Impact of physical activity during pregnancy on infant neurodevelopment

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Objectives: To investigate prospectively the impact of physical activity during pregnancy on infant neurodevelopment, considering relevant confounding factors, physical activity intensity and the trimester of pregnancy in which it is performed.

Methods: Prospective follow-up study of 791 pregnant women from the first trimester of pregnancy to 40 days postpartum. Three intensity levels of physical activity were assessed in each trimester of pregnancy by the International Physical Activity Questionnaire (IPAQ). Infant neurodevelopment was assessed at 40 days postpartum by the third edition of the Bayley Scales for Infant Development-Third Edition (BSID-III). Analysis adjusted by sociodemographics, anxiety symptoms, lifestyle habits, quality of diet, body mass index, postpartum depressive symptoms and mother-infant attachment.

Results: ANCOVA analysis have shown that 40 days old infants of mothers in the moderate and high PA groups in the 3rd trimester obtained 3.2 and 3.8 points higher scores respectively in the language total scale; and 4.1 and 5.1 points higher scores respectively in the motor total scale than infants of mothers in the low PA group.

Conclusion: Moderate to high intensity physical activity during pregnancy has a positive impact on infant neurodevelopment. More specific recommendations must be incorporated in international guidelines and into maternal education sessions to improve infants' neurodevelopment.

Keywords: physical activity, pregnancy, neurodevelopment, intensity, trimester.

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INTRODUCTION

The Developmental Origin of Health and Disease (DOHaD) theory postulates that the origins of lifestyle-related disease are formed at the time of fertilization, embryonic, fetal, and neonatal stages by the interrelation between genes and the environments (nutrition, stress, or environmental chemicals) (Arima, & Fukuoka, 2020). During pregnancy, the positive impact of physical activity (PA) on maternal health is well known for improving maternal cardiovascular function, sleep, mood, psychological well-being and preventing obesity (Petrov Fieril, Glantz, Fagevik Olsen, et al., 2015). Moreover, regular PA during pregnancy seems to reduce the incidence of obstetrical outcomes such a preterm or instrumental delivery (Poyatos-León et al., 2015), as well as to improve new-born general health (Murtezani et al., 2014).

As far as the effects of PA during pregnancy on offspring neurodevelopment are concerned, animal models suggest that maternal exercise has a beneficial influence on pup brain development, since more hippocampal neurogenesis along with better memory and learning abilities have been found (Akhavan et al., 2013; Parnpiansil et al., 2003). Even, Ancatén et al., (2017) have shown that PA during pregnancy may reverse the negative effects of stress on the amygdala during that period. In humans, limited research is available. Recently, in a Randomized Controlled Trial (RCT), Labonte-Lemoyne et al, (2016) found that 8 to 12 days old newborns of women in the physical active group showed better sound discrimination and auditory memory than newborns in the sedentary group, assessing also the neuroelectric response of the newborn brain with electroencephalography (EEG) and concluding that newborns in the active group born with better brain maturity. On the other hand, early research found that infants of mothers who continued being active during pregnancy showed better orientation and self-regulation abilities at 5 days postpartum (Clapp et al., 1999), better psychomotor development at 12 months (Clapp et al., 1998) and better IQ scores at 5 years old (Clapp, 1996) in comparison with the offspring of women who voluntarily decided to stop exercising. More recent studies have found an association between the mother’s PA during pregnancy and better infant language development at 15 months (Jukic et al., 2013) and at 2 years (Polanska et al., 2015), and better cognitive development scores (Domingues et al., 2014) after adjusting for many potential confounders. However, although it seems that the evidence would indicate that PA during pregnancy has a positive effect on children's mental development, also there are other studies that found no significant results (Ellingsen et al., 2019; Hellenes et al., 2015). These studies compared the cognitive development of two groups of children whose mothers followed a standardized protocol of physical activity during pregnancy with a group of children whose mothers followed the usual recommendations and assessed infant development at 18 months and at 7 years old without taking into account other potential confounders.

As can be seen, all the studies involved vary greatly as regards the methodologies used to evaluate and quantify the amount and quality of PA that pregnant women perform during pregnancy. Some studies have assessed the PA retrospectively or only consider PA carried out in leisure time while other implement PA protocols without assessing final PA performed. Álvarez-Bueno et al., (2018) and Niño et al., (2018) point out that these methods are more prone to bias and that further investigations should be carried out to assess PA concurrently,and using methods that make it possible to clarify whether there are different effects at different points in pregnancy or if a dose-response effect is present. In this respect, Petrov Fieril et al. (2015) showed that moderate-to-vigorous resistance exercise does not jeopardize the health of mother and baby during pregnancy, although they did not evaluate neurodevelopment, and in a recent review Beetham et al. (2019) came to the same conclusion, but again none of the included studies looked at the neurodevelopment of the babies after birth.

Although PA seems to have an impact on neurodevelopment, there are several other prenatal conditions that have a bearing on cognitive development. Some of these are maternal nutrition(Cortés-Albornoz et al., 2021), smoking (Hernández-Martínez et al., 2016), emotional states (O'Donnell et al., 2014), birth related conditions (Polidano et al., 2017), among others, and these conditions must be considered when these relationships are studied. So, the main aim of the present study is therefore to investigate prospectively the influence of PA throughout pregnancy on infant neurodevelopment (assessed by cognitive, language and motor development tasks) addressing the main gaps in the literature, so the specific aims are to study if there are a dose response-effect considering different levels of PA intensity and the trimester of pregnancy in which it is performed, adjusting for many pre and perinatal potential confounding factors.

METHODS

Design and procedure

This is an observational prospective follow-up study of pregnant women covering from the first trimester of pregnancy to 40 days postpartum. The participants were women from the ECLIPSES study (Arija et al., 2014), a community randomized controlled trial (RCT) about iron supplementation. Pregnant women were recruited during their first visit for prenatal care (at gestational week ≤12) and were followed during pregnancy (in the 24th, and 36th weeks) and at 40 days after delivery by midwives from the Sexual and Reproductive Women's Health Care Services (ASSIR) of the Catalan Institute of Health (ICS) in Tarragona, Spain. The inclusion criteria were healthy adult woman older than 18 years at ≤12 weeks of gestation, able to understand the local language (Spanish or Catalan) and the characteristics of the study, and who signed the informed consent form. The exclusion criteria were multiple pregnancy, having taken iron supplements during the months prior to enrolment, hypersensitivity to egg protein, previous severe illness (immunosuppression), or any chronic disease that could affect nutritional development (cancer, diabetes, malabsorption, chronic hepatitis and liver cirrhosis).

Questionnaires, clinical data, and blood samples were collected during regular prenatal care visits and consultations. Infant development assessment and data collection were done by two trained psychologists from the NUTRISAM research team during a special visit in the postpartum period. These researchers were blind to the prenatal PA status at the moment of the assessment.

The study was designed in agreement with the Declaration of Helsinki/Tokyo. All procedures involving human subjects were approved by Clinical Research Ethics Committee of the Jordi Gol University Institute for Primary Care Research, the Pere Virgili Health Research Institute and by the Spanish Agency for Medicines and Medical Devices. Signed informed consent was obtained from all women participating in the study.

Participants

A total of 791 pregnant women were included in the study at the 12th week of pregnancy. Over the course of the study period part of the sample drop out with a total of 547 and 465 women participating at the 24th and 36th weeks of pregnancy respectively. At 40 days postpartum we have data on 502 infants and their mothers. The main reasons for losing participants were voluntary abandonment (22.75%), exclusion criteria during pregnancy (5.82%), miscarriage (1.64%) and follow-up losses (2.28%).

Figure 1 shows the participants in every study stage and assessments.

Measurements

Regular physical activity during pregnancy was assessed using the *International Physical Activity Questionnaire - Short Form* (IPAQ-SF) (Craig et al., 2003). This is made up of 7 questions about the frequency of and time spent sitting, walking and in moderate and vigorous PA in a normal week, computed in METs (multiples of the basal metabolic rate) per minute. According to the IPAQ-SF scoring protocol, a total quantitative METs score for vigorous, moderate, walking, and total PA; and a categorical variable classifying in low, moderate and high intensity PA was computed for each woman and each trimester of pregnancy. The IPAQ-SF have shown good psychometric properties in Spanish population (Mantilla Toloza & Gómez-Conesa, 2007)

The infants' mental development was assessed using the *Bayley Scales for Infant Development - Third Edition* (BSID-III) (Bayley, 2006). This is an individually administered examination that evaluates the current developmental functioning of infants from 0 to 42 months old. It consists of three general scales and four subscales: the *cognitive scale*, *language scale* (*receptive language* subscale, and the *expressive language* subscale); the *motor scale* (*fine motor* subscale and *gross motor* subscale). The *cognitive*, *language* and *motor* scales scores are standardized IQ scores with a theoretical mean of 100 and a standard deviation of 15. The *receptive language*, *expressive language*, *fine motor,* and *gross motor* subscales scores are scaled scores with a theoretical mean of 10 and a standard deviation of 3.

Adjustment measurements

Data for obstetric and neonatal variables were collected from the medical records of each woman. These variables are the mother's age, mother's body mass index in each trimester of pregnancy, smoking during pregnancy, infant sex, mode of delivery, neonatal birth weight (in grams, measured with a SECA electronic weighing scale accurate to 10 gr), gestational age at birth (in weeks, verified by ultrasound in obstetric examinations), and infant feeding.

Socioeconomic status (SES) was estimated in accordance with the Hollingshead index (Hollingshead, 2011)and by combining the data for the mother's and the father's jobs and education.

Anxiety symptoms during pregnancy were assessed using the Spanish version of the *State-Trait Anxiety Inventory* (STAI) (Spielberger et al., 1997). This is a questionnaire of 40 items that evaluates state anxiety (the level of transient and situational anxiety) and trait anxiety (the level of dispositional and stable trait anxiety). For this research we used the trait anxiety score which ranges from 20 to 60 points. The Spanish version of the STAI have shown good psychometric properties (Spielberger et al., 1997) also, during pregnancy(Meades & Ayers, 2011)

The quality of the pregnant women's diet was estimated in each trimester of pregnancy according to their adherence to the Mediterranean diet (Trichopoulou et al., 2003). Usual dietary intake was assessed using a *Food Intake Frequency Questionnaire* (Trinidad et al., 2008), then from this information the total score was computed in a range from 0 (minimal adherence to the traditional Mediterranean diet and less quality of diet) to 18 (maximal adherence and high quality of diet). These food questionnaires have been adapted to Mediterranean Spanish pregnant women showing good psychometric properties (Trinidad et al., 2008).

Iron deficiency anemia was determined at the 12th and 36th weeks of gestation and defined, following the World Health Organization (World Health Organization, 2008), as hemoglobin levels <110 g/L and serum ferritin <12 µg/L.

Depressive symptoms during postpartum were assessed using the *Edinburgh Postpartum Depression Scale* (EPDS) (Cox, et al., 1987; Gutierrez-Zotes et al., 2018), which is a 10-item questionnaire with scores ranging from 0 to 30 points for detecting symptoms of depression in the perinatal period. This questionnaire has shown good psychometric properties in community Spanish sample (Garcia-Esteve et al., 2003)

Finally, mother-infant attachment during postpartum was assessed using the Parent Stress Index - Short Form (Abidin, 1995), which is a 36-item questionnaire with scores ranging from 11 to 55 points for measuring the stress directly associated with the parenting role obtaining a total score for parent-child dysfunctional interaction. This questionnaire has shown good psychometric properties in community sample of Spanish mothers of infants from 0 to 8 years old (Rivas et al., 2021).

Statistical analysis

Descriptive analyses of the general characteristics of mothers and infants were performed. Differences according to trimester of pregnancy and PA intensity level were assessed using the chi-squared test for categorical variables and repeated measures ANOVA for continuous parametric variables.

To assess if there are differences in the infant mental development scales scores according to PA intensity categories, ANCOVA analysis was performed. The adjustment variables used were family socioeconomic level, mother's age, infant's sex, mother smoking during pregnancy, mother's trait anxiety, mother's quality of diet, mother's iron deficiency anemia, mother's body mass index increase between first and third trimester, infant's gestational age at birth, infant birth weight, postpartum depression symptoms, mother-infant attachment and infant breastfeeding. Estimated adjusted means were obtained and Sidak posthoc analysis was used to assess significant differences between PA intensity categories in each trimester.

RESULTS

Participants' characteristics

Sociodemographical and perinatal characteristics of the sample are shown in table 1. The maternal age was 30.86 ± 5.1 years and a 41.50% of the sample was categorized as medium socioeconomical level. A 14,40% of pregnant women reported to smoke during pregnancy, and a mean score of 11.54 ±6.7 in the STAI questionnaire. The mean of the BMI increase from the week 12th to the 36th was 3.72 ± 1.6 kg/m^2. In relation to obstetric outcomes, a 68.6% of women had a non-instrumental delivery and a mean of 39.7 ±1,4 weeks of gestation.

Infants showed normal mean scores in the developmental tasks.

Physical activity level and nutritional and psychological data by trimester of pregnancy

Table 2 shows the mean scores for each category of PA, state anxiety, quality of diet, mother's body mass index and percentages of iron deficiency anaemia during pregnancy, by pregnancy trimester. As regards physical activity, the highest scores were found in the second trimester of pregnancy in each category. On the other hand, trait anxiety, iron deficiency anaemia and body mass index increased significantly from the 12^{th} to 36^{th} week of gestation ($F=32.457$, $p<0.001$; $X^2=32.238$, $p<0.001$; $F=37.869$, $p<0.001$ respectively) while pregnant quality of diet remained stable ($F=0.655$; $p=0.655$).

Table 3 shows descriptive variables by PA level and trimester of pregnancy. There were no differences between groups of PA level in any sociodemographic, prenatal, perinatal and postnatal variables.

Association between PA during pregnancy and BSID-III scores

Table 4 shows the mean scores for the BSID-III scales according to the three levels of PA in each trimester of pregnancy, the estimated means after adjusting for confounding variables, and the statistics of these mean differences.

In general, the highest mean scores and estimated mean scores were found in the moderate and high intensity PA groups. In the first trimester, a tendency in obtaining significantly higher scores in the fine and total motor scales was observed in the high PA group. In the third trimester, significant lower mean scores were found in the expressive, receptive and total language scales and in the fine, gross and total motor scales in the low PA groups.

DISCUSSION AND CONCLUSION

The main aim of the present study has been to investigate prospectively the relationship between PA during pregnancy on infant neurodevelopment assessed by cognitive, language and motor development tasks at 40 days postpartum considering different levels of PA intensity and the trimester of pregnancy in which it was performed. Our results have shown that, after adjusting for many important confounders, infants of mothers in the moderate and high PA groups in the third trimester had a better performance in scales assessing language and motor development.

At 40 days old, the language scale of the BSID-III assesses the infant sound perception, sound discrimination and the ability to react to auditory stimuli, in this sense, our results are similar to previous studies which showed that infants of mothers who stayed active during pregnancy achieved better ability to respond to visual and auditory stimulus and better sound discrimination (Clapp et al., 1999; Labonte-Lemoyne et al., 2016). Similar results have been shown in older infants (Jukic et al., 2013) suggesting that the relationship between PA and these areas of mental functioning might continue throughout the development process. Our results also show that infants of mothers in the moderate and high PA groups have better motor development, as shown earlier by Clapp et al. (1998) and recently by McMillan (2019). In contrast to our results, in a RCT with a structured 12 weeks during pregnancy PA protocol, no significant improvement in child cognitive function was found at 18 months old nor at 7 years old (Ellingsen et al., 2019; Hellenes et al., 2015), however, although the study design is more robust than ours, the infant assessments were done at 18 months and at 7 years when other important variables might be mediating this relationship. Moreover, in this study PA protocol was composed by aerobic, strength and balance exercises without considering the women PA preferences nor different ways to maintain a pleasant physically active lifestyle affecting to motivation to exercise and to adherence to treatment, for instance. In this sense, animal studies have shown that voluntarily PA during pregnancy enhanced the spatial learning acquisition while when physical activity was forced, it may increase the stress of the pregnant animal, and this should be considered in evaluation of the observed effects (Akhavan et al., 2013).

In relation to the intensity of PA activity undertaken, our results have shown there is an association between moderate and high PA intensity and better execution in language and motor tasks. In this sense, previous studies analyzed considered (some of them retrospectively) whether pregnant women remained active during pregnancy or her level of activity during leisure time, but they did not consider the intensity of the PA. In this sense, other studies, that no considered infant neurodevelopment, concluded that moderate-to-vigorous resistance exercise does not jeopardize mother and baby's health during pregnancy (Beetham et al., 2019; Petrov Fieril, Glantz, & Fagevik Olsen, 2015). Although literature and our results seem to support the moderate to high intensity PA during pregnancy (if there are no medical conditions that advise against it), international guidelines vary greatly in relation to the intensity and the time that a pregnant should spent exercising each week (Evenson et al., 2014; The American College of Obstetricians and Gynecologists, 2015). In this sense, the *American College of Obstetricians and Gynecologists,* recommends that pregnant women without complications should spend at least 30 minutes on moderate-intensity PA activity most days of the week, while the latest WHO recommendations (World Health Organization, 2018) stated that *a healthy lifestyle includes aerobic physical activity and strength-conditioning exercise aimed at maintaining a good level of fitness throughout pregnancy.* International guidelines should therefore be adapted to detail the recommendations of PA during pregnancy.

One of the specific aims of our study has been to assess if there is a different impact of PA according to the trimester of pregnancy in which it has been practiced. Previous research has shown that in the third trimester there is an increase of vulnerability to environmental insults (Aranda et al., 2017; Voltas et al., 2020) due to important neurodevelopmental milestones that occur, such as synapse formation and myelination and the rapid increase of brain volume (Georgieff et al., 2018; Thompson & Nelson, 2001). Our results also suggest that it is a sensible period to protective factors too, being that in our sample, infants of mothers in moderate and high PA groups during the third trimester performed better in the cognitive domains assessed.

In relation to the confounding factors used to adjust the analysis, our results show that there are no relationships between PA and pregnant anxiety levels or quality of their nutrition, fact that could explain the relationships found. Therefore, these results are explained by the impact of PA by itself. Moderate and vigorous PA have been related to lower levels of general inflammation interleukin 6 (IL-6) release (Lee et al., 2019) and lower levels of general inflammation, and literature indicates that there is a relationship between inflammation and neurodevelopment (Jiang et al., 2018). In this sense, Spann et al. (2018) concluded that maternal immune activation (especially levels of CRP and IL-6) during the third trimester is associated with later neurodevelopmental outcomes suggesting that babies might mobilize an adaptive neurodevelopmental response to the presence of maternal immune activation. It could be that the release of IL-6 by PA during pregnancy promotes biological resilience along the lines the authors indicate, thereby preventing neurodevelopmental disorders (Jiang et al., 2018).

Our results should be interpreted bearing in mind the limitations of the study. First, it is an observational study that only enables us to establish association relationships.

Second, PA estimation has been self-reported and several studies have shown that IPAQ-SF tends to overestimate PA performed (Finger et al., 2015). However, the IPAQ-SF easy administration has facilitated the prospective repeated assessment of the PA undertaken at different times of pregnancy obtaining a fairly accurate estimation of the intensity of the total PA in leisure time, at work and at home. On the other hand, is important to highlight that, although infants of mothers in the moderate-to high PA groups have obtained significantly higher scores in the motor and language total scales of the BSID-III, these scores, as well as the scores of infants of mothers in the low PA group, are within the normal range. Nevertheless, one of the strengths of our study is the use of data from a cohort that have been carefully monitored in each trimester of pregnancy allowing us to adjust analysis for an important number of confounders, helping us to fine-tune the relationships under study and demonstrate that PA during pregnancy is an important factor. Finally, as regards infant cognitive development is concerned, was measured individually by trained infant psychologists with expertise in infant development using the BSID-III (Bayley, 2006), which is a reliable measure of neurodevelopment, internationally used to provide a reliable measure of infant cognitive development status at early life. Our results enable us to conclude that physical activity during pregnancy has a significant positive association to infant neurodevelopment. Considering the intensity of the PA undertaken, the moderate-to-high level of PA is associated to better infant language and motor development domains. The recommendation for pregnant women is to maintain moderate to vigorous activity that should be incorporated into maternal education sessions to improve infant's neurodevelopment.

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Figure 1. Participants and assessments

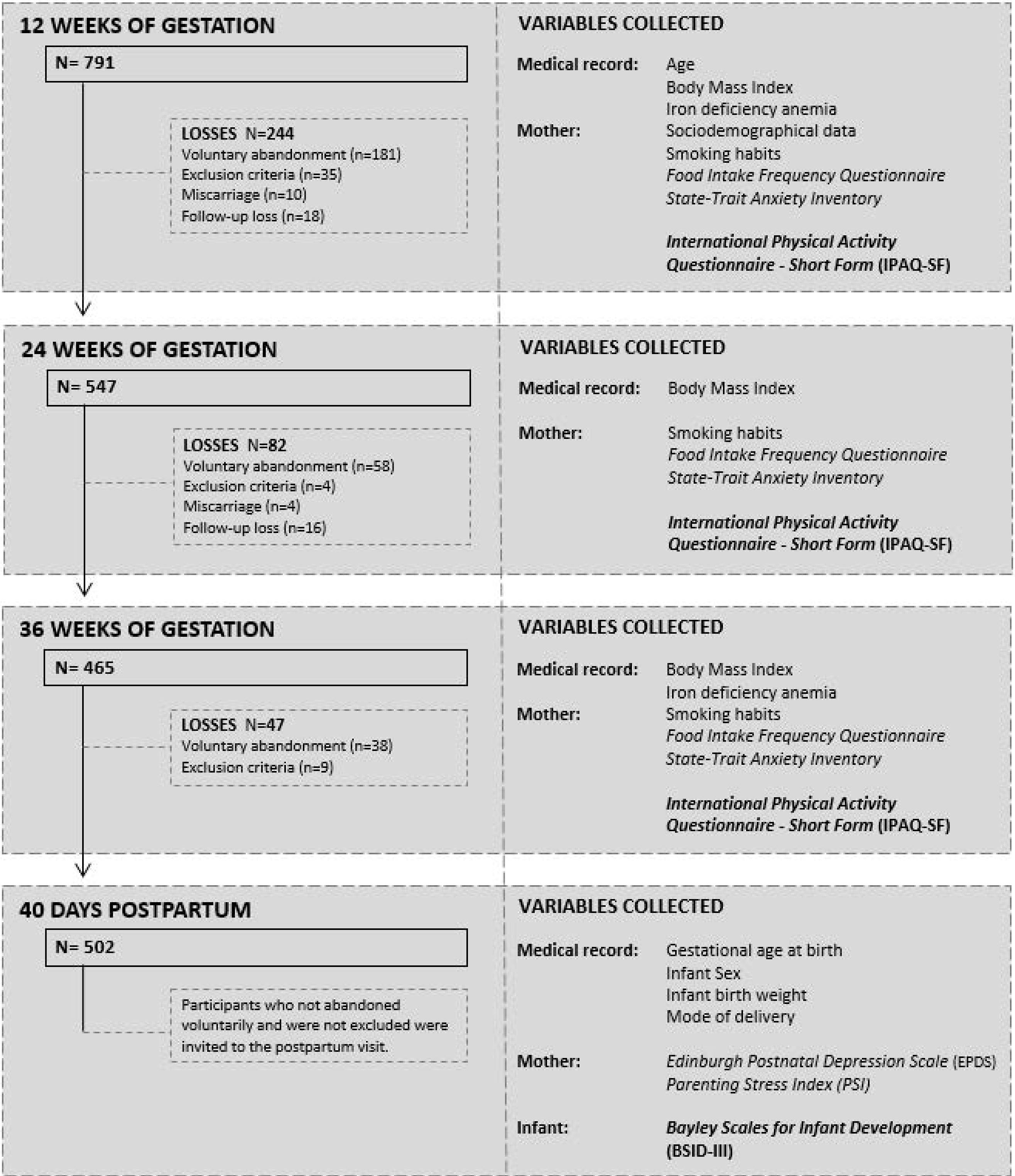

Table 1. Sociodemographic and perinatal descriptive variables

	Mean (SD) **n (%)**
Family socioeconomic status [b]	
Low	219 (43.5)
Medium	209 (41.5)
High	74 (14.9)
Mother age at birth (years) [a]	30.986 (5.1)
Mother tobacco use during pregnancy (no) [b]	429 (85.6)
Body Mass Index increase (kg/m^2) [a]	3.72 (1.6)
Mother prenatal Trait Anxiety (total score) [a]	11.54 (6.7)
Infant sex (girls) [b]	249 (49.3)
Mode of delivery [b]	
Non-Instrumental	344 (68.6)
Instrumental - forceps	67 (13.3)
Instrumental - caesarean	91 (18.1)
Gestational age (weeks) [a]	39.70 (1.4)
Birth weight (gr) [a]	3278.30 (460.9)
Infant feeding (breastfeeding) [b]	414 (82.0)
Postpartum depression symptoms (total score) [a]	6.987 (5.0)
Mother-infant attachment (total score) [a]	17.34 (7.9)
Bayley Scales for Infant Development	
Total cognitive score [a]	101.767 (8.9)
Total language score [a]	96.21 (8.3)
Receptive language score [a]	10.62 (2.1)
Expressive language score [a]	8.106 (1.6)
Total motor score [a]	107.659 (11.3)
Fine motor score [a]	11.546 (2.0)
Gross motor score [a]	11.108 (2.3)

[a] Results shown as mean and standard deviation (SD)
[b] Results shown as number and percentage (%)

Table 2. Physical activity level, nutritional and psychological data comparison by trimester of the pregnancy.

	1st trimester	2nd trimester	3rd trimester	F (p) X² (p)
Physical activity (METs)				
Vigorous PA (METs) [a]	416.3~~0~~ (1596.5)	609.1~~06~~ (2515.0)	400.4~~1~~ (1570.5)	1.539 (0.216)
Moderate PA (METs) [a]	438.9~~85~~ (1256.9)	630.8~~0~~ (1579.1)	385.8~~0~~ (966.2)	8.028 (0.005)
Walking PA (METs) [a]	1251.1~~07~~ (1099.5)	1456.7~~69~~ (1296.6)	1402.2~~17~~ (1212.6)	7.448 (0.007)
Total PA (METs) [a]	2079.7~~4~~ (2556.8)	2696.6~~55~~ (3884.6)	2180.3~~25~~ (2551.6)	8.026 (0.005)
Physical activity (categories) [b]				
Low	95 (22.1)	74 (17.9)	77 (19.5)	7.043 (0.134)
Moderate	247 (57.6)	236 (57.0)	243 (61.7)	
High	87 (20.3)	104 (25.1)	74 (18.8)	
Mother prenatal Trait Anxiety (total score) [a]	17.4~~38~~ (8.6)	17.8~~4~~ (8.2)	19.3~~25~~ (8.8)	32.457 (<0.001)
Iron deficiency anaemia (yes) [b]	1.0~~0~~ (0.2)		34.0~~0~~ (6.7)	32.238 (<0.001)
Quality of diet (total score) [a]	9.9~~2~~ (2.6)	9.8~~1~~ (2.6)	9.9~~85~~ (2.6)	0.655 (0.419)
Body mass index (Kg/m2) [a]	24.9~~87~~ (4.3)	26.9~~89~~ (4.3)	28.6~~59~~ (4.5)	37.869 (<0.001)

[a] Results shown as mean and standard deviation (SD). Differences according to trimesters assessed by Chi-squared test.
[b] Results shown as number and percentage (%). Differences according to trimesters assessed by ANOVA test.

Table 3. Sociodemographic and perinatal descriptive variables comparison by physical activity by trimester

	1rt Trimester				2nd Trimester				3rd Trimester			
	Low n=95	Moderate n=247	High n=87	F (p) X^2 (p)	Low n=74	Moderate n=235	High n=104	F (p) X^2 (p)	Low n=77	Moderate n=242	High n=74	F (p) X^2 (p)
Family socioeconomic status[b]												
Low	43.2 (41)	40.1 (99)	48.2 (42)	4.071 (0.396)	41.7 (30)	39.1 (90)	54.8 (57)	9.274 (0.055)	47.4 (76)	38.8 (92)	48.6 (74)	3.873 (0.423)
Medium	44.2 (42)	41.3 (102)	41.9 (36)		47.2 (35)	45.2 (104)	34.6 (36)		39.5 (30)	46.0 (109)	35.1 (26)	
High	12.6 (12)	18.6 (46)	10.5 (9)		12.5 (9)	18.2 (42)	10.106 (11)		13.2 (10)	15.2 (36)	16.2 (12)	
Mother age at birth (years)[a]	30.60 (5.5)	31.20 (4.7)	30.656 (5.6)	0.775 (0.641)	30.92 (5.0)	31.34 (5.0)	29.83 (5.6)	3.103 (0.146)	31.325 (5.3)	31.00.99 (5.0)	30.03 (5.1)	1.286 (0.277)
Mother tobacco use during pregnancy (no)[b]	90.4 (85)	83.4 (206)	85.1 (74)	2.681 (0.262)	83.6 (61)	86.9 (205)	85.6 (89)	0.520 (0.771)	83.1 (64)	88.0 (213)	79.7 (59)	3.244 (0.197)
Body Mass Index increase (Kg/m²)[a]	3.656 (1.5)	3.73 (1.6)	3.92 (1.9)	1.020 (0.362)	3.877 (2.0)	3.71 (1.6)	3.768 (1.5)	0.073 (0.930)	3.765 (1.9)	3.74 (1.5)	3.81 (1.65)	0.186 (0.830)
Iron deficiency anemia (yes)[b]	0 (0)	1 (0.4)	0 (0)	0.739 (0.691)					6 (7.8)	12 (4.9)	8 (10.8)	3.395 (0.183)
Quality of diet (total score)[a]	9.655 (2.1)	10.09.98 (2.0)	9.63 (2.0)	1.974 (0.140)	9.82 (2.0)	9.92 (2.1)	9.71 (2.1)	0.381 (0.683)	9.90 (2.01.94)	9.80 (2.1)	10.00 (2.1)	0.272 0.762)
Mother prenatal Trait Anxiety (total score)[a]	11.438 (6.0)	11.329 (6.5)	12.107 (7.0)	0.398 (0.672)	12.546 (6.8)	10.94 (6.1)	11.878 (7.0)	1.475 (0.230)	11.875 (7.2)	11.41 (6.4)	11.21 (6.5)	0.127 (0.880)
Mode of delivery[b]												
Non-Instrumental	67.4 (64)	70.9 (175)	60.9 (53)	7.158 (0.128)	73.0 (54)	68.6 (162)	65.7 (67)	2.322 (0.677)	66.2 (51)	69.0 (167)	67.6 (50)	0.463 (0.977)
Instrumental -Forceps	8.4 (8)	13.8 (34)	16.3 (14)		9.5 (7)	12.3 (29)	16.7 (17)		14.3 (11)	12.4 (30)	14.9 (11)	
Instrumental -Cesarean	24.4 (23)	15.4 (38)	23.3 (20)		17.6 (13)	19.1 (45)	17.6 (18)		19.5 (15)	18.7 (45)	17.6 (13)	
Gestational age (weeks)[a]	39.769 (1.6)	39.70 (1.4)	39.879 (1.3)	0.139 (0.874)	40.039.90 (1.5)	39.765 (1.5)	39.70 (1.4)	0.850 (0.428)	39.766 (1.4)	39.878 (1.4)	39.93 (1.2)	0.730 (0.482)
Birth weight (gr)[a]	3249.547 (480.3)	3270.218 (452.658)	3360.545 (466.2)	1.570 (0.290)	3327.03 (509.76)	3260.436 (452.0)	3318.51 (452.6)	0.908 (0.404)	3310.13 (423.72)	3297.657 (448.7)	3285.0 (469.1)	0.059 (0.942)
Postpartum depression symptoms (total score)[a]	7.12 (77)	6.659 (177)	7.06.93 (70)	0.321 (0.725)	7.44 (54)	6.545 (174)	7.3 (90)	1.233 (0.293)	7.767 (61)	6.64 (185)	7.3 (63)	1.125 (0.326)
Mother-infant attachment (total score)[a]	17.109 (95)	17.546 (238)	16.437 (84)	0.623 (0.537)	17.875 (71)	16.73 (232)	17.985 (102)	0.976 (0.378)	16.876 (75)	16.879 (237)	17.40 (71)	0.200 (0.819)

[a] Results shown as mean and standard deviation (SD). Differences according to trimesters assessed by Chi-squared test.
[b] Results shown as number and percentage (%). Differences according to trimesters assessed by ANOVA test.

Table 4. Bayley Scales for Infant Development Scores by physical activity level and by trimester adjusted for sociodemographics

	Low[a]		Moderate[b]		High[c]		F (p)	Sidak
	Mean (SD)	Estimated mean (SE)	Mean (SD)	Estimated mean (SE)	Mean (SD)	Estimated mean (SE)		
First Trimester	n=77		n=196		n=72			
Total Cognitive Scale	100.219 (8.7)	100.34 (1.00.99)	101.879 (7.8)	101.64 (0.766)	103.01 (10.73)	103.326 (1.02)	2.124 (0.121)	
Total Language Scale	94.987 (8.7)	94.989 (0.92)	96.93 (7.7)	96.986 (0.657)	96.878 (8.2)	97.06.96 (1.00.95)	1.836 (0.161)	
Receptive Language Scale	10.34 (2.4)	10.34 (0.24)	10.985 (1.9)	10.985 (0.2148)	10.93 (2.0)	10.94 (0.325)	1.994 (0.138)	
Expressive Language Scale	7.987 (1.5)	7.987 (0.217)	8.107 (1.5)	8.105 (0.11)	7.94 (1.5)	8.07.98 (0.218)	0.376 (0.687)	
Total Motor Scale	105.71 (10.8)	105.84 (1.33)	107.328 (12.3)	107.217 (0.84)	110.10 (10.8)	110.327 (1.438)	2.855 (0.059)	ac (0.064)
Gross Motor Scale	10.875 (2.5)	10.875 (0.327)	11.02 (2.3)	11.03 (0.217)	11.658 (2.6)	11.656 (0.328)	2.233 (0.109)	
Fine Motor Scale	11.108 (2.1)	11.13 (0.22)	11.54 (1.9)	11.50 (0.14)	11.878 (1.9)	11.80 (0.23)	2.608 (0.075)	ac (0.068)
Second Trimester	n=61		n=188		n=91			
Total Cognitive Scale	101.31 (8.5)	101.14 (1.10)	101.329 (9.5)	101.328 (0.63)	103.24 (6.8)	103.438 (0.91)	2.005 (0.140)	
Total Language Scale	96.438 (7.9)	96.435 (1.04)	96.436 (7.9)	96.32 (0.659)	96.82 (8.5)	96.90 (0.986)	0.161 (0.851)	
Receptive Language Scale	10.64 (2.2)	10.61 (0.327)	10.876 (2.04)	10.878 (0.215)	10.82 (2.13)	10.81 (0.22)	0.188 (0.831)	
Expressive Language Scale	8.10 (1.4)	8.12 (0.219)	8.07.96 (1.5)	8.07.94 (0.11)	8.107 (1.5)	8.11 (0.216)	0.599 (0.589)	
Total Motor Scale	106.51 (16.3)	106.31 (1.50)	107.218 (10.437)	107.326 (0.986)	109.33 (10.985)	109.329 (1.325)	1.344 (0.261)	
Gross Motor Scale	11.11 (2.6)	11.107 (0.31)	10.94 (2.2)	11.00.97 (0.218)	11.549 (2.54)	11.545 (0.325)	1.174 (0.311)	
Fine Motor Scale	11.548 (1.7)	11.546 (0.325)	11.40 (2.04)	11.439 (0.14)	11.657 (2.0)	11.60 (0.21)	0.348 (0.715)	
Third Trimester	n=71		n=219		n=70			
Total Cognitive Scale	100.63 (7.3)	100.81 (1.008)	101.62 (8.9)	101.6569 (0.6571)	102.53 (8.3)	102.509 (1.02)	0.696 (0.499)	
Total Language Scale	93.549 (8.2)	93.659 (1.00.945)	96.83 (8.1)	96.82 (0.535)	97.43 (6.9)	97.439 (1.00.96)	5.205 (0.006)	ab (0.010); ac (0.015)
Receptive Language Scale	10.21 (2.4)	10.22 (0.3246)	10.876 (2.04)	10.876 (0.140)	11.11 (1.7)	11.08 (0.3249)	3.086 (0.047)	ac (0.047)
Expressive Language Scale	7.52 (1.655)	7.54 (0.2179)	8.13 (1.548)	8.11 (0.101)	8.01 (1.5)	8.03 (0.218)	3.903 (0.021)	ab (0.017)
Total Motor Scale	106.05.96 (10.2)	106.13 (1.4368)	107.01 (12.1)	107.01 (0.8775)	111.439 (10.7)	111.22 (1.438)	4.250 (0.015)	ac (0.029); bc (0.025)
Gross Motor Scale	10.62 (2.5)	10.63 (0.3280))	11.01 (2.2)	11.02 (0.2159)	11.987 (2.6)	11.83 (0.328)	4.831 (0.009)	ac (0.008); bc (0.039)
Fine Motor Scale	11.30 (1.8)	11.31 (0.231)	11.43 (2.02)	11.43 (0.131)	11.989 (2.01.95)	11.988 (0.23)	1.748 (0.176)	

Models adjusted by: mother's age (years), trait anxiety (total score), quality of diet (total score), iron deficiency anemia (0: No; 1: Yes), body mass index increase (kg/m2), smoking during pregnancy (0: No; 1: Yes), infant sex (0: boy; 1: girl), gestational age at birth (weeks), mode of delivery (0: Non-instrumental; 1: Instrumental), infant birth weight (gr), family socioeconomic status (low; medium; high), mother-infant attachment (total score), postpartum depression symptoms (total score); infant feeding (1: formula; 2: breastfeeding).

Posthoc analysis by Sidak.

Con formato: Sangría: Izquierda: 0 cm