Prospective cohort studies also suggest that depression and anxiety during pregnancy or after childbirth are predictors for GWG and PPWR (14-16).

The postpartum period itself is a critical period in which women experience changes at the psychological, behavioural, social, and biological level with fluctuations over short time periods. To provide better insight into the temporal and causal relationship between maternal mental health and medical outcomes, longitudinal study designs with measurements of health and wellbeing at different critical time points are needed.

To the best of our knowledge, no studies have focussed on the evolution of mental health in the first year after childbirth and the impact on weight and body composition in women with excessive GWG. Women with excessive GWG represent one-third of the pregnant population and are a high-risk group for short- and long-term weight-related health problems. Insight

into the impact of the evolution of mental health on these women's body composition would assist in the development of targeted and tailored postpartum weight management strategies. As low sense of coherence (SOC) and quality of life (QoL) are associated with postpartum depressive symptoms (17, 18), adding both mental health outcomes to our study may lead to important innovative insights. Therefore, we aimed to study the evolution of levels of depression and anxiety, SOC and QoL during the first year after childbirth in women with excessive GWG and investigated whether the baseline values (6 weeks after childbirth) and evolution affected PPWR and maternal body composition one year after childbirth.

Materials and methods

Study design

The INTER-ACT study (ClinicalTrials.gov; NCT02989142) was a multicentre, randomized controlled trial, targeting women with a history of excessive GWG. Details of the INTER-ACT methodology are available elsewhere (19).

For the current analysis we focussed on the control group only to investigate the evolution of mental health during the first year after childbirth and the impact on PPWR and body composition. The control group completed questionnaires and received anthropometric measurement without receiving the INTER-ACT lifestyle intervention.

All participants confirmed their participation by informed consent. The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Clinical Trial Center/ Ethical Committee UZ Leuven (protocol code B322201730956 / S59889).

Participants

Participant recruitment was conducted between May 2017 and April 2019 in six hospitals in Belgium: University Hospital Leuven, University Hospital Antwerp, Gasthuiszusters Antwerp, St-Franciscus Hospital Heusden-Zolder, Jessa Hospital Hasselt and Hospital Oost-Limburg Genk. In the first 2 to 3 days postpartum, during their hospital stay, women were recruited and adequately informed by qualified research nurses. Women were eligible if they had experienced excessive GWG according to the 2009 National Academy of Medicine guidelines

(NAM) (20), aged ≥ 18 years and if they were Dutch speaking. Women were ineligible if they had a twin birth, were underweight at the start of pregnancy (BMI <18.5), had a history of bariatric surgery, diabetes mellitus, kidney disease, a mental disorder or stillbirth. The study nurse assessed eligibility of potential participants based on history and medical record data. In total 1450 women were included.

After enrolment all participants were registered in the electronic Case Report Form (eCRF) system 'Castor' (https://data.castoredc.com/) and electronically randomized to the intervention arm (n= 724) or the control arm (n= 726), the latter being the study population of this manuscript. Randomization was performed by the biostatistician within the first week after childbirth, using an allocation ratio 1:1 support by block randomization (block size 4,6 and 8) and stratification by hospital. Blinding was not possible due to the nature of the intervention.

Finally, 523 participants received a 1st study visit at 6 weeks after childbirth. Of these, 505 met the inclusion criteria for the current analyses, being completion of both the mental health questionnaire and body measurements at the first visit. Following the first study visit, a second study visit (6 months after childbirth) was completed by 371 participants (i.e., completion of both mental health questionnaire and body measurements at 6 months after childbirth or completed both first and third study visit completely). A third study visit (12 months after childbirth) was completed by 278 participants (i.e., mental health questionnaire and body measurements) (Figure 1).

[insert figure 1]

Data collection and measurement

Questionnaires and anthropometrics were collected at 6 weeks, 6 months and 12 months after childbirth with a maximum range of 2 weeks before to 4 weeks after the established timepoint. Data collection took place at home of the participant, in hospital or elsewhere, according to the preference of the participant. If women became pregnant during the 12

months follow-up, their study visits during pregnancy were not included in the current analysis.

Medical record data

Pregnancy- and birth-related data were extracted from the medical records by research nurses at the time of recruitment.

Pre-pregnancy weight was self-reported, weight at childbirth was self-reported or measured by medical personnel on admission at the birth unit. Based on these two weight measurements, total gestational weight gain was calculated and assessed whether women had excessive GWG according to the NAM guidelines (20) (Table S1).

Anthropometrics

Height was measured (rounded to 0.1cm) at the first study visit using a Seca 213 stadiometer (Seca, Hamburg, Germany), while women were standing upright with the head in the Frankfurt plane position (21). Waist circumference was measured (rounded to 0.1 cm) by using a Seca 201 tape (Seca, Hamburg, Germany), and defined as the midway between the lowest rib and the hip bone (22). All research staff received intensive training to ensure adequate and consistent measurements. The training consisted of a theoretical part, as well as a practical part. During the practical part, all researchers performed the measurements several times on test subjects and under the supervision of an experienced anthropometrist. The measurement of waist circumference was repeated 3 times and the mean score was reported. In case of deviations (>0.5cm), the measurement was repeated until agreement was obtained. Weight and body composition at the 6-week, 6-month, and 12-month study visit was electronically measured using a Tanita MC 780 SMA bio- electric impedance (BIA) device (Tanita Corporation, Tokyo, Japan) with three frequencies (5, 50 and 250 KHz). Results were automatically saved immediately after measurement. BIA is a non-invasive, reliable and safe clinical approach, which is well accepted by patients (23). In addition, the use of a BIA device allows us to perform body composition assessments during home visits. Body mass index (BMI) was calculated as weight (kg)/ height (m^2). PPWR was defined by subtracting pre-

pregnancy weight from the weight at that point in time. Percentage gestational weight gain loss (%GWGL) was calculated for every measurement time point by using the following formula:

$$\frac{\text{weight at delivery - postpartum weight}}{\text{gestational weight gain}} \text{ x100\%}$$

Questionnaires

Each participant received a personal link to the questionnaire (sent from the eCRF) two weeks before the scheduled study visit. If the questionnaire was not completed within a week, reminders were sent one week and 2 days before the study visit.

Demographics

At baseline (i.e., 6 weeks after childbirth), self-reported age, education level, ethnicity, employment status, family composition and family income were obtained.

Mental health

Characteristics of the mental health questionnaires are presented in table 1.

As shown in previous research, the Edinburgh Postnatal Depression Scale (EPDS) is appropriate for measuring levels of depression and anxiety after childbirth (24). The questionnaire contained one question about self-harming, generating an integrated alert in the eCRF system 'Castor' requesting immediate response from the research staff. A cut-off score of ≥10 is recommended for the detection of mild to severe postpartum depression (25). The Gotland Male Depression Scale (GMDS) complemented the EPDS as it is a valid instrument for measuring non-typical suicidality-related symptoms of depression and using both scales can increase the detection rate of depressive symptoms (26, 27). Cut-off scores were defined in 3 classes: <13 = no signs of depression; 13-26 indicated possible major depression; ≥27 clearly indicated depression (28).

The Spielberger State Trait Anxiety Inventory 6-item (sSTAI-6) (29) is a validated, reliable measure of maternal postpartum anxiety (30). Because of the extensiveness of the

questionnaire within the study, we used the 6-item version of the sSTAI to make completing the questionnaire less time consuming for participants. A cut-off score of 40 is commonly used to predict postnatal anxiety and mood disorder with the original 20-item questionnaire (30, 31). Therefore, the numeric sum score of the 6-items was converted to a range between 20 to 80 by using the following formula (32): 6-item sum score / 6 x 20.

Previous research indicated that three questions from the EPDS questionnaire were also sensitive for measurement of anxiety (33). The three items (3-4-5) were brought together under the EDS-3A and were used in the current analysis to enhance validity. We used a cut-off score of 5, due the specificity of 90% and less misclassification than a lower cut-off as shown in previous research (33).

The Sense Of Coherence (SOC) was measured with the 13-item short scale (SOC-13), derived from the original 29-item Orientation to Life Questionnaire (34). For the current analyses the format of the Institute for Data Collection and Research (centERdata) was used (35). The SOC reflects women's ability to deal with stressors of daily life and consists of 3 elements: the comprehensibility, which is being able to understand the situation; the manageability, which is being able to do something about the situation and make choices; and the meaningfulness, which is making sense to it. A low SOC score (<70) indicated that participants were less able to understand, influence and make sense of situations, while a high sense of coherence (≥70) indicated a better ability to cope with stressful situations in life.

Quality of Life (QoL) was assessed using a Linear Analogue Scale (LAS). A score from 0 to 100 could be indicated with 0 representing a poor quality of life and 100 an extremely good quality of life. The LAS was one comprehensive score, summarizing physical, psychological, and social aspects.

Cronbach's alpha was performed for all mental health measurements, which was acceptable (α = ≥.70 <.80) for EDS-3A, good (α = ≥.80 <.90) for EPDS, GMDS, sSTAI-6 to excellent (α = ≥.90) for SOC-13 at each timepoint.

[insert Table 1]

Other variables

Questions on the baby's diet (breastfeeding, formula feeding or combined) and on history of depression and anxiety were based on previous research (36-38).

Data Analysis

Statistical analyses were performed by using Statistical Package for the Social Science (SPSS) version 27.0 (IBM, Armonk, New York) and Statistical Analysis System (SAS) version 9.4 (Cary, New York). The Kolmogorov-Smirnov test, skewness, and kurtosis, as well as plots and histograms were used to assess the normal distribution of continuous variables. Mental health variables showed a skewed distribution and were therefore analysed with non-parametric tests.

Descriptive characteristics were presented as frequencies and percentages for categorical variables and mean and standard deviation or median and interquartile range for continuous variables.

Differences in participant characteristics and drop-out, differences between participant characteristics and mental health as well as differences in mental health and PPWR were analysed by using the likelihood ratio chi- square test or the Fisher exact test (if expected cell count ≤10) for categorical variables. The unpaired t- test or the Mann- Whitney U- test were performed to analyse differences between continuous variables. Spearman's rho test was used to assess the association between two continuous variables.

For each mental health outcome variable (sSTAI-6, EDS-3A, EPDS, GMDS, SOC-13, QoL), a mixed model was conducted with time of mental health measurement as an explanatory variable, in order to assess their evolution over the first year after childbirth. An unstructured correlation matrix was modelled in order to take into account the dependency between the several measurements from the same mother. We considered a breakpoint at six months after childbirth (broken line regression), to assess whether the evolution between week 6 and month 6 differed from the evolution between the months 6 and 12.

Mixed model analyses with a random intercept, random slope for time and unstructured correlation structure were performed to examine predictors of PPWR, %GWGL, fat

percentage and waist circumference change in the first year after childbirth. A broken line regression was considered for the time effect, with a break point at 6 months, allowing a difference in effect during the first months after childbirth compared to 6 months after childbirth. Potential predictors tested in the models were sSTAI-6, EPDS, EDS-3A, SOC-13, LAS and GMDS. We adjusted for those explanatory variables that were associated to the respective outcome variables as in the paper of Bijlholt et al. (2021) (39): pre-pregnancy BMI, excessive kilograms gestational weight gain, sex of the infant, mother started exclusive breastfeeding or not, depression in the past and multiparity. For each of the 6 mental health explanatory variables, the interaction term with BMI class was considered, as was the interaction term with time. We performed variable selection on the 6 mental health variables in order to end up with parsimonious models.

A P-value of < 0.05 was considered statistically significant.

Results

Participant characteristics

Baseline characteristics of the participants are shown in table 2.

Women who dropped out at the end of the study period (12 months postpartum) had lower level of education (26% vs 36% master's degree level, P=0.003), lower rate of normal pre-pregnancy BMI (43% vs 54%, P=0.047) and higher GWG in women with overweight: 17kg vs 15kg, P=0.01, when compared to women with complete follow-up. Lower levels of mental health at baseline were found in women who dropped out: median EPDS 7 vs 5, P=0.002; median sSTAI-6 40 vs 36.7, P=0.008; median EDS-3A 4 vs 3, P=<0.001 (table 2).

[insert Table 2]

Baseline mental health at 6 weeks after childbirth

Six weeks postpartum, 28% of women reported high levels of depressive symptoms (EPDS ≥10) and 9% showed major depression (GMDS ≥ 13). Nearly half of women reported high levels of anxiety (46% sSTAI-6 ≥40 and 34% EDS-3A ≥5), a low sense of coherence (47% SOC-

13 <70) and a low QoL score (48% QoL <80). Depressive symptoms and anxiety were more prevalent in women with lower education, lower family income, in a single parent- and newly formed families, in women aged under 25 years who did not breastfeed, and in those with a history of depression and anxiety (Table S2).

Evolution in mental health during the first year after childbirth (mixed models)

Anxiety increased during the first year postpartum: monthly increase of +0.38, P=0.003 (from estimated mean 38.9 at week 6 till mean 42.8 at 12 months, i.e., one-point higher on one of the questions of sSTAI-6) (Figure 2). Quality of life decreased in the first year postpartum: -0.39 per month, P=0.008 (from mean 77.0 at 6 weeks till 73.4 at 12 months) (Figure 2). There was no statistical evidence for an evolution in EPDS, EDS-3A, SOC-13 and GMDS during the first year postpartum (P=0.38, 0.22, 0.95 and 0.26, respectively).

[insert Figure 2]

PPWR

Twelve months postpartum 70% of women showed PPWR and 23% of them had a weight retention of ≥5kg (max 18kg). Women who completed secondary school had significant higher PPWR (mean 3.5 kg, SD 6.2) at 12 months compared to women with a bachelor (mean 1.7kg, SD 4.7, P=0.015) or master (mean 1.2kg, SD 4.2, P=0.009) degree. We found a positive correlation between GWG and weight retention at 12 months postpartum in women with either normal pre-pregnancy weight (spearman's rho (r_s= 0.317, P=<0.001) or pre-pregnancy overweight (r_s= 0.205, P=0.047).

Women with ≥5kg PPWR at 12 months also reported worse mental health at 6- and 12 months postpartum compared to women with <5kg PPWR (Table 3).

[insert Table 3]

Impact of mental health on body composition

Linear mixed models revealed that at 6 weeks postpartum, women with depressive symptoms (EPDS ≥10) had a higher fat percentage (0.9%, P=0.01) at 6 weeks postpartum, which remained higher at 12 months. However, there was no statistical significant change from 6 weeks to 12 months postpartum. A high SOC (≥80) at 6 weeks postpartum was related to a lower fat percentage of -0.8% at 6 weeks after childbirth (P=0.01), with again no improvement or deterioration in the first year after childbirth.

The mental health variables sSTAI-6, EDS-3A, GMDS and QoL showed no statistical significant associations with changes in fat % during the first year postpartum.

Depressive symptoms (EPDS score ≥10) at 6 weeks after childbirth were also associated with a higher waist circumference of +1.3cm at 6 weeks postpartum (P=0.02), with no improvement or deterioration in the first year after childbirth.

The mental health variables sSTAI-6, EDS-3A, GMDS, SOC-13 and QoL showed no statistical significant association with changes in waist circumference during the first year postpartum.

None of the six mental health variables (sSTAI-6, EDS-3A, EPDS, GMDS, SOC-13, QoL) were associated to PPWR or %GWGL the first year after childbirth.

More details are presented in table 4.

[insert Table 4]

Discussion

This is the first longitudinal study evaluating mental health and its relationship with weight and body composition in women with previous excessive gestational weight gain. Overall, we showed a high prevalence of mental health problems in the early postpartum period, a deterioration over time and a clear relationship between poor mental health and unhealthy weight retention and body composition. These findings are worrisome and should be considered a call for attention and action.

We showed a remarkably high prevalence of women who reported poor mental health outcomes at 6 weeks after childbirth. We believe this is related to the fact that our sample consisted of a large number of women with high pre-pregnancy BMI (51%) and exclusively

women with excessive GWG. Cunningham et al. (2018) (8) previously showed that women with high pre-pregnancy BMI and excessive GWG were at higher risk for postpartum depression at 6- and 12 months after childbirth compared to those with a normal pre-pregnancy BMI and adequate weight gain. Our results suggest that women with high pre-pregnancy BMI and excessive GWG are already mentally vulnerable at 6 weeks postpartum. Additionally, it seems that their mental wellbeing was not increasing but rather decreasing throughout the first year after childbirth. Selection bias might have affected these results, as our sample consisted of 44% multiparous women and a history of experiencing mental health problems after previous childbirth which might have been a trigger for participating in the INTER-ACT project. Nevertheless, routine screening for anxiety, depression, as well as low SOC and QoL during the early postpartum period is indicated, especially in women with obesity and/or excessive GWG.

One year after childbirth, 70% of the study population still had some degree of weight retention and 23% of them retained 5kg or more. Most importantly, further analyses in body composition showed that a high SOC at 6 weeks after childbirth was associated with lower body fat (%) in the first year after childbirth and depressive symptoms at 6 weeks after childbirth were associated with higher body fat (%) and higher waist circumference the first year after childbirth. These important findings have not been previously reported and indicate that a better mental wellbeing in the early postpartum period can have a positive impact on body composition outcomes in the first year following childbirth.

Interestingly, in the multivariate models, no association was found between mental health at 6 weeks after childbirth and PPWR or % GWGL in the first year after childbirth. This suggests that in order to fully assess the impact of mental health, we should not only focus on weight (PPWR and %GWGL) as is currently common in research and follow-up programs, but also on women's body composition. Moreover, previous research showed that excess body fat is an important risk factor for multiple health problems (e.g., stroke, hypertension, cancer) (40) and high waist circumference is associated with a higher degree of central adiposity and obesity-related diseases (e.g., cardiovascular disease, type 2 diabetes mellitus, mortality) (41, 42).

In most European countries, perinatal care programs typically end 6 weeks after childbirth (43, 44) while our results illustrate that 6 weeks after childbirth is a critical time point at which many women still require mental support. Moreover, from our mixed model, we illustrated an increase in levels of anxiety and a decrease in QoL from 6 weeks to 12 months after childbirth. Previous research showed that 30% to 50% of women with postpartum depression retained a severe depression during the first year after childbirth and even in later life (45).

To assess body composition, a Tanita MC 780 SMA BIA device was used. Some studies indicated validity problems related to the use of multifrequency BIA techniques. The BIA-method may underestimate fat mass and overestimate total body water in postpartum women with overweight and obesity (46). In patients with severe abdominal obesity, the percentage of body fat may be overestimated (23). Nevertheless, there was evidence that there is no significant difference in the detection of changes in fat mass between multifrequency BIA and DEXA scan (46). Besides, a recent study of Bai (2020) (47) showed excellent repeatability in body composition during pregnancy. A recent review indicated that the BIA measurement tool is important in revealing interactions between fat mass and adverse effects in mother and child. Using the BIA method during the postpartum period can be of added value in the prediction of future health care problems such as obesity, diabetes type 2, cardiovascular disease (23) and is suitable to detect changes in fat mass over time (46). Due the recent evidence, portability and non-invasive approach, the BIA-method was an appropriate method to monitor body composition in our study sample.

The sSTAI-6 showed an increase in levels of anxiety over the first year after childbirth. Anxiety measured with the sSTAI-6 represented feelings in terms of “I feel tense – upset – worried at this moment”. Motherhood and caring for a child entails constant evolving situations, both in the early and late postpartum period (e.g., breastfeeding, return to work, resuming social activities) and many of the anxieties reported with the sSTAI-6 will therefore be related to concerns about motherhood. Perinatal health care providers should focus on reduction of anxiety in this uncertain period, focussing on reassurance and empowerment. Concurrently, this key-role should be stressed in training and continuous education of perinatal health care providers and needs substantial focus in lifestyle programs as well.

The strengths of this study was the involvement of a large study population, the longitudinal prospective study design, and the analysis of four different mental health outcomes. Incorporating QoL and SOC provided new insights and supported the mental health outcomes in an equal direction. Moreover, studying body composition variables in terms of fat% and waist circumference besides weight was of added value because this allows us to provide a more detailed assessment of women's health.

However, there were some limitations too. Although women with overweight and obesity comprise approximately 30% to 50% of women in the reproductive age (2, 6), our results cannot be fully generalized to the whole population of postpartum women. Our sample only included women with previous excessive GWG. Excessive GWG in women with overweight and obesity has previously been associated with higher levels of postpartum depression and anxiety (8, 10, 48) and is additionally considered one of the most important risk factors for PPWR (1). This should be taken into account when interpreting the prevalence of PPWR at 12 months postpartum (70%), as well as interpreting the high numbers of mental health problems at 6 weeks postpartum. A second limitation was that our study population was not in a position to adhere to the recommendations for conducting the BIA measurement. BIA measurements should not be performed when participants are dehydrated, within 4 hours of consuming food and drink, with an unemptied bladder and within 12 hours of intensive exercise (23). For example, during the lactation period it is not recommended that women fast for 4 hours or more. Further, physical activity before the BIA measurement was not assessed. Therefore, our results could not be controlled for the impact of maternal physical activity in the 12 hours before BIA measurement. A third limitation in our study was that our sample mainly consisted of working women (91%) with at least a bachelor's degree (71%). Previous studies showed significant higher risks for postpartum mood and anxiety disorders in women with a low level of education and low income (12). A fourth limitation in our study was the lack of prenatal screening for anxiety and depression, because prenatal depression and anxiety are important predictors for postpartum depression which we could not account for (13). A fifth limitation was the use of self-reported mental health screening questionnaires. Results for poor mental health may be underreported due to shame and

minimization, which can even underreport the problem of mental health in new mothers. A last limitation in this study is that PPWR was calculated based on self-reported pre-pregnancy weight. Self-reported pre-pregnancy weight is prone to errors (49). In some cases, under-reporting is observed compared to objective measures by health care providers (50).

Conclusion

Women with previous excessive GWG showed a high prevalence of anxiety and depressive symptoms, low sense of coherence and low quality of life at 6 weeks after childbirth, including a significant increase in higher levels of anxiety and lower quality of life throughout the first year after childbirth. Depressive symptoms and low sense of coherence at 6 weeks postpartum predicted unfavorable outcomes for body fat and waist circumference in the first year after childbirth. Postnatal care pathways with targeted and extended counselling approaches for women's mental wellbeing for at least up to 6 months after childbirth needs to be explored in controlled trials.

Conflicts of interest statement

The authors declared no conflict of interest.

Acknowledgments

Author' contribution; HVU, AB, LA and RD contributed to the conception and design of this study. HVU and MB contributed to obtaining the data. HVU and LA elaborated on the data. All authors contributed to the interpretation of data. HVU drafted the paper; AB, LA, RD, MB, YJ, VC and AS have critically revised. All authors approved the submitted and final version of the manuscript.

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Data sharing plan; The study protocol is publicly available. Data requests may be submitted to the Principal Investigator accompanied by a proposal with a planned objective for use of data.

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Tables

Table 1. Characteristics of the mental health questionnaires

	Depression		Anxiety		SOC	QoL
	EPDS	GMDS	sSTAI-6	EDS-3A	SOC-13	QoL
Items	10	13	6	3	13	1
Scale	4- point Likert Scale	4- point Likert Scale	4- point Likert Scale	4- point Likert Scale	7- point Likert Scale	Lineair Analogue Scale
Range numeric score	0-30 [a]	0-39 [a]	20-80 [a]	0-9 [a]	13-91 [b]	0-100 [a]
Cut-off score	≥ 10	< 13 13-26 ≥ 27	≥40	≥5	< 70	Median [c]

EPDS= Edinburgh Postnatal Depression Scale; GMDS = Gotland Male Depression Scale; sSTAI-6= spielberger State-Trait Anxiety Inventory- 6 item; EDS-3A = Edinburgh Depression Scale-3 Anxiety subscale; SOC = Sense Of Coherence; QoL= Quality of Life
a: The higher the score, the higher the level of depression/ anxiety/ QoL
b: The higher the score, the better the sense of coherence
c: Cut-off is the median calculated at each individual timepoint (6 weeks, 6 months, 12 months after childbirth)

Table 2. Participant characteristics

		Baseline. 6 weeks pp (n= 505)		A completed one-year follow-up Yes (n= 278)		No (n= 227)		P- value
		mean	SD	mean	SD	mean	SD	
Age at birth, mean (SD), range		31	4	31	4	31	4	0.72
		n	%	n	%	n	%	
Parity	Primiparous	282	56	163	59	119	52	0.18
	Multiparous	223	44	115	41	108	48	
Education	Secondary level	147	29	65	24	82	36	**0.003**
	Bachelor's level	198	39	112	40	86	38	
	Master's level and above	160	32	101	36	69	26	
Employment status	Employed	462	92	254	91	208	92	1
	Unemployed	43	8	24	9	19	8	
Etnicity	White European	470	93	263	95	208	91	0.16
	Other ethnicity	35	7	15	5	20	9	
Method of conception	Spontaneous	456	92	250	93	206	91	0.51
	ART	39	8	19	7	20	9	
	Missing	*10*		*9*		*1*		
Method of delivery	Spontaneous	346	69	193	70	153	67	0.16
	Vacuum- extraction/ forceps	45	9	30	11	15	7	
	Primairy section (planned)	58	11	26	9	32	14	
	Secondary section (urgent)	56	11	29	10	27	12	
Exclusive breastfeeding at 6 weeks postpartum	Yes	282	56	162	58	120	53	0.24
	No	223	44	116	42	107	47	
Family composition	Biological parents							
	Single parent family	29	6	13	5	16	7	0.37
	Two parent family	437	86	246	88	191	84	
	Blended family	39	8	19	7	20	9	
Family income (monthly)	Less than 2000 euro	34	7	19	7	15	7	0.12
	2000-3000 euro	90	19	41	15	49	23	
	3000-4000 euro	215	45	119	45	96	45	
	4000 or above	139	29	86	33	53	25	
	Missing	*27*		*13*		*14*		
History of depressive feelings	Yes	75	15	34	13	41	19	0.06
	No	408	85	234	87	174	81	
	Missing	*22*		*10*		*12*		
History of anxiety feelings	Yes	53	11	25	9	28	13	0.24
	No	429	89	243	91	186	87	
	Missing	*23*		*10*		*13*		
Pre- pregnancy BMI	NW	247	49	149	54	98	43	**0.047**
	OW	182	36	94	34	88	39	
	OB	76	15	35	12	41	18	
		median	IQR	median	IQR	median	IQR	
Gestational weight gain in kg	Among NW	19	17-21	19	17-21	19	17-21	0.95
	Among OW	16	13-19	15	13-17	17	14-20	**0.01**
	Among OB	14	12-17	14	11-16	15	12-17	0.44
Anxiety score	sSTAI-6 (20-80)	37	30-47	37	27-43	40	33-46	**0.008**
	EDS-3A (0-9)	4	3-6	3	1-5	4	2-6	**<0.001**
Depression score	EPDS (0-30)	6	4-11	5	3-9	7	4-10	**0.002**
	GMDS (0-39)	5	2-9	5	2-9	6	3-9	0.20
Sense of Coherence score	SOC (13-91)	70	63-78	71	63-77	70	60-76	0.22
Quality of life score	(0-100)	80	71-85	80	71-85	80	72-84	0.71

pp= postpartum; ART = assisted reproductive treatment; BMI= body mass index; NW= normal weight; OW= overweight; OB= obesity; sSTAI-6= spielberger State-Trait Anxiety Inventory- 6 item; EDS-3A = Edinburgh Depression Scale- 3 Anxiety subscale; EPDS= Edinburgh Postnatal Depression Scale; GMDS = Gotland Male Depression Scale; SOC = Sense Of Coherence

Significance level was calculated using the Likelihood ratio chi- square test for categorical variables and the Mann- Whitney U test for continue variables.

Table 3. Differences in mental health between women with <5kg and ≥ 5kg PPWR at 12 months postpartum

	PPWR <5kg 12M pp n= 215 (77%)	PPWR ≥ 5kg 12M pp n= 63 (23%)	
	median (IQR)	median (IQR)	P- value
6 weeks postpartum			
sSTAI-6	36.7 (30-43)	36.7 (33-43)	0.36
EDS-3A	3 (1-4)	4 (2-5)	0.07
EPDS	5 (4-9)	7 (3-10)	0.20
GMDS	5 (2-9)	4 (2-9)	0.92
SOC-13	71 (63-78)	70 (60-75)	0.19
QoL	80 (74-85)	75 (66-83)	**0.004**
6 months postpartum			
sSTAI-6	36.7 (30-43)	40 (37-50)	**0.01**
EDS-3A	3 (1-4)	4 (2-5)	0.104
EPDS	5 (3-9)	8 (5-10)	**0.005**
GMDS	4 (2-9)	6 (4-11)	**0.03**
SOC-13	72 (63-79)	66 (60-75)	**0.03**
QoL	80 (71-85)	72 (62-80)	**<0.001**
12 months postpartum			
sSTAI-6	40 (33-47)	40 (37-50)	0.127
EDS-3A	3 (2-4)	4 (2-5)	**0.05**
EPDS	6 (2-10)	6 (4-12)	0.086
GMDS	5 (2-10)	7 (4-10)	**0.04**
SOC-13	73 (62-80)	66 (58-74)	**0.002**
QoL	78.5 (70-85)	75 (65-80)	0.098

PPWR= postpartum weight retention; pp= postpartum; IQR = interquartile range; sSTAI-6= spielberger State-Trait Anxiety Inventory- 6 item; EDS-3A = Edinburgh Depression Scale-3 Anxiety subscale; EPDS= Edinburgh Postnatal Depression Scale; GMDS = Gotland Male Depression Scale; SOC = Sense Of Coherence

Significance level was calculated using the Mann- Whitney U test.

Table 4. Factors at six weeks postpartum in association with evolution of weight and body composition up to 12 months postpartum (N= 505 at 6 weeks after childbirth, N= 371 at 6 months after childbirth, N= 278 at 12 months after childbirth)

		PPWR in kg			%GWGL			Fat%			Waist circumference in cm		
		Starting point (W6)	Monthly evolution W6-M6	Monthly evolution M6-M12	Starting point (W6)	Monthly evolution W6-M6	Monthly evolution M6-M12	Starting point (W6)	Monthly evolution W6-M6	Monthly evolution M6-M12	Starting point (W6)	Monthly evolution W6-M6	Monthly evolution M6-M12
BMI (REF)	NW	**5.5**	**-0.5**	**-0.3**	**66.9**	**3.2**	**2**	**31.8**	**-0.5**	**-0.3**	**82.5**	**-1.0**	**-0.5**
	OW	**3.9**	**-0.2**	**-0.2**	**66.9**	**2.2**	**2.2**	**37.6**	**-0.2**	**-0.2**	**88.7**	**-0.6**	**-0.4**
	OB	**2.1**	**0.1**	**-0.1**	**66.9**	**0.6**	**1.8**	**41.2**	**0.1**	**-0.1**	**99.3**	**-0.5**	**-0.4**
EGWG- per 1 kg	NW	**+1.0**	**-0.04**	**-0.04**	**-2**	*NS*	*NS*	**+0.4**	*NS*	*NS*	**+0.4**	*NS*	*NS*
	OW	**+0.8**	**-0.04**	**-0.04**	**-2**	*NS*	*NS*	**+0.2**	*NS*	*NS*	**+0.4**	*NS*	*NS*
	OB	**+1.0**	**-0.04**	**-0.04**	**-2**	*NS*	*NS*	**+0.2**	*NS*	*NS*	**+0.4**	*NS*	*NS*
Boy	NW	*NS*	**-0.2**	**+0.1**	*NS*	**+0.9**	*NS*	**-1**	*NS*	*NS*	*NS*	**-0.2**	**+0.2**
	OW	*NS*	**-0.2**	**+0.1**	*NS*	**+0.9**	*NS*	**-1**	*NS*	*NS*	*NS*	**-0.2**	**+0.2**
	OB	*NS*	**-0.2**	**+0.1**	*NS*	**+0.9**	*NS*	**-1**	*NS*	*NS*	*NS*	**-0.2**	**+0.2**
Started excl BF	NW	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
	OW	**-1.1**	*NS*	*NS*	**+7.9**	*NS*	*NS*	**-1.0**	*NS*	*NS*	*NS*	*NS*	*NS*
	OB	**-2.2**	*NS*	*NS*	**+14.5**	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Depression in past	NW	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
	OW	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
	OB	**-2.3**	*NS*	*NS*	**+17.5**	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Multiparity	NW	*NS*	*NS*	*NS*	**-8**	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
	OW	*NS*	*NS*	*NS*	**-8**	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
	OB	*NS*	*NS*	*NS*	**-8**	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
EPDS high (cut- off ≥10)	NW	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	**+0.9**	*NS*	*NS*	**+1.3**	*NS*	*NS*
	OW	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	**+0.9**	*NS*	*NS*	**+1.3**	*NS*	*NS*
	OB	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	**+0.9**	*NS*	*NS*	**+1.3**	*NS*	*NS*
SOC high (cut-off ≥70)	NW	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	**-0.8**	*NS*	*NS*	*NS*	*NS*	*NS*
	OW	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	**-0.8**	*NS*	*NS*	*NS*	*NS*	*NS*
	OB	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	**-0.8**	*NS*	*NS*	*NS*	*NS*	*NS*

BF= breastfeeding; BMI= body mass index; EGWG= excessive kilograms gestational weight gain; M6= 6 months postpartum; M12= 12 months postpartum; NW= normal weight; OB= obese; OW= overweight; PPWR= postpartum weight retention; W6= 6 weeks postpartum; %GWGL= percentage gestational weight gain loss
EPDS= Edinburgh Postnatal Depression Scale; SOC= Sense Of Coherence
Also the spielberger State-Trait Anxiety Inventory -6 item (sSTAI-6), Edinburgh Depression Scale-3 anxiety subscale (EDS-3A); Gotland Male Depression Scale (GMDS) and Quality of Life (QoL) were included as explanatory variables in each of the four models, but none of them showed statistical significant associations with the outcomes.

Images

Figure 1;

Title/caption = **Figure 1.** Flow chart of participant follow-up

Figure 2;

Title =

Figure 2. The estimated evolution of sSTAI-6 and QoL based on the mixed model (N= 505 at 6 weeks, N= 371 at 6 months, N= 278 at 12 months postpartum).

Caption=

sSTAI-6 = spielberger State-Trait Anxiety Inventory-6 item: monthly mean increase of +0.38 (standard error 0.13), P=0.003

QoL= Quality Of Life: monthly mean decrease of -0.39 (standard error 0.15), P=0.008