



Full Length Article

Correlation between maternal and infant cortisol varies by breastfeeding status



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ABSTRACT

Objective: The objective of this study was to examine associations of mother and infant salivary cortisol, measured three times over the course of a day, and assess whether these varied by breastfeeding status.

Methods: We conducted a cross-sectional study of 54 mothers and their infants aged 4–11 months. Mothers collected their own saliva and that of their infants upon awakening, 30 min after waking and at bedtime. Breastfeeding status was reported by mothers and cortisol level was measured in saliva in $\mu\text{g/dl}$ using standard techniques. We used generalized linear models to evaluate relationships between maternal and infant cortisol levels, and assessed whether the relationship differed by breastfeeding status: formula only compared to partial and full breastfeeding, adjusting for infant sex, race, age, maternal education, and family income.

Results: Thirty-four infants received formula only and 20 were either partially or fully breastfed. Breastfeeding was associated with higher household income, higher maternal education, and white race. Cortisol levels were higher among breastfed infants at all three time points. After adjustment, maternal cortisol levels were related with infant cortisol at bedtime only (regression estimate 0.06; 95% CI: 0.10, 1.1; $p=0.02$). The adjusted association between bedtime maternal and infant cortisol was stronger among breastfeeding dyads than among formula-feeding dyads (regression estimate 1.0; 95% CI: 0.1, 2.0; $p=0.04$ vs. 0.6; CI: $-0.1, 1.3$; $p=0.10$). In addition, we assessed the influence of maternal education and household income in our adjusted model; income strengthened the observed association, whereas maternal education did not change the estimate.

Conclusions: Breastfeeding mothers and infants had significant correlations for cortisol at bedtime, while formula-feeding dyads did not. These data suggest that several factors may contribute to cortisol synchrony observed in mother/infant dyads, including the transfer of cortisol in human milk, physical interaction such as skin-to-skin contact, and shared environment. In addition, our findings support household income as a possible contributor.

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1. Introduction

Breastfeeding is an important predictor of long-term health (American Academy of Pediatrics, 2012; World Health Organization, 2002), but little is known about how it influences stress-related hormone levels in infants. One potential mechanism is the transfer of biologically active elements, such as cortisol, through human milk. Infants who are breastfed in their first year of life have higher cortisol levels than formula-fed infants (Cao et al., 2009) and studies suggest that cortisol present in human milk may be transmitted via breastfeeding from mother to baby (Bright, Granger, & Frick, 2011; Patacchioli et al., 1992; Stenius et al., 2008). In addition, breastfeeding may influence infant cortisol levels through the physical interactions that occur between mother and infant, leading to greater synchrony in cortisol levels. Breastfeeding dyads typically have more skin-to-skin contact, and mothers who engage in frequent skin-to-skin contact have cortisol levels that are more highly correlated with their infants than those who do not (Mörelus, Örténstrand, Theodorsson, & Frostell, 2015). Breastfeeding mothers also spend more time soothing, holding, and cuddling their infants, compared to mothers who formula feed their infants (Smith & Ellwood, 2011). Since shared environment is known to influence correlation of cortisol levels between individuals, more frequent interaction between breastfeeding mothers and their infants could influence synchrony. A study of infants and mothers in neonatal intensive care units found that mothers and infants who stayed together 24 h each day from admission to discharge had cortisol levels that were correlated at discharge whereas dyads who did not stay together were not correlated (Mörelus, Broström, Westrup, Sarman, & Örténstrand, 2012).

Several studies have assessed whether cortisol levels among mothers and their infants are linked, but none have examined differences by feeding method (Bright et al., 2011; Clearfield, Carter-Rodriguez, Merali, & Shober, 2014; Middlemiss, Granger, Goldberg, & Nathans, 2012; Spangler, 1991; Stenius et al., 2008). Stenius et al. (2008) compared salivary cortisol levels of 51 six-month-old infants to that of their parents, sampled in the morning, afternoon, and evening. They found a strong, positive association between mothers and infants at each time point, but a weak association between fathers and infants in the afternoon and evening only. The majority of infants in the study were breastfed; therefore, the authors were not able to compare breastfed to formula-fed infants. Spangler and colleagues (Spangler, 1991) found positive correlations in salivary cortisol levels between 14 mothers and their infants but were not able to assess differences by feeding status. Similarly, Bright et al. (2011) examined associations in salivary cortisol levels of 32 mothers and their infants or toddlers and found positive correlations at each of four assessments measured throughout the day. Clearfield et al. (2014) compared 16 high socio-economic status (SES) mothers and their infants to 16 low SES dyads to determine whether cortisol synchrony differed by SES. They sampled in the morning, afternoon, and evening and found that high SES dyads were significantly correlated in the evening only. Low SES dyads were not significantly correlated at any of the three time points assessed. Additionally, Middlemiss and colleagues (Middlemiss et al., 2012) examined maternal-infant interactions and cortisol levels in 25 dyads throughout a 5-day sleep training program, meant to induce stress, to determine if synchronicity in hypothalamic-pituitary-adrenal (HPA) axis activity was established and maintained. They found a positive association between maternal and infant cortisol levels throughout the day, at the initiation of a bedtime sleep routine, and after transition to sleep during the first few days of the program.

Since the majority of these studies included only breast- or mixed-feeding mothers and infants, it is still unclear whether correlations in cortisol levels are present in exclusively formula-feeding dyads. The purpose of this study was to evaluate associations of salivary cortisol between mothers and their infants, and assess the extent to which these associations differed by breastfeeding status. Based on findings from previous studies, we hypothesized that cortisol levels would be correlated among breastfeeding but not formula-feeding dyads.

2. Materials and methods

2.1. Study population

Participants were part of the Newborn Epigenetic Study (NEST), an observational cohort designed to examine epigenetic influences on the development of child adiposity. Information about the NEST study and its protocols are available elsewhere (Hoyo et al., 2011). Briefly, between 2009 and 2012, 1700 pregnant women were enrolled from one of five prenatal clinics in Durham, NC, USA. Infants were excluded from the NEST study if they were born <28 weeks gestation, were not feeding by mouth at hospital discharge, were in the hospital for more than 21 days post birth, or had health conditions that would interfere with normal feeding. From this cohort we enrolled a sub-sample of 54 mother/infant dyads in the spring of 2011 to evaluate factors affecting maternal and infant stress. This sample size was dictated by available funding.

To participate in the sub-study, infants had to be between 0 and 12 months of age and mothers had to agree to a home visit and had to be willing to collect saliva samples from themselves and their infants the following day. We mailed a letter of invitation to a random sample of 200 NEST women whose infants met the age criterion for inclusion. We enrolled the first 54 women who called the study coordinator in response to the letter and were willing to participate in the sub-study. We conducted home visits with each mother/infant dyad to implement the assessments; visits lasted approximately 1.25 h. Mothers provided written informed consent for their participation and that of their infants. This research was conducted in accord with prevailing ethical principles; the institutional review board of Duke University Medical Center approved this study and its protocol.

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