Factors influencing participation and regular attendance in a program combining physical activity and nutritional advice for overweight and obese pregnant women.

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Abstract

Background: Educational programs incorporating physical activity (PA) sessions and nutritional workshops have demonstrated potential benefits for overweight and obese pregnant women. However, participation in such programs remains challenging. This study aimed to investigate factors influencing participation and regular attendance while examining changes in health behaviors, as well as obstetric and neonatal outcomes.

Methods: Between 12 and 22 weeks of gestation, pregnant women with a BMI ≥ 25 kg/m2 were invited to join an educational program combining three collective nutritional workshops and 12 weekly PA sessions. Regardless of program uptake and regular attendance, women's PA levels, eating behaviors, and affectivity were assessed using validated questionnaires at 20-24 weeks, 32-34 weeks, and postpartum. Multivariable logistic regression model was used to determine factors influencing participation.

Results: Among the 187 enrolled women in the research, 61.5% agreed to participate in the program. Among them only 45% attended 6 or more sessions, and only 8.7% attending 6 or more PA sessions. Participation was motivated by problematic eating behaviors and low PA levels at baseline, while regular attendance was mainly positively influenced by higher household incomes. No significant difference was observed between participants and non-participants in terms of change in eating behaviors, PA level and affectivity. However, at the 32-34 week visit, regular participants had higher positive affectivity but also higher cognitive restraints than non-regular participants, a difference that did not maintain at postpartum.

Conclusion: The educational program combining nutrition and PA showed itself to be safe. Women facing health behavior challenges displayed willingness to initiate the program, but tailored interventions addressing their individual challenges are needed to improve attendance.

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Key words:

obesity, overweight, pregnancy, newborn, physical activity, nutrition, well-being, uptake, attendance, retention

Introduction

Obesity is a major threat to public health and has been listed as the sixth most important risk factor contributing to the overall burden of disease worldwide. In 2022, the World Health Organization estimated that almost 60% of adults in the European region were overweight or affected by obesity, with obesity alone concerning almost 23% of adults (1). These numbers reflect a significant and increasing problem encountered in obstetrics (2–4). Pregnancy is a special time for family health education. A balanced diet with dietary advice and appropriate physical activity (PA) adapted to pregnancy could help control weight gain in mothers with obesity (5). The objectives of treatment by nutritionists and dietitians are to improve the quality of the diet, in particular by reducing excessive intake of simple carbohydrates and fat, by increasing fiber-rich foods and restoring the sensations of hunger and satiety to induce more adaptive eating behaviors (6). Starting a PA during pregnancy can seem difficult because pregnancy is often associated with more fatigue and thus a need to rest. These ideas must be deconstructed since the practice of reasonable and adapted PA such as active walking, gymnastics or swimming during pregnancy is not dangerous and provides real benefits for the mother (lower cesarean rate, reduction of fatigue, lumbar pain and anxiety) (7–9) and for the newborn (improvement of memory and learning capacities and adaptation to stressful situations) (10). The American College of Obstetricians and Gynecologists (ACOG) recommends low to moderate intensity PA for all pregnant women for at least 20-30 min daily (11) and the French National Authority for Health (HAS) supported these standards in 2019 by recommending a weekly average of 150 to 180 min(12).

Previous studies suggest that management of maternal obesity during pregnancy through educational programs offering nutritional advice and appropriate PA could break this vicious circle (13,14). If we want this type of program to be followed by women and thus have an effect, it is important to understand the motivational levers influencing participation in the intervention program and also regular attendance. However, to date, few studies have been conducted to assess the psychosocial and medical determinants that influence the participation in such programs.

In a meta-analysis on various studies evaluating interventions based on PA and/or on nutritional advice to control weight gain in pregnant women, the authors found that such programs reduced gestational weight gain by an average of 1.4 kg in intervention groups compared to control groups. In spite of this effect, interventions groups did not differ from control groups in the proportion of women exceeding the gestational weight recommended

by the Institute of Medicine. These contrasting results could be explained by the participation rate in the program, as discussed by the authors of the meta-analysis who regret the paucity of information on participation and attendance (5). Thus, while they concluded that it was useful to set up intervention programs, they also suggested that participation and attendance, as well as the factors that influence them, should be assessed.

The primary objective of our study was to determine the factors that explain participation and attendance to a lifestyle intervention in pregnant women. Thereby, we investigated whether socio-medico-behavioral factors might influence the participation and attendance in a program combining PA and nutritional advice, conducted in pregnant women that were overweight or suffering from obesity. Secondary goals were to analyze the evolution of PA, eating behaviors and affectivity during participation and to examine obstetric and neonatal outcomes according to participation.

METHODS

Type of study and inclusion criteria

We performed a single-center prospective study in pregnant women, aged of 18- to 45-year-old with singleton pregnancy, and a BMI ≥ 25 kg/m2.

Procedure and ethical authorization

At antenatal visits, we systematically offered pregnant women between 12 and 22^{+6} weeks of gestation to participate in a program combining nutritional workshops and PA sessions. Our intervention was presented as an educational program called “Eat well, move well for baby’s health”. The program was not offered to women with a medical condition that could interfere with PA: history of more than two miscarriages, severe heart disease (arrhythmia, history of myocardial infarction), first trimester bleeding, multiple pregnancy, unstable thyroid disease, pre-existing hypertension and diabetes.

Women could opt to participate or not in this program, thus self-selecting into participant and non-participant group. In both cases, they were asked if they agreed to be included in a study aiming to evaluate the factors that influence program participation and to collect data on pregnancy, delivery, neonatal and postpartum outcomes (See additional file 1 for an overview of the study). The subjects had complete oral and written information. A signed informed consent was collected for each subject before their entry into the study. This protocol was approved by the « Comité de Protection des Personnes Nord-Ouest IV (Ethics Committee) » (2015-A01085-44). This study was registered on the ClinicalTrial.gov site at number

NCT02701426. The analysis concerned all women who maintained their consent until the end of the study, including patients who did not complete the entire program.

Description of the educational program

The "Eat well, move well for baby's health" program occurred between 24 and 36 weeks of pregnancy. In terms of nutritional support, participants were asked to follow 3 collective workshops in groups of 10 to 15 participants, lasting 2 hours and spread over 12 weeks (i.e., 1 workshop per month) after the initial assessment. These workshops aimed to inform women on nutritional guidelines for pregnancy and gestational weight gain both adapted to overweight and obese women. These workshops took place in the therapeutic kitchen, which allowed the realization of culinary workshops. Detailed content of the 3 nutritional workshops is provided in the additional file 2.

In terms of PA, the program (adapted to pregnancy) included sessions developed by the North Committee of the French Federation of Physical Education and Voluntary Gymnastics (EPGV) with aerobics and gentle muscle strengthening and lasted 12 weeks per patient. Three weekly slots were proposed in the maternity ward with schedules adapted to working hours. Women were asked to attend at least one session per week, with a strong invitation to do an additional second and third session on their own, outside the maternity ward. The additional sessions could be an active walk, an indoor gym class in a club, an aqua gym session, or even home exercises suggested by the sports coach. Each session was limited to 10-12 patients to allow advice personalization by the coach. Gradually, the patients were further encouraged to increase their practice. They could note and follow their evolution using a logbook.

Measures and assessments

Three questionnaires that assessed eating behavior, PA and affectivity were submitted to women between 20 and 24 weeks, between 32 and 34 weeks and at the postpartum visit (6 to 8 weeks after delivery).

Eating behavior was assessed using the TFEQ (18 items) validated in French and tested in pregnant women (15–17). Three eating behavioral factors are examined in this questionnaire: cognitive restraint (CR), i.e, the conscious effort to restrict food intake to control body weight, emotional eating (EE), i.e., the tendency to eat in response to negative emotions, and uncontrolled eating (UE), i.e., the tendency to overeat along with a loss of control around food consumption.

Physical activity was assessed using the Pregnancy Physical Activity Questionnaire (PPAQ) (18). This self-administered questionnaire provided a qualitative (type of activity) and

quantitative view of the activity with 33 questions. An intensity was assigned to each activity using the Metabolic Equivalents (MET) table. The MET is a unit used to estimate the metabolic cost of PA. The value of 1 MET is approximately equal to a person's resting energy expenditure. The time devoted to each activity, as reported by the woman herself, was then multiplied by the corresponding intensity to obtain the average energy expenditure per week (MET.hours/week). The activities were classified into 5 categories by type: household/care (13 activities), occupational (5 activities), transportation (3 activities), sports/exercises (7 activities plus 2 open-ended questions), and inactivity (3 activities). In addition, each activity was categorized into 4 categories based on its intensity: sedentary (<1.5 METs), light (1.5-2.9 METs), moderate (3.0-6.0 METs) and vigorous (>6.0 MET). The variable studied as a participation factor was the total number of METs per hour of PA per week of the patients, defined as total PA (MET.h/week). The volume of total PA corresponded to light activity if score < 600 MET.h/wk, moderate if the score was between 600-1500 MET.h/wk and intense > 1500.h/wk.

Affectivity was assessed using the PANAS questionnaire, which is sensitive to changes over time, and is intended to measure mood through positive and negative affectivity. The PANAS is validated in French and has been used in pregnant women (19–22).

To meet the primary goal, which was to study the variables influencing program participation, we analyzed 12 *a priori* candidate variables: age, pre-gestational BMI, comorbidities (hypertension, history of cesarean section and early gestational diabetes detected in the 1st trimester), parity, socio-professional category, income, smoking, TFEQ (3 dimensions), PPAQ and PANAS (2 dimensions) scores.

To meet secondary goals, which were to analyze the evolution of diet, PA and affectivity during the program and to examine obstetric and neonatal outcomes according to participation and attendance, we defined *attendance* according to the number of PA and nutritional sessions attended. Women were classified as regular when they attended six sessions or more (e.g., 3 nutritional workshops + 4 PA sessions) and non-regular when they attended five sessions or less.

Statistical analyses

Categorical variables were expressed as numbers (percentage). Quantitative variables were expressed as mean (standard deviation, SD) or as median (interquartile range, IQR) for non-Gaussian distribution. Normality of distributions were assessed using histograms and the Shapiro-Wilk test. We firstly assessed the determinants of participation in the educational

program in bivariate analyses using Student's t test or Mann-Whitney U-test, according to the distribution of quantitative determinants, using the Chi-square test (or the Fisher's exact test in case of expected cell frequency <5) for categorical variables and using the Chi-Square trend test for ordinal variables. Determinant associated to the participation at the level of 0.10 in bivariate analyses were introduced into a multivariable logistic regression model using Firth's penalized likelihood approach to account smaller number of patients. Collinearity among candidate factors was examined by calculating the variance inflation factor (VIF). Odds ratios (ORs) of participants vs. non-participants and their 95% confidence intervals (CIs) were estimated as effect size. The same methodology was used to identify determinants of attendance in the educational program among participants. Due to collinearity between socio-professional status, personal income and household income, the household income was selected as candidate variable into the multivariable model.

Obstetrical and neonatal outcomes were compared according to participation by using the Student's t-test or Mann-Whitney U-test according to distribution of quantitative outcomes and by using Chi-square test (or Fisher's exact test) for binary outcomes.

The evolution of the health-related behaviors parameters over the time was compared between participants vs. non-participants using a longitudinal analysis of covariance (ANCOVA) taking into account the correlation between the repeated measures within the same subject. A linear mixed model (unstructured covariance pattern model) on the follow-up visit change (32-34 weeks and postpartum) from baseline (20-24 weeks) in each behavior parameter was used by including participation status, time (as 2-level categorical variable), and the interaction term between participation status and time as fixed effects. In this model, baseline value of the studied behavior parameter, age, pre-gestational BMI and educational level were considering as pre-specified covariables. Adjusted mean difference in change from baseline between participants and non-participants calculated from LSMEANS values are reported as effect size. Statistical testing was done at the two-tailed α-level of 0.05. No statistical comparisons were done for categorical variables with a frequency <8 in the overall sample. Data were analyzed using the SAS software version 9.4 (SAS Institute, Cary, NC).

RESULTS

Sample

A total of 195 patients consented to be enrolled in our study, 7 withdrew their consent along the way and 1 had termination of pregnancy at 17 weeks. A total of 187 patients were included in the study.

Factors influencing the participation in the educational program

Among the 187 patients included in the study, 115 (61.5%) agreed to participate in the educational program and 72 (38.5%) declined to participate.

Socio-demographic, medical and behavioral factors known at baseline were compared between participants vs non-participants (Table 1a). Among the socio-demographic variables, association of participation with socio-professional category showed a trend towards the threshold of significance (p = 0.066), with a higher proportion of unemployed individuals and skilled non-manual workers, but lower proportions of skilled manual workers in participants compared to non-participants. There were no significant differences in age, educational level, income; neither in medical history, although for the latter, overall proportions of comorbidities such as prior hypertension and early gestational diabetes were low (<10%).

Among health-related behaviors, problematic eating behaviors (TFEQ) were significantly higher in participants compared to non-participants. In addition, PA (PPAQ) was lower among participants although the difference did not reach the significance level (p = 0.084). Positive and negative affectivity (PANAS) were not significantly different between the two groups, even if negative affectivity was non-significantly slightly higher in participants (p = 0.11). In the multivariable model (Table 1b), only cognitive restraint and PA remained significantly associated with the participation: a higher cognitive restraint was associated with participation, OR = 1.02, 95% CI (1.00 to 1.04), whereas a higher PA was associated with non-participation, OR = 0.97, 95% CI (0.95 to 0.99).

Factors influencing the attendance in the educational program

For two women, the information about regularity was missing. Among the participants, only 51 women (45%) were classified as regular. The median of attendance percentage at nutritional workshops was 66.7% [IQR 0-100] and 8.3% [IQR 0-66.7] at PA sessions. A total of 34 women (30%) did not attend any of the 3 nutritional workshops and 46 women (41%) did not perform any PA session. On the contrary, 19 women (17%) participated in 12 or more sessions, including 5 women (4%) who performed more than 20 sessions.

As shown in Table 2.a, age, educational level, and incomes (personal or household) were significantly higher in regular compared to non-regular attendees. Moreover, regular attendees were more often skilled non-manual worker or intellectual/managerial workers than non-regular attendees, but the difference did not reach the significance level (p = 0.074). No differences were found in medical variables between the two groups. Among behavioral and psychological variables, compared to non-regular attendees, regular ones had lower uncontrolled eating (p = 0.049), higher positive affectivity (p = 0.003) and lower negative affectivity (p = 0.023). In the multivariate model (Table 2.b) only household income remained significantly associated with attendance: a higher income was associated with regular participation, OR = 1.69, 95% CI (1.07 to 2.66).

Efficacy of the educational program on the health-related behaviors and affectivity (Figure 1 and Table 3)

Eating behavior. Uncontrolled eating tended to decrease in each group between baseline and the 32nd-34th week visit and up to the post-partum visit. No difference was found between the two groups after adjustment (mean difference in change from baseline (95%CI): 1.4 (-2.6 to 5.3) at the 32nd-34th week visit and 2.7 (-2.2 to 7.5) at post-partum visit).

No significant change was observed for emotional eating or for cognitive restraint in each group. No significant difference was found between the two groups.

Physical activity. PA decreased significantly in each group between baseline and the 32nd-34th week visit (-61 (-90 to -32) in participants vs -67 (-100 to -33) in non-participants), but without significant difference between the two groups. However, PA tended to increase between baseline and post-partum visit in participants (12 (-24 to 48)) whereas it tended to decrease in non-participants (-20 (-63 to 23)), although no significant difference was found between the two groups (p = 0.16).

Affectivity. No significant change was observed in positive affectivity in the two groups between baseline and 32nd-34th week visit. Between baseline and post-partum assessment, positive affectivity increased significantly in participants (2.6 (1.1 to 4.2)) but not significantly in non-participants (1.5 (-0.4 to 3.3)), although the difference between the two groups did not reach the significance level (p = 0.19).

The negative affectivity tended to decrease in each group whatever the visit. No difference was observed between the two groups.

Comparisons of the evolution of health-related behaviors in regular vs non-regular participants (Figure 2 and Table 4)

Eating behavior. No significant changes were observed in either group for uncontrolled eating or emotional eating. No difference was found between the two groups. However, significant increase was observed between baseline and 32nd-34th week in regular participants for cognitive restraint whereas it tended to decrease in non-regular, thus a significant difference was found between the two groups at the 32nd-34th week visit (-6.4 (-11.8 to -1.0)). At post-partum visit the difference between the two groups did not reach the significance level (-6.3 (-13.1 to 0.4)).

Physical activity. PA decreased significantly in each group between baseline and the 32nd-34th week visit (-44 (-78 to -10) in regular participants vs -61 (-91 to -31) in non-regular participants), but no significant difference was found between the two groups. However, PA tended to increase between baseline and post-partum visit in each group, but no significant difference was found between the two groups (p = 0.66).

Affectivity. Positive affectivity increased significantly in regular participants at 32nd-34th weeks and at post-partum, whereas it increased only at postpartum in non-regular participants, explaining the significant difference at the 32nd-34th weeks visit between the two groups (-3.2 (-5.2 to -1.2)). A gap was observed between the two groups for negative affectivity at the 32-34 week visit but did not reach the significance level (1.8 (-0.1 to 3.8), p = 0.060). No difference was found at the post-partum visit.

Effects of the educational program on maternofetal outcomes

No significant effects of the educational program were observed in any of the 17 maternofetal outcomes tested when comparing participants to non-participants (Table 5).

Discussion

In our sample, 61.5% of women agreed to participate in the educational program. This number corresponds to the upper limit of the range of patient participation in self-management programs for chronic diseases, including obesity, that goes from 10 to 60% (23–25). Concerns for the health of their baby may explain the “high” rate of participation in these women, also retrieved in an individual weight management advice during pregnancy with 78% of attendance at the first appointment (26). However, only 45% of participants in our study and 41% in the previous cited individual program (26) attended classes regularly. This rate of drop-out is problematic as long-term positive outcomes depend on high attendance (27,28).

Attendance at PA sessions was particularly low since 50% of women attended less than 8.3% of these sessions. Interestingly, the factors that explained participation were different from those that explained attendance. Participation was mainly driven by problematic eating behaviors, especially cognitive restraint, and low levels of PA. These difficulties seemed to trigger participation. It suggests that women are aware of their behavioral problems and willing to try something to help them to cope, regardless of their education and income, which did not impact participation contrary to usual results in the scientific literature. Our program being free may explain why income did not affect the decision to participate. Furthermore, social desirability, i.e., the tendance to behave in the way expected by others and society, may also explain the decision to participate, as pregnant women are strongly expected to do the best for the health of their baby. However, once the program started, the difficulties usually associated with lower attendance in scientific literature were also found to lessen attendance in our study, namely lower education (23,29) and income, younger age (29), emotional difficulties (30) and problematic eating behavior (29). Income was the only variable that significantly explained attendance in the multivariable model. Women with lower socio-economic status or belonging to ethnic minorities may consider health to be a lesser priory (31). Moreover, in challenging socio-economic contexts, the lack of time and support from their partners, which are widely recognized as significant barriers to PA (32), may also be an issue. Furthermore, educational group interventions, although in our case limited to 12 people per group to maximize personalized advice, may be deemed too general and not tailored to specific personal challenges and situations (31). Such interventions are often designed by highly educated researchers and clinicians who may lack perspective on the challenges encountered by obese women with a low socio-economic status or emotional difficulties. Therefore, feasibility studies aiming to assess the acceptability of interventions by participants and attrition rates, are more and more recommended before complex interventions such as our intervention (33,34). Even though in our study the program was designed by an association with grounded experience towards the targeted population, co-construction of the interventions with patients as partners (35,36) may further help to ensure that the intervention meets the actual needs of patients and can be grounded in some way in their lives. To further help patients implement PA and healthy dietary in their daily life, programs could greatly benefit from sessions focused on behavioral change techniques (BCT). BCT have been indexed and classified in the famous taxonomy of Susan Michie et al. (37), and their associations with patients' outcomes have been tested in numerous conditions. In a

systematic review of PA intervention for overweight and obese pregnant women (38), the most used BCTs in successful interventions were instructions on how to perform behavior, behavioral practice/rehearsal, two elements that were carried out in our program, but also self-monitoring of behavior, which was only encouraged in our program, and social support, goal setting outcome and problem solving, which were not addressed in the program. Another promising way to improve retention rates may be to conduct e-interventions or combining face-to-face and online sessions as they demonstrate higher retention rates (39) and positive outcomes such as reduced gestational weight gain (40).

The evolution of PA and positive affectivity, according to participation, showed an interesting pattern. Although statistical differences were not found, participants demonstrated a favorable evolution in PA and positive affectivity between baseline and post-partum, contrary to non-participants. PA, which is well-known to improve emotion regulation, even during pregnancy (41), may explain improvement in positive affectivity in participants. Regarding eating behaviors, the program did not improve anything and an increase in cognitive restraint was even experienced in regular attendees at 32-34 weeks. Eating behaviors may require more time to be changed and should thus probably be addressed before pregnancy to improve health outcomes. Indeed, the program did not improve any mother and infant health outcomes, which confirms the results of a recent meta-review showing almost no health benefit of lifestyle interventions in overweight or obese pregnant women (42). As discussed in the meta-review, pregnancy, which already implies many changes and difficulties, may in fact not be the best period to initiate a behavioral change but rather to consolidate previous change of habits.

Limits

This is single-center research in Northern France, which limits the generalization of the results. However, Northern France is the region most impacted by obesity in France (43) and thus a very relevant region for such a study. Contextual data around the intervention are also missing. For example, we have no information on the support received (or not) by women in their family regarding their attendance to the intervention and their change of health behaviors whereas evidence shows that the opinion and support of family impact attendance (29,38). We do not know either how the intervention was conducted and perceived by participants whereas peer-support and conviviality by the facilitators are also known to contribute to attendance (31). Due to low attendance, statistical power may be lacking to compare regular versus non-regular participants. Finally, results on maternofetal outcomes

should be read with extreme caution. Indeed, since the study was not designed to test the effectiveness of the program, no randomization or adjustment for confounding variables in analyses related to maternofetal outcomes were carried out.

Conclusion

The educational program combining nutrition and PA proved to be safe and successful in enhancing PA levels and addressing emotional eating. Women facing health behavior difficulties displayed willingness to initiate the program, but tailored interventions addressing their individual challenges could improve attendance.

DECLARATIONS

Ethics approval and consent to participate

The study was approved by the French Ethics Committed « Comité de Protection des Personnes (CPP) Nord-Ouest IV » (2015-A01085-44). Informed consent was obtained from all the participants.

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and analysed during the current study are not publicly available as they are the exclusive property of the University Hospital of Lille (CHU de Lille). However, they are available upon reasoned and well-founded request to the corresponding author after authorisation by the CHU de Lille.

Competing interests

No competing interests

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Authors' contributions

PD and MP designed the study and the intervention, acquired the funding, and managed the study in the field. EM and MT assisted with data acquisition and the preparation of figures. CLP designed the physical activity sessions. PD, MP, and SL wrote the article. PD and MP

prepared the supplemental files. HB and VD analyzed the data, wrote the tables, and the results section accordingly. SL created the figures. All authors approved the submitted version.

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Table 1.a – Baseline Factors Influencing Participation in the educational program

	N	Participants n = 115	N	Non-participants n = 72	*p-value*
Socio-demographic status					
Age	115	29.7 ± 5.1	72	28.8 ± 4.7	0.26
Socio-Professional Category	115		71		0.066
-Unemployed/unskilled manual worker		40 (34.8)		21 (29.6)	
-Skilled manual worker		17 (14.8)		22 (31.0)	
-Skilled non-manual worker		42 (36.5)		19 (26.8)	
-Intellectual/managerial profession		16 (13.9)		9 (12.7)	
Educational level	115		71		0.67
- < NVQ level 1,2		7 (6.1)		1 (1.4)	
- College bachelor degree		32 (27.8)		29 (40.9)	
- Graduation		76 (66.1)		41 (57.7)	
Personal income per month	115		70		0.34
- <763€		27 (23.5)		14 (20.0)	
- 763€-1265€		31 (27.0)		24 (34.3)	
- 1266€-1905€		36 (31.3)		25 (35.7)	
- 1905€-2600€		13 (11.3)		7 (10.0)	
- >2600€		8 (7.0)		0 (0)	
Household income per month	115		70		0.28
- <763€		7 (6.1)		2 (2.9)	
- 763€-1265€		15 (13.0)		5 (7.1)	
- 1266€-1905€		16 (13.9)		11 (15.7)	
- 1905€-2600€		29 (25.2)		23 (32.9)	
- >2600€		48 (41.7)		29 (41.4)	
Medical history					
Number of nullipara	115	69 (60.0)	72	36 (50.0)	0.18
Body mass index	114	30.0 [27.5-32.8]	72	30.0 [26.9-32.4]	0.63
History of hypertension	115	2 (1.7)	72	2 (2.8)	NA
History of c-section	115	8 (7.0)	72	7 (9.7)	0.50
Early gestational diabetes	115	11 (9.6)	72	5 (6.9)	0.53
Health related behaviors					
Smoking (ever smoked / no)	115	11 (9.6)	72	8 (11.1)	0.73
TFEQ scores	112		72		
- Cognitive restraint		39.8 ± 17.2		32.6 ± 18.6	0.009
- Uncontrolled eating		35.0 ± 18.1		27.0 ± 17.7	0.004
- Emotional eating		43.8 ± 23.7		30.2 ± 22.8	<0.001
PPAQ (score in MET.h/week)	111	227.9 [161.7-293.8]	72	240.5 [185.2-335.3]	0.084
PANAS	112		71		
- Positive affectivity		34.0 ± 6.1		33.3 ±6.5	0.49
- Negative affectivity		21.5 ±7.0		19.8 ±6.1	0.11

Values expressed as numbers (%), mean ± SD or median (IQR);
Abbreviations: SD = Standard Deviation; IQR = Interquartile Range, NA = Not applicable, TFEQ = Three Eating Questionnaire scores; PPAQ = Pregnancy physical activity questionnaire; PANAS = Positive and Negative Affect Schedule (PANAS-SF). MET = Metabolic Equivalent of Task

Table 1.b – Multivariable model of Factors Influencing Participation in the educational program

	OR (95%CI)*	p-value
Socio-Professional Category		0.67
Unemployed/unskilled manual worker	1.00 (ref)	
Skilled manual worker	0.63 (0.25 to 1.61)	
Skilled non-manual worker	1.13 (0.50 to 2.53)	
Intellectual/managerial profession	0.92 (0.32 to 2.66)	
TFEQ scores		
Cognitive restraint	1.02 (1.00 to 1.04)	0.029
Emotional eating	1.02 (0.99 to 1.03)	0.066
Uncontrolled eating	1.02 (0.99 to 1.04)	0.15
PPAQ (score in MET.h/week), per 10-unit increase	0.97 (0.95 to 0.99)	0.045

Abbreviations: OR: Odds Ratio, 95%CI: 95% Confidence interval, TFEQ = Three Eating Questionnaire scores, PPAQ = Pregnancy physical activity questionnaire, MET = Metabolic Equivalent of Task

*OR are expressed for one unit increase unless otherwise indicated, and estimated in favor of participation in the educational program

Table 2.a – Baseline Factors influencing attendance in the educational program

	N	Regular n = 51	N	Non-regular n = 62	*p-value*
Socio-demographic status					
Age, years	51	31.2 ± 4.7	62	28.4 ± 5.1	0.003
Socio-Professional Category	51		62		0.074
-Unemployed/unskilled manual worker		12 (23.5)		26 (41.9)	
-Skilled manual worker		7 (13.7)		10 (16.1)	
-Skilled non-manual worker		21 (41.2)		21 (33.9)	
- Intellectual/managerial profession		11 (21.6)		5 (8.1)	
Educational level	51		62		0.003
- < NVQ level 1,2		0 (0)		6 (9.7)	
- College bachelor degree		10 (19.6)		21 (33.9)	
- Graduation		41 (80.4)		35 (56.4)	
Personal income	51		62		0.006
- <763€		8 (15.7)		18 (29.0)	
- 763€-1265€		11 (21.6)		19 (30.7)	
- 1266€-1905€		18 (35.3)		18 (29.0)	
- 1905€-2600€		8 (15.7)		5 (8.1)	
- >2600€		6 (11.8)		2 (3.2)	
Household income	51		62		<0.001
- <763€		0 (0)		7 (11.3)	
- 763€-1265€		4 (7.8)		10 (16.1)	
- 1266€-1905€		6 (11.8)		10 (16.1)	
- 1905€-2600€		9 (17.6)		19 (30.6)	
- >2600€		32 (62.7)		16 (25.8)	
Medical history					
Number of nullipara	51	27 (52.9)	62	41 (66.1)	0.15
Body mass index	50	29.1 [27.3-31.3]	62	30.1 [27.6-35.1]	0.19
History of hypertension	51	1 (2.0)	62	1 (1.6)	NA
History of c-section	51	4 (7.8)	62	4 (6.4)	1
Early gestational diabetes	51	7 (13.7)	62	4 (6.5)	0.22
Health related behaviors					
Smoking (ever smoked / no)	51	4 (7.8)	62	7 (11.3)	0.75
TFEQ scores	50		60		
- Cognitive restraint		41.0 ± 19.5		38.6 ± 15.4	0.48
- Uncontrolled eating		30.1 ± 18.4		37.7 ± 17.1	0.049
- Emotional eating		42.8 ± 25.9		43.7 ± 21.4	0.84
PPAQ (score in MET.h/week)	50	226.9 [184.5-287.0]	59	236.7 [159.52-308.3]	0.51
PANAS	50		60		
- Positive affectivity		35.9 ± 4.6		32.7 ±6.5	0.003
- Negative affectivity		19.7 ± 5.9		22.5 ±6.8	0.023

Values expressed as numbers (%), mean ± SD or median [IQR];
Abbreviations: SD = Standard Deviation; IQR = Interquartile Range, NA = Not applicable, TFEQ = Three Eating Questionnaire scores; PPAQ = Pregnancy physical activity questionnaire; PANAS = Positive and Negative Affect Schedule (PANAS-SF). MET = Metabolic Equivalent of Task

Table 2.b – Multivariable model of Factors influencing attendance in the educational program

	OR (95%CI)*	p-value
Age, years	1.06 (0.97 to 1.17)	0.20
Educational level		0.80
< NVQ level 1,2	1.00 (ref)	
College bachelor degree	3.36 (0.09 to 119.45)	
Graduation	2.95 (0.09 to 102.84)	
Household income	1.60 (1.02 to 2.49)	0.04
TFEQ scores		
Uncontrolled eating	1.00 (0.97 to 1.02)	0.71
PANAS		
Positive affectivity	1.05 (0.97 to 1.14)	0.23
Negative affectivity	0.96 (0.89 to 1.04)	0.40

Abbreviations: OR: Odds Ratio, 95%CI: 95% Confidence interval, TFEQ = Three Eating Questionnaire scores, PPAQ = Pregnancy physical activity questionnaire, MET = Metabolic Equivalent of Task
*OR are expressed for one unit increase and estimated in favor of regular attendance

Table 3. Evolution of eating behaviors, physical activity, and affectivity according to participation

	Participants	Non-participants	Difference in change from baseline[#]	
	Mean (95%CI)*	Mean (95%CI)*	Mean (95%CI)	p-value
Uncontrolled eating				
20-24 weeks (Baseline)	35.0 (31.7 to 38.2)	27.0 (23.0 to 31.0)		
32-34 weeks	30.1 (26.8 to 33.4)	25.4 (21.3 to 29.4)		
Post-partum	29.0 (25.5 to 32.4)	25.6 (21.3 to 29.9)		
Change (32-34 wks – baseline) [#]	-2.0 (-5.9 to 1.9)	-0.6 (-5.2 to 3.9)	1.4 (-2.6 to 5.3)	0.50
Change (post-partum – baseline) [#]	-3.4 (-7.6 to 0.9)	-0.7 (-5.7 to 4.3)	2.7 (-2.2 to 7.5)	0.28
Emotional eating				
20-24 weeks (Baseline)	43.6 (39.2 to 47.9)	30.2 (24.7 to 35.6)		
32-34 weeks	37.1 (32.7 to 41.6)	29.2 (23.6 to 34.7)		
Post-partum	39.3 (34.8 to 43.9)	32.4 (26.7 to 38.2)		
Change (32-34 wks – baseline) [#]	-0.8 (-6.0 to 4.3)	1.2 (-4.8 to 7.3)	2.1 (-3.3 to 7.4)	0.44
Change (post-partum – baseline) [#]	1.5 (-4.0 to 7.0)	4.1 (-2.4 to 10.6)	2.6 (-3.6 to 8.8)	0.40
Cognitive restraint				
20-24 weeks (Baseline)	39.7 (36.2 to 43.1)	32.6 (28.3 to 37.0)		
32-34 weeks	41.1 (37.5 to 44.6)	34.1 (29.7 to 38.5)		
Post-partum	40.8 (37.1 to 44.4)	35.7 (31.1 to 40.3)		
Change (32-34 wks – baseline) [#]	1.8 (-2.3 to 6.0)	-0.1 (-5.0 to 4.8)	-2.0 (-6.3 to 2.4)	0.38
Change (post-partum – baseline) [#]	1.7 (-2.9 to 6.2)	1.6 (-3.7 to 7.0)	0.0 (-5.3 to 5.2)	0.99
Physical activity				
20-24 weeks (Baseline)	242 (219 to 266)	290 (261 to 319)		
32-34 weeks	207 (182 to 231)	220 (190 to 250)		
Post-partum	282 (257 to 308)	267 (234 to 300)		
Change (32-34 wks – baseline) [#]	-61 (-90 to -32)	-67 (-100 to -33)	-5.3 (-32.8 to 22.2)	0.70
Change (post-partum – baseline) [#]	12 (-24 to 48)	-20 (-63 to 23)	-32.0 (-77 to 13)	0.16
Positive affectivity				
20-24 weeks (Baseline)	34.0 (32.7 to 35.2)	33.4 (31.8 to 34.9)		
32-34 weeks	34.1 (32.8 to 35.3)	32.3 (30.7 to 33.9)		
Post-partum	35.8 (34.5 to 37.1)	33.9 (32.3 to 35.6)		
Change (32-34 wks – baseline) [#]	1.0 (-0.5 to 2.5)	0.0 (-1.8 to 1.8)	-1.0 (-2.6 to 0.6)	0.22
Change (post-partum – baseline) [#]	2.6 (1.1 to 4.2)	1.5 (-0.4 to 3.3)	-1.1 (-3.0 to 0.6)	0.19

Negative affectivity				
20-24 weeks (Baseline)	21.4 (20.2 to 22.6)	19.9 (18.4 to 21.4)		
32-34 weeks	19.9 (18.7 to 21.2)	19.0 (17.5 to 20.6)		
Post-partum	19.9 (18.7 to 21.2)	19.1 (17.5 to 20.7)		
Change (32-34 wks – baseline) #	-0.9 (-2.4 to 0.5)	-0.6 (-2.3 to 1.1)	0.3 (-1.2 to 1.8)	0.69
Change (post-partum – baseline) #	-0.9 (-2.5 to 0.7)	-0.6 (-2.4 to 1.2)	0.3 (-1.4 to 2.1)	0.71

* Mean (95%CI) were estimated from mixed model considering variance of the three repeated measure of each outcome.
# changes were adjusted for baseline value, age, pre-gestational BMI and educational level.

Table 4. Evolution of eating behaviors, physical activity, and affectivity according to attendance

	Regular	Non-regular	Difference in change from baseline#	
	Mean (95%CI)*	Mean (95%CI)*	Mean (95%CI)	p-value
Uncontrolled eating				
20-24 weeks (Baseline)	31.0 (26.0 to 36.0)	37.6 (33.0 to 42.1)		
32-34 weeks	29.2 (24.7 to 33.7)	30.4 (26.2 to 34.5)		
Post-partum	28.2 (23.5 to 32.9)	28.1 (23.5 to 32.6)		
Change (32-34 wks – baseline) #	-1.8 (-7.0 to 3.4)	-3.2 (-7.6 to 1.2)	-1.4 (-6.4 to 3.6)	0.58
Change (post-partum – baseline) #	-2.8 (-8.7 to 3.1)	-5.0 (-10.4 to 0.3)	-2.2 (-8.6 to 4.2)	0.50
Emotional eating				
20-24 weeks (Baseline)	42.7 (36.1 to 49.3)	43.4 (37.4 to 49.5)		
32-34 weeks	36.4 (30.4 to 42.4)	37.0 (31.4 to 42.6)		
Post-partum	41.1 (34.3 to 47.9)	36.7 (30.3 to 43.2)		
Change (32-34 wks – baseline) #	-2.2 (-9.5 to 5.1)	-1.8 (-8.0 to 4.5)	0.4 (-6.6 to 7.5)	0.90
Change (post-partum – baseline) #	2.7 (-5.0 to 10.3)	-2.0 (-8.8 to 4.8)	-4.6 (-12.5 to 3.2)	0.24
Cognitive restraint				
20-24 weeks (Baseline)	40.5 (35.6 to 45.4)	38.8 (34.3 to 43.3)		
32-34 weeks	44.5 (39.6 to 49.4)	38.0 (33.5 to 42.5)		
Post-partum	44.0 (38.6 to 49.3))	37.7 (32.5 to 42.9)		
Change (32-34 wks – baseline) #	5.8 (0.4 to 11.3)	-0.6 (-5.3 to 4.1)	-6.4 (-11.8 to -1.0)	0.020
Change (post-partum – baseline) #	5.6 (-0.6 to 11.7)	-0.8 (-6.4 to 4.8)	-6.3 (-13.1 to 0.4)	0.066
Physical activity				
20-24 weeks (Baseline)	226 (193 to 259)	258 (228 to 288)		
32-34 weeks	206 (180 to 233)	206 (181 to 231)		
Post-partum	278 (241 to 31)	291 (253 to 327)		

Change (32-34 wks – baseline) #	-44 (-78 to -10)	-61 (-91 to -31)	-17 (-50 to 15)	0.28
Change (post-partum – baseline) #	26 (-19 to 71)	14 (-28 to 56)	-12 (-65 to 41)	0.66
Positive affectivity				
20-24 weeks (Baseline)	35.9 (34.2 to 37.5)	32.8 (31.3 to 34.3)		
32-34 weeks	36.2 (34.6 to 37.8)	32.5 (31.0 to 34.0)		
Post-partum	36.7 (35.1 to 38.3)	35.7 (34.1 to 37.3)		
Change (32-34 wks – baseline) #	2.8 (0.8 to 4.8)	-0.4 (-2.1 to 1.3)	-3.2 (-5.2 to -1.2)	0.002
Change (post-partum – baseline) #	3.1 (1.0 to 5.1)	2.7 (0.8 to 4.5)	-0.4 (-2.6 to 1.8)	0.72
Negative affectivity				
20-24 weeks (Baseline)	19.6 (17.8 to 21.4)	22.5 (20.8 to 24.2)		
32-34 weeks	18.2 (16.4 to 19.9)	21.2 (19.5 to 22.8)		
Post-partum	19.2 (17.4 to 20.9)	20.0 (18.3 to 21.7)		
Change (32-34 wks – baseline) #	-1.8 (-3.7 to 0.2)	0.0 (-1.7 to 1.8)	1.8 (-0.1 to 3.8)	0.060
Change (post-partum – baseline) #	-0.7 (-2.8 to 1.4)	-1.0 (-3.0 to 1.0)	-0.3 (-2.6 to 1.9)	0.77

* Mean(95%CI) were estimated from mixed model considering variance of the three repeated measure of each outcome.

changes were adjusted for baseline value, age, pre-gestational BMI and educational level.

Table 5 – Obstetrical and neonatal outcomes according to participation

	N	Participants n = 115	N	Non participants n = 72	*p-value*
Complication	115	43 (37.4)	71	24 (33.8)	0.62
8. Gestational diabetes	43	24 (55.8)	24	14 (58.3)	0.84
9. Gestational hypertension	43	4 (9.3)	24	0 (0)	NA
10. Preeclampsia	43	0 (0)	24	1 (4.2)	NA
11. Preterm PROM	43	0 (0)	24	1 (4.2)	NA
12. Premature Birth	43	3 (7.0)	24	2 (8.3)	NA
Gestational weight gain (kg)	109	11.6 ± 7.2	70	10.6 ± 5.8	0.58
C-section	113	31 (27.4)	71	15 (21.1)	0.34
Instrumental vaginal delivery	82	20 (24.4)	56	11 (19.6)	0.51
Birth weight (g)	113	3405 ± 516	71	3481 ± 509	0.33
Umbilical pH < 7.10	113	18 (15.9)	70	5 (7.1)	0.081
Apgar score at 1min < 7	113	4 (3.5)	71	2 (2.8)	NA
Shoulder dystocia	111	4 (3.6)	71	1 (1.4)	NA
Transfer in ICU	113	3 (2.6)	71	2 (2.8)	NA
Breastfeeding **Formula feeding** **Mixed feeding**	105	65 (61.9) 26 (24.8) 14 (13.3)	64	32 (50.0) 25 (39.1) 7 (10.9)	0.14
Post-partum BMI at T3 (kg/m^2)	98	30.9 [28.8-34.5]	62	30.6 [27.7-33.4]	0.23
Baby's weight at T3 (g)	104	4894 ± 623	63	4787 ± 775	0.35

Values expressed as numbers (%), mean ± SD or median [IQR]; T3 = 6 to 8 weeks after delivery
Abbreviations: SD = Standard Deviation; IQR = Interquartile Range, NA = Not applicable

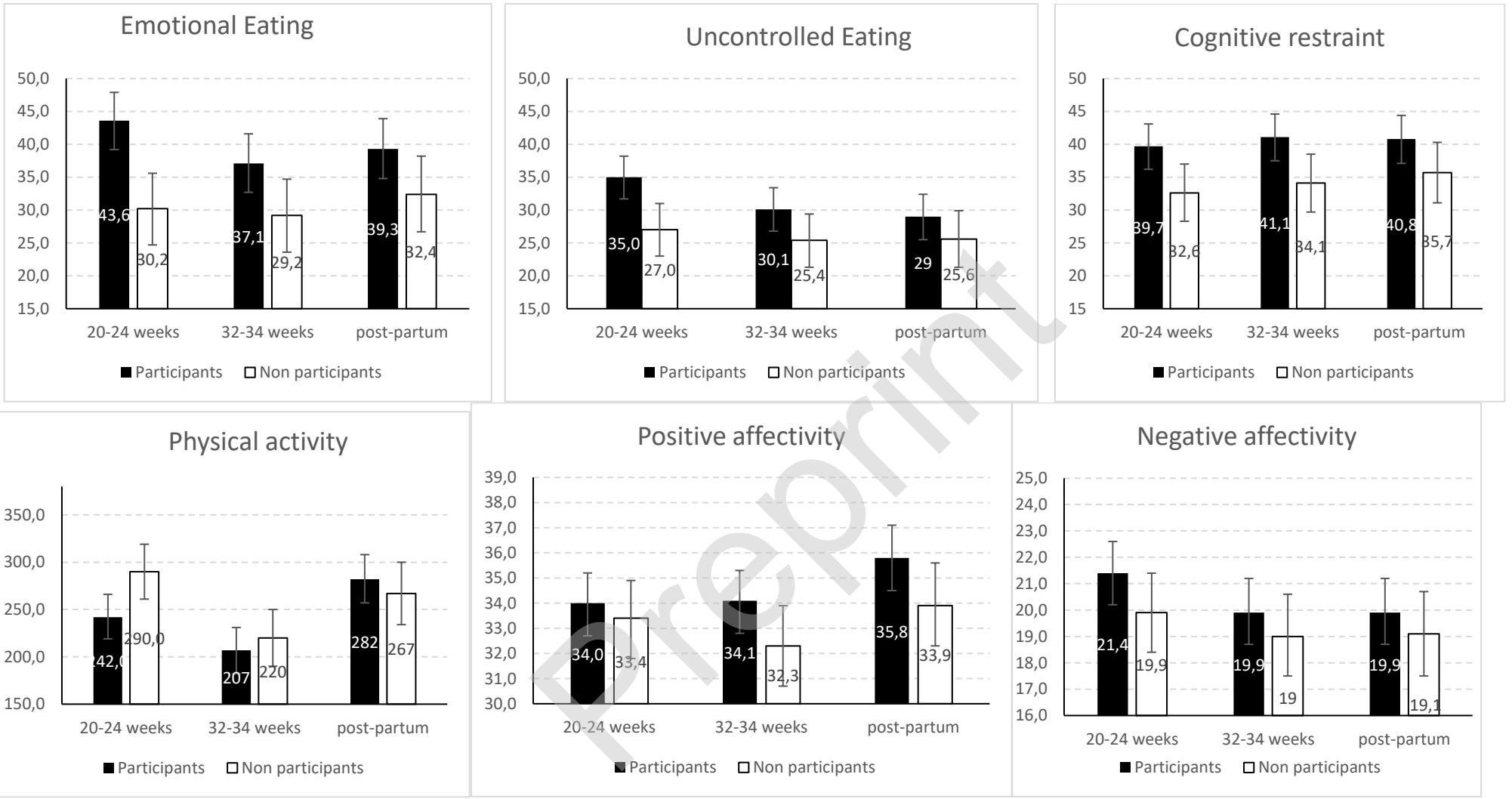


Figure 1. Means of eating behaviors, physical activity (Met.h per week) and affectivity according to *participation*.

Note. Error bars = 95% confidence intervals of the means. Means and 95%CI were estimated from mixed model considering variance of the three repeated measure of each outcome.

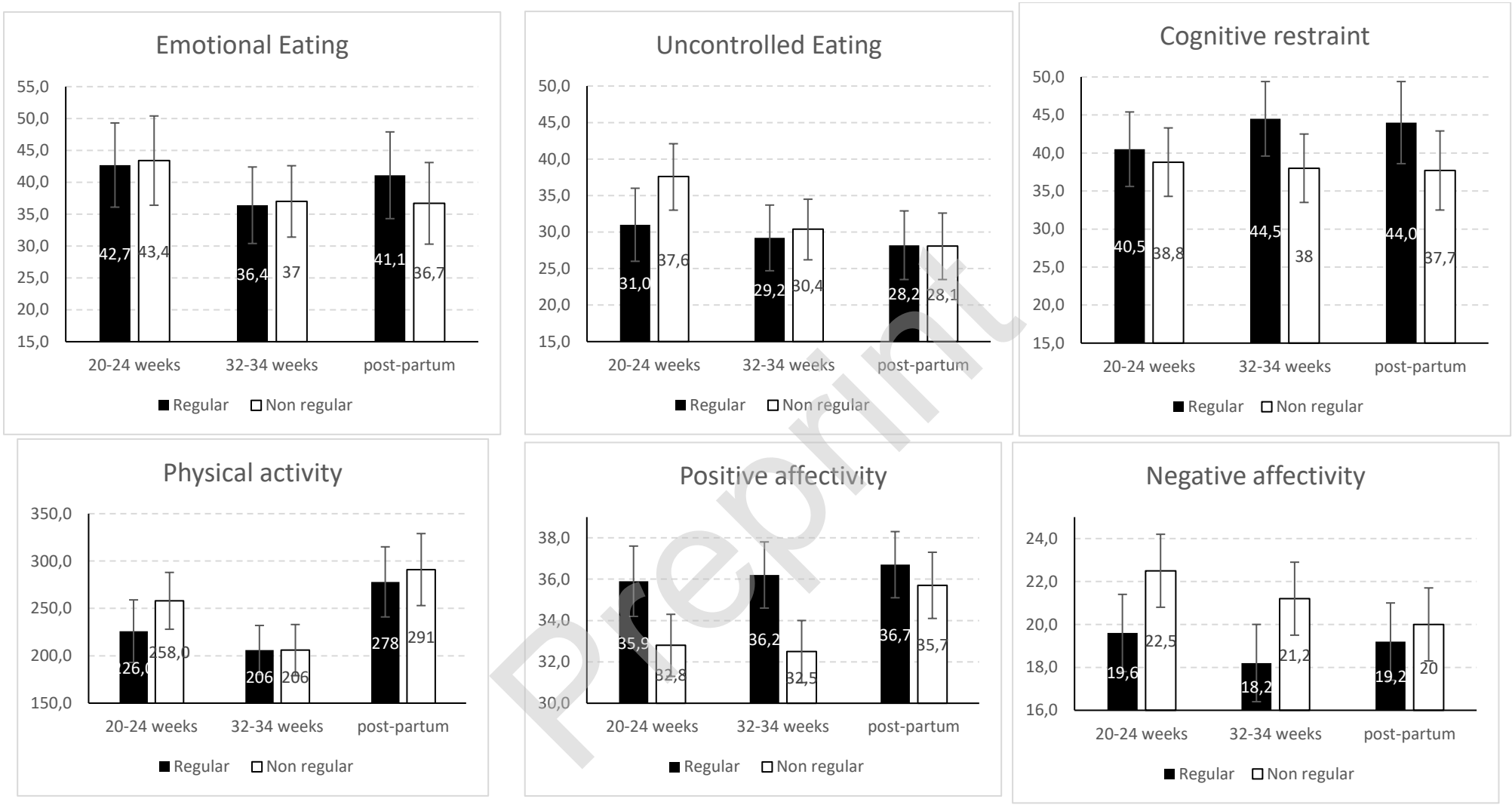
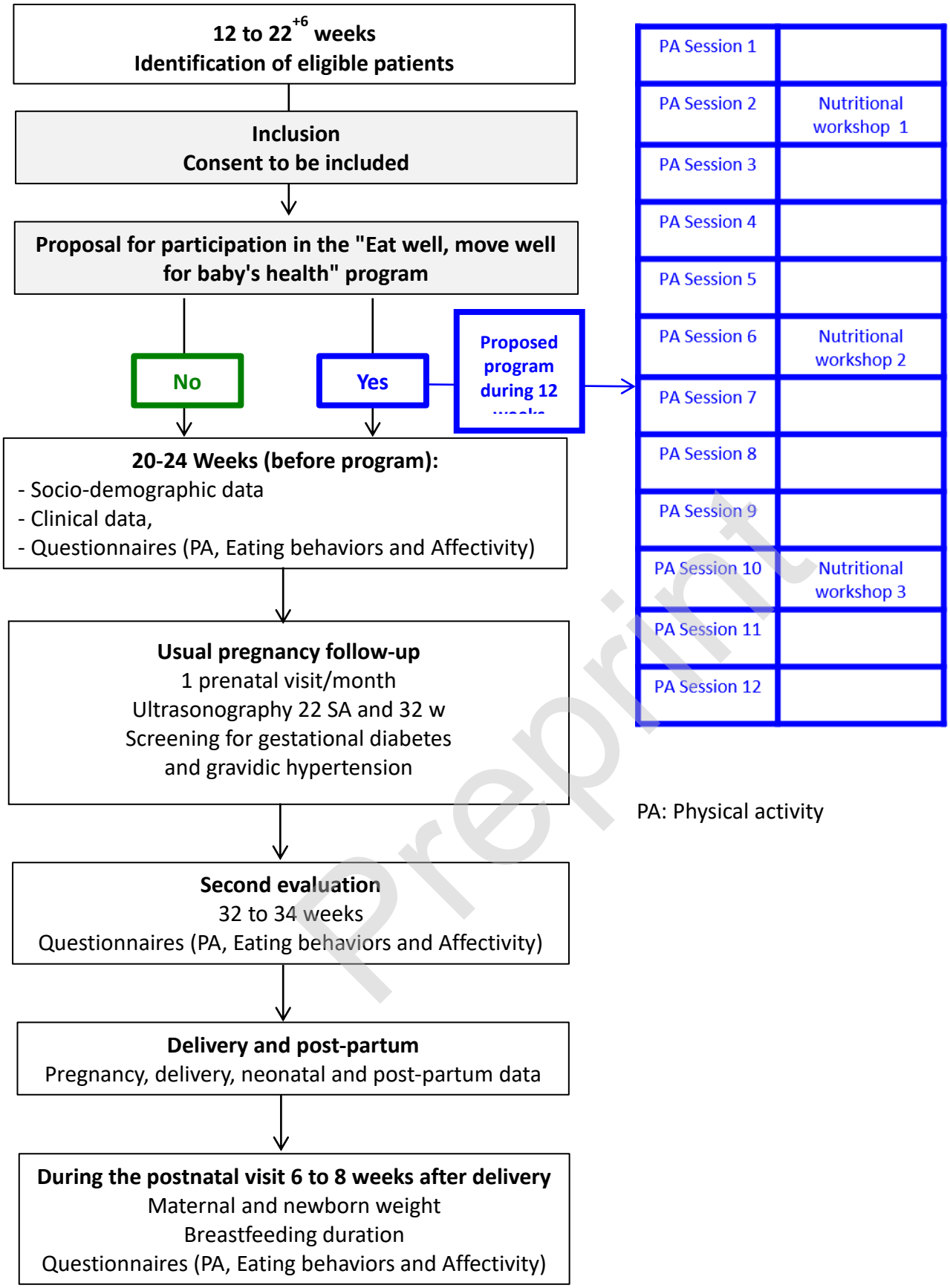


Figure 2. Means of eating behaviors, physical activity (Met.h per week) and affectivity according to *attendance*.

Note. Error bars = 95% confidence intervals of the means. Means and 95%CI were estimated from mixed model considering variance of the three repeated measure of each outcome.



PA: Physical activity

Additional file 1. Overview of the study