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Basal and reactivity levels of cortisol in one-month-old infants born to overweight or obese mothers from an ethnically and racially diverse, low-income community sample

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ABSTRACT

Establishing typical values of the steroid hormone cortisol at rest and after challenge is critical for understanding how environmental factors impact stress regulation and overall development, beginning at birth. Yet most extant samples are small or based upon low-risk populations, and few studies address the potential role of maternal weight during pregnancy in their study designs or sampling strategy. Here we report basal and reactivity levels of salivary cortisol within a racially and ethnically diverse sample of 132 infants approximately one month of age (Age in days: M = 37.61, SD = 7.27) born to lower income overweight or obese mothers. Reactivity was assessed in response to a multi-domain infant stressor paradigm, which included assessment via the Newborn Behavioral Observation (NBO) system and extensive anthropometric measurements. Sample means for basal, post stressors, and reactivity to the NBO were significantly lower than those reported in reviews of low-risk samples. Parity was associated with cortisol levels such that first-born infants had lower resting cortisol and higher reactivity than infants born to multiparous women. Latino infants had lower basal cortisol. No other demographic characteristics significantly predicted cortisol. The variability in cortisol levels present in this sample suggests that considerable psychophysiological diversity may exist in samples of low-SES or high-risk participants. Findings provide useful ranges for samples of racially and ethnically diverse newborns from low-income families.

1. Introduction

Understanding the development of the hypothalamic-pituitary-adrenal (HPA) axis *in utero* and recruitment of this system during early life has become important for understanding how the stress-response system develops and functions across the life course, beginning at birth (Wadhwa et al., 2009). Cortisol, a steroid hormone that is secreted when the HPA axis is activated, is a commonly-used proxy for estimating the functionality of the HPA axis (Jansen et al., 2010). As researchers increase efforts to understand development and fashion interventions designed to support healthy cortisol regulation (Slopen et al., 2014), generalizable reference ranges for basal and reactivity are necessary for proper interpretation of cortisol data. Yet normative patterns of salivary cortisol reactivity, in particular, have not been adequately determined in diverse populations (Hunter et al., 2011). This study contributes to the literature by reporting basal cortisol and reactivity profiles established in a sample of approximately one-month-old infants born to ethnically and racially diverse, low-SES, overweight or obese mothers.

Previous studies of infants tend to be based on samples with underlying clinical issues, such as colic (White et al., 2000) or prematurity (Grunau et al., 2007; Herrington et al., 2004; Mehler et al., 2015; Morelius et al., 2016), or include mothers with a history of maltreatment (Martinez-Torteya et al., 2015). In addition, the majority of studies are conducted predominantly with White Non-Hispanic samples (Davis et al., 2011; Grunau et al., 2007; Herrington et al., 2004; Martinez-Torteya et al., 2015; White et al., 2000); older infants (Davis et al., 2011; Grunau et al., 2007; Hibel et al., 2015; Martinez-Torteya et al., 2015; Provenzi et al., 2016a; Provenzi et al., 2016b; White et al., 2000) and/or middle class/low risk samples (Gunnar and Donzella, 2002; Haley and Stansbury, 2003). A review Jansen et al. (2010) showed that a limited number of published studies have examined salivary cortisol basal and reactivity levels in infants under 3 months of age; of those studies, sample sizes are small, ranging between 10 and 60 participants, with only two studies including samples over 100. Moreover, all studies included in the review were low-risk. The few studies

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focused on infants from ethnic or racial minority families included smaller sample sizes and administered infant stressors within 24–48 h after birth (Keenan et al., 2007; Keenan et al., 2002); targeted the impact of prenatal stress (Luecken et al., 2013), or involved older infants, smaller samples and infants exposed to drugs in utero (Haley et al., 2006). Keenan et al. (2002, 2007) based upon the same sample, used the Neonatal Behavioral Assessment Scale (NBAS) (a measure similar to the one used in the present study, but more cumbersome and harder to administer) and a heel stick to stress infants within the first two days of life, but data collected from infants so close to the stressful experience of birth raises the possibility of confounded results (Mears et al., 2004). Although the majority of studies examined infant basal cortisol, since 2010 a number of other major studies or reviews about infant cortisol reactivity have been published focusing on a variety of variables including preterm infants (Morelius et al., 2016), sex differences in childhood (van der Voorn et al., 2017), adverse experiences (Hunter et al., 2011), mother-infant adrenocortical attunement (Hibel et al., 2015), or SES and race/ethnicity in older children (Tackett et al., 2017).

Although interest in infant cortisol regulation appears to be growing, there is sparse literature examining the association with maternal Body Mass Index (BMI), which may be important because prenatal factors such as maternal obesity may have a "programming" effect on endocrine and immune function in the developing infant (Elhassan et al., 2015; Wadhwa et al., 2009). This area of research is vital given that approximately 70% of the adult population in the United States (66.2% of women, 73% of men) is either overweight (BMI = 25 to < 30) or obese (BMI = 30 or higher), and rates are even higher among women of color (82% of African Americans, 77.1% of Latinas/Hispanics) (Centers for Disease Control and Prevention (CDC), 2016; Flegal et al., 2016). Among the few extant studies, the only one that examined maternal *pre-pregnancy* BMI (Elhassan et al., 2015) found no association between pre-pregnancy maternal BMI and diurnal cortisol or reactivity in pre-school children. Two other studies reported no association between maternal pregnancy weight gain and fasting plasma cortisol concentrations in children 8.5 years of age (Phillips et al., 2005), or between postpartum maternal BMI and infant cortisol (Luecken et al., 2015; Phillips et al., 2005). More research is needed in this important domain.

Finally, this research also focuses on low-SES families, a large, yet understudied, population. Approximately 30% of the U.S. population lives in "low income" households, with incomes less than 200% of the Federal Poverty Level (FPL) (Henry J. Kaiser Family Foundation, September 22, 2017), and three-quarters of the U.S. population live in homes with incomes less than 500% of the FPL (Doty, 2005). The overall poverty rates for African American or Latino/Hispanic children are 34% and 28%, respectively (The Annie E. Casey Foundation, 2017). Thus, the predominant focus of experimental research on higher income families precludes our ability to truly understand physiological development and functioning within this important and large population of infants.

The specific goals of this study were to provide ranges for newborn basal and reactivity cortisol that might be generalizable to a broader population than is typically assessed (particularly for reactivity) and to examine potential sociodemographic predictors of levels. To address limitations in the extant literature, we provide novel data from a relatively large community sample of healthy young infants born to predominantly low-income women from a range of racial/ethnic and educational backgrounds who were overweight or obese prior to becoming pregnant. We assessed cortisol in infants younger than those typically studied in order to add to the knowledge base about HPA-axis development early in infancy, but after the physiological stress associated with delivery is likely to have passed (Mears et al., 2004). Building upon evidence that physical stressors (e.g., inoculations (Thompson et al., 2015)) provide robust responses, but with a desire to assess reactivity to more environmentally-normative experiences than a "heel-stick," we assessed reactivity using a prolonged protocol that combined a series of typical, developmentally-appropriate physical and social challenges. Though we did not have specific hypotheses, we expected that infants would exhibit a detectable increase in cortisol, in response to the complex stressor protocol, with sufficient variability to discern whether sociodemographic factors were associated with differences in newborn cortisol values.

2. Method

2.1. Participants

The Stress, Eating, and Early Development study (SEED) is a longitudinal study designed to investigate the associations between prenatal stress and weight gain on child health and development in a cohort of 162 mother-infant dyads (see Bush et al., 2017 for details). Inclusion criteria were that women be 18–45 years of age, 8–23 weeks pregnant with a singleton gestation, have a BMI of 25–40, and incomes less than 500% of the FPL (75% of the participants lived at or less than 200% of the FPL). Medical conditions that may interfere with baseline body composition (e.g. diabetes, abnormal glucose screen in early pregnancy, hypertension and eating disorders) were exclusionary.

2.2. Procedures

To accommodate new mothers and improve enrollment within the first several weeks of birth, mothers and their babies were invited to either come to the university clinic or to be assessed in their home. Newborn assessments were completed with 147 mother-child pairs at roughly one month of age, and data for this study are derived from the 132 infants with viable cortisol values at that visit (see Table 1 for

Table 1
Descriptive data for analytic sample.

Variable	n	Mean (SD) or n (%)
Infant		
Age at assessment (days)	132	37.61 (17.27)
Gestational Age at birth (days)	132	277.59 (8.94)
Birthweight (kg.)	132	4.47 (0.72)
Sex (female)	132	68 (51.52%)
Race	132	
Caucasian		20 (15.15%)
African – American		40 (30.30%)
Multiracial/Other		65 (49.24%)
Not-Reported		7 (5.30%)
Ethnicity (Hispanic or Latino)		59 (44.70%)
Vaginal vs. Caesarian Birth	132	94 (71.21%)
Breast fed vs. non-breastfed	131	103 (78.63%)
Home Assessment vs. Clinic Visit	132	106 (80.30%)
Mothers		
Age (years)	132	28.24 (5.66)
Parity (First born)	132	78 (59.09%)
Marital Status (married or in a committed relationship)	131	88 (67.18%)
*Income	128	$24,418 ($20,301) Range: $0–$86,000
Education	132	
Some High School		12 (9.09%)
High School / GED		28 (21.21%)
Some College, Vocational training or Associate degree		66 (50.00%)
Baccalaureate or Graduate Degree		26 (19.70%)
Maternal Pre-pregnancy BMI	132	30.91 (5.14); Range = 25–44
Study Protocol		
Cortisol Sampling (Time of Day)		12:00pm (SD = 1.5 h.); range = 9:00am–4:30pm
Duration of NBO Testing (minutes)		10.81 (3.5)

*Note: 75% of the sample was at or below the "low income threshold of 200% FPL.