Maternal pre-pregnancy body mass index and offspring temperament at 3 months: A brief report

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ABSTRACT

Introduction: Pre-pregnancy obesity has been linked to emotional and behavioural problems in offspring, though it remains unclear when the presence of these difficulties first emerges.

Method: We examined the association between maternal pre-pregnancy body mass index (BMI) and temperament at 3 months of age in the offspring of 16 women residing in Hamilton, Ontario. Infant temperament was measured using the Infant Behaviour Questionnaire Revised, which specifically examined surgency/extraversion, negative affectivity, and orienting/regulation.

Results: A statistically significant association was observed between maternal BMI and infant negative affectivity ($B=0.05$, 95% CI=0.01-0.08), which remained significant after adjusting for confounding variables ($B=0.04$, 95% CI=0.01-0.08).

Conclusion: The current study provides evidence that fetal exposure to high maternal BMI during pregnancy is associated with increased negative affectivity in infants at 3 months of age. The results suggest that the intrauterine environment associated with high maternal BMI may influence temperament at a very early stage in development.

INTRODUCTION

Obesity is a significant public health problem affecting up to 38% of women entering pregnancy.¹ Maternal adiposity is associated with a range of complications in infants including macrosomia and fetal distress.² This research also suggests that the adverse effects of exposure to maternal obesity may extend beyond the perinatal period. In keeping with the Developmental Origins of Health and Disease (DOHaD) hypothesis,³ exposure to excess maternal adiposity during gestation can increase offspring susceptibility to physical health problems, such as asthma, and mental health problems.⁴⁻⁸ More specifically, studies suggest that children born to mothers who were overweight or obese during pregnancy are at an increased risk for neurodevelopmental problems including cognitive, emotional, and behavioural difficulties.^{5,6} These children are also more likely to be diagnosed with psychological disorders including externalizing problems (eg attention deficit hyperactivity disorder), internalizing problems (eg anxiety and depression), eating disorders, and psychotic illness as they progress to adulthood.^{7,8}

Despite the recent surge of evidence linking maternal pre-pregnancy adiposity to emotional and behavioural problems in offspring, it is not known when these relations first emerge or how

they present. Indeed, only a few studies have examined offspring outcomes prior to one year. Aubuchon-Endsley et al found that 2 day-old infants had poorer self-regulation (self-soothing capabilities) when their mothers were obese prior to pregnancy and had gestational weight gain above the Institute of Medicine Guidelines (>11-20 pounds).^{9,10} Girchenko et al found that offspring (mean of 17 days old) of mothers who were overweight or obese had high levels of regulatory behavioural problems.¹¹ As these outcomes were measured very soon after birth, it may be too early to detect problems that are predictive of risk for difficulties occurring later in life.

Research shows that the prenatal environment can impact the systems mediating stress and reward sensitivity, which may affect personality traits throughout life.¹² However, more data on the specific impact of exposure to maternal pre-pregnancy adiposity on very early offspring neurodevelopment are still required to improve our understanding of the course and nature of these links. Temperament, the constitutionally-based individual differences in affect, activity, attention, and self-regulation emerging very early in life,¹³ is relatively stable and predictive of risk for later behavioural problems.^{14,15} At 3 months of age, infants begin to develop preliminary emotion regulatory behaviours while having limited environmental exposures, and so measures of temperament taken at this time can provide useful insights into the impact of intrauterine exposures on neurodevelopment.¹³ Given this background, we set out to investigate associations between maternal pre-pregnancy body mass index (BMI) and infant temperament at 3 months of age, hypothesizing that increased BMI would be associated with increased temperament problems.

METHOD

We utilized data from 16 women and their infants recruited in the second trimester of pregnancy from the ultrasound department at St. Joseph's Healthcare Hamilton in Ontario, Canada. Women were eligible to participate if they were >18 years old, could communicate in English, and had a singleton pregnancy. Women were excluded if they had a BMI <18.5 kg/m², had been diagnosed with diabetes mellitus, or if they required assisted reproductive technologies to conceive. All participants provided written informed consent and the study was approved by the Hamilton Integrated Research Ethics Board.

Infant temperament was reported by the mother and measured using the Infant Behaviour Questionnaire Revised (IBQ-R).¹⁶ The IBQ-R is a 191-item scale comprised of three major subscales: surgency/extraversion, negative affectivity, and orienting/regulation. The surgency/extraversion scale measures activity and pleasure. The negative affectivity scale measures distress, fear, and

sadness. The orienting/regulation scale measures attention and soothability. Questions are scored on a 7-point Likert-type scale (never=1, always=7).

Maternal height was measured with a stadiometer at 28 weeks of gestational age and weight was recorded at both the time of enrolment and at 28 weeks of gestational age. The average of these two weights was used to calculate BMI (in kg/m²).

We examined two statistical models, the first examining bivariate associations between pre-pregnancy BMI and IBQ-R scales and the second adjusted for known confounding variables (infant sex, maternal socioeconomic status (SES), lifetime major depressive disorder (MDD), and smoking during pregnancy). The IBQ-R scales were analyzed as a continuous variable as there are no clinical cut-offs for temperament.¹⁶ Socioeconomic adversity was defined as one or more of the following: lone-parent status, social assistance support, or residence in a rental dwelling. Lifetime presence of MDD was assessed using the Mini International Neuropsychiatric Interview (MINI).¹⁷ Mothers self-reported whether they smoked during pregnancy.

RESULTS

Table 1 contains the characteristics of the 16 mother-infant pairs. The mean age of the mothers was 30.7 years and pre-pregnancy BMI was 28.2 kg/m².

Characteristics	Participants (n = 16)
Maternal age, mean±SD, y	30.69±5.03
Maternal pre-pregnancy body mass index, mean±SD, kg/m ²	28.17±8.66
18.5 – 24.9	6 (37.5%)
25 – 29.9	5 (31.3%)
>30	5 (31.3%)
Lifetime Major Depressive Disorder, No. (%)	5 (31.3)
Relationship Status, No. (%)	
Single	1 (6.2)
Married	10 (62.5)
Common-Law	5 (31.3)
Receiving Social Assistance, No. (%)	6 (37.5)
Living in a Rental Dwelling, No. (%)	6 (37.5)
Smoking During Pregnancy, No. (%)	3 (18.8)
Infant Sex, No. (%)	
Male	8 (50)
Female	8 (50)

Table 1. Participant sample characteristics at 28 weeks of gestational age

Associations between maternal pre-pregnancy BMI and infant temperament are found in Table 2. A statistically significant association was observed between maternal BMI and infant negative affectivity (B=0.05, 95% CI=0.01-0.08), which remained significant after adjusting for confounding variables (B=0.04, 95% CI=0.01-0.08). Associations between maternal BMI and the surgency/extraversion and orienting/regulating sub-scales were not statistically significant.

Table 2. Maternal pre-pregnancy body mass index and infant temperament scores

	Unadjusted		
	B	SE	95% CI
Negative affectivity	0.05	0.02	(0.01;0.08)
Surgency/Extraversion	0.02	0.03	(-0.03;0.07)
Orientating/Regulation	-0.02	0.01	(-0.04;0.01)

	Adjusted ^a		
	B	SE	95% CI
Negative affectivity	0.04	0.02	(0.01;0.08)
Surgency/Extraversion	-0.01	0.03	(-0.06;0.05)
Orientating/Regulation	-0.02	0.03	(-0.06;0.01)

^aAdjusted for infant sex, maternal socioeconomic status, lifetime major depressive disorder, and smoking during pregnancy

DISCUSSION

The current study provides evidence that fetal exposure to maternal adiposity during pregnancy is associated with increased levels of negative affectivity in infants at 3 months of age. These results suggest that the neurodevelopmental effects of exposure to maternal adiposity during gestation may emerge very early in life and, given the similarity of negative affectivity to later emotional and behavioural problems, may be the precursor of later difficulties.

Rodriguez found that children of women who were obese prior to and during pregnancy were twice as likely to receive a high rating on negative emotionality from their kindergarten teachers.¹⁸ The only other study that has examined links between maternal pre-pregnancy BMI and temperament to date did so at one year of age but failed to find an association.¹⁹ However, these null findings may have been due to the use of a different scale and a categorical definition of temperament.

Evidence from rodent animal models suggest that fetal exposure to maternal adiposity is associated with impairments in reward sensitivity and behavioural regulation.²⁰⁻²⁴ Hypomethylation of the dopamine transporter gene in the ventral striatum and altered function of mesolimbic dopamine neurons has been reported in these offspring, resulting in decreased reward sensitivity and increased hyperactivity.^{20,21} Behavioural problems occurring as a result of abnormal development of these reward systems may also be due to impaired hypothalamic stress responses, altered gene expression in the prefrontal cortex, and decreased serotonergic axon density in areas of the brain necessary for adaptive self-regulation.²²⁻²⁴ Furthermore, evidence from human infants is suggestive of decreased connectivity in the dorsal anterior cingulate cortex and prefrontal networks as well as compromised white matter development in the anterior portion of the brains of 2-week old offspring exposed to prenatal obesity.^{25,26} These areas of the brain mediate adaptive self-regulation and dysregulated development of these areas could play a role in negative affectivity in infants at 3 months of age.^{27,28}

The results of the current study should be interpreted with its limitations in mind. First, it utilizes a small sample and the

observational nature of this study does not allow for causal inference. Additionally, a high BMI may not accurately depict adiposity in all participants. There also may be confounding variables that we were unable to adjust for (eg maternal diet). Finally, we relied on maternal reports of infant behaviour, which can be associated with bias outside of the adjustment for factors that may influence this (eg maternal depression).

We report that increased maternal pre-pregnancy BMI is associated with elevated levels of negative affectivity in offspring as early as 3 months of age. That this association persists despite adjustment for confounding variables suggests that the intrauterine environment associated with maternal adiposity may influence temperament at a very early stage in development. Future studies should attempt to confirm these findings using larger samples, direct measurements of maternal adiposity, and neurobiological markers of temperament. Additionally, future studies should continue to examine mothers and offspring and analyze temperament and behavioural outcomes over time. Maintaining follow-ups of mothers and children from this study can contribute to the tremendous potential of the DOHaD hypothesis and can be used to inform interventions that reduce the risk of mental and physical health problems across the lifespan of offspring.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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