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# Concordance of mother–daughter diurnal cortisol production: Understanding the intergenerational transmission of risk for depression

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## ABSTRACT

A growing body of research is demonstrating concordance between mother and child diurnal cortisol production. In the context of maternal history of depression, intergenerational concordance of cortisol production could contribute to hypercortisolemia in children of depressed mothers, which has been shown to increase risk for MDD. The current study is the first to examine concordance in diurnal cortisol production between mothers with a history of depression and their never-depressed, but high-risk, children. We collected salivary cortisol across 2 days from mothers with (remitted; RMD) and without (CTL) a history of recurrent episodes of depression and their never-depressed daughters. As expected, RMD mothers and their daughters both exhibited higher cortisol production than did their CTL counterparts. Moreover, both across and within groups, mothers' and daughters' cortisol production were directly coupled. These findings suggest that there is an intergenerational concordance in cortisol dysregulation that may contribute to hypercortisolemia in girls at familial risk for depression.

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In the United States alone, 10–15 million children under the age of 18 live with a depressed parent (England & Sim, 2009); approximately half of these children will develop depression by adulthood (Beardslee, Versage, & Gladstone, 1998; Goodman et al., 2011; Williamson, Birmaher, Axelson, Ryan, & Dahl, 2004). Indeed, parental depression is associated with a three- to five-fold increase in children's risk for developing a depressive episode. Moreover, compared with children of well parents who develop depression, children of depressed parents tend to have an earlier age of depression onset, longer episode duration, and greater functional impairment (Hammen, Shih, Altman, & Brennan, 2003; Keller et al., 1986). Little is known, however, about mechanisms through which risk for major depressive disorder (MDD) is transmitted from parent to child (Fig. 1).

Dysregulation of the hypothalamus–pituitary–adrenal (HPA) axis has been found consistently to be related to elevated depressive symptoms and to familial risk for depression across a variety

of ages, making it a potential mechanism underlying the transmission of risk for depression (Chrousos & Gold, 1992; Ehlert, Gaab, & Heinrichs, 2001; Goodman & Gotlib, 1999; Guerry & Hastings, 2011; Holsboer, 2000). Researchers have shown that anomalous diurnal cortisol production is a core neurobiological abnormality in depression. Compared to never-depressed controls, currently and formerly depressed adults exhibit a steeper cortisol awakening response (CAR), higher peak cortisol in the morning, and higher overall cortisol levels across the day (Bhagwagar, Hafizi, & Cowen, 2005; Dienes, Hazel, & Hammen, 2013; Vreeburg et al., 2009; although see Knorr, Vinberg, Kessing, & Wetterslev, 2010, for more equivocal results). Although altered functioning of the HPA axis may be a consequence of depression, a growing body of research is now beginning to document that dysregulation of this system precedes and even contributes to the onset of illness. Indeed, several investigations of children and adolescents at high risk for depression show that increased vulnerability for MDD is associated with heightened diurnal cortisol secretion (Chen, Joormann, Hallmayer, & Gotlib, 2009; Mannie, Harmer, & Cohen, 2007). For example, Mannie et al. (2007) observed risk-related elevations in cortisol levels in the first 30 min after waking. These findings parallel data presented by Halligan, Herbert, Goodyer, and Murray (2004)

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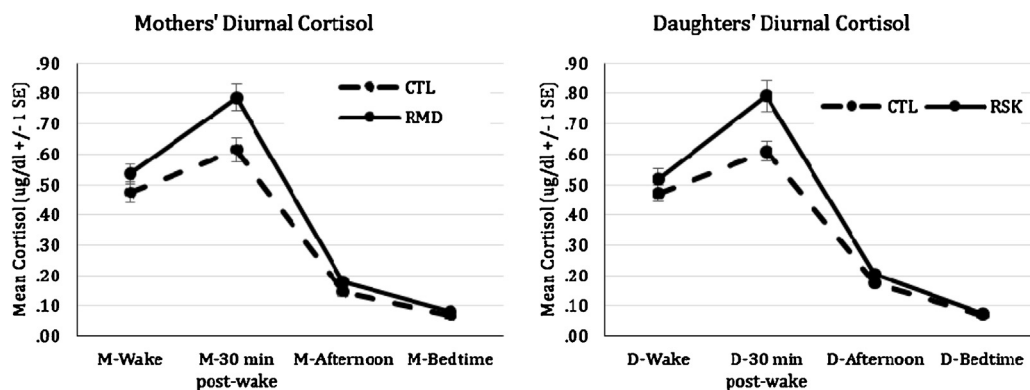


Fig. 1. Diurnal cortisol at waking, 30 min post-waking, mid-afternoon (approximately 3:30pm), and 30 min before bedtime for mothers with (RMD) and without (CTL) a history of depression and their high-risk (RSK) and low-risk (CTL) daughters.

showing that youth at risk for psychopathology exhibit higher morning cortisol secretion than do their low-risk peers. Importantly, in their sample of high-risk youth, Halligan and colleagues also found that hypercortisolemia predicted symptoms of depression 3 years later (Halligan, Herbert, Goodyer, & Murray, 2007; see also Goodyer, Tamplin, Herbert, & Altham, 2000; Harris et al., 2000). This finding was replicated in an unselected sample of older adolescents: those participants who showed a steeper CAR were more likely to develop MDD in the upcoming year (Adam et al., 2010).

Investigators have attempted to understand and predict children's diurnal HPA-axis activity by examining the concordance, or synchrony, between parent and child diurnal cortisol production. In samples of healthy dyads, children's diurnal cortisol patterns have been closely related to their mothers' cortisol production (e.g., Mörelius, Broström, Westrup, Sarman, & Örténstrand, 2012; Stenius et al., 2008). In fact, maternal cortisol level is among the strongest determinants of children's cortisol production (Bright, Granger, & Frick, 2012). Mörelius et al. (2012), for example, examined diurnal cortisol secretion in mothers and their 6-month-old infants and found strong correlations between mother and child cortisol levels in the morning, afternoon, and evening. Although studies of dyadic concordance have typically focused on mothers and their infants (e.g., Laurent, Ablow, & Measelle, 2011), high levels of concordance between mother and child diurnal cortisol production have been reported throughout childhood and adolescence (Papp, Pendry, & Adam, 2009; Young, Vazquez, Jiang, & Pfeffer, 2006).

Concordance between mother and child diurnal cortisol production becomes particularly important in the context of maternal psychopathology, especially in the context of disorders such as depression that are frequently associated with increased cortisol production. In the context of mothers' depression-related hypercortisolemia, intergenerational concordance of cortisol production could potentiate hypercortisolemia in their children, which has been shown to increase individuals' risk for depression (Halligan et al., 2007; Adam et al., 2010). Despite considerable evidence showing intergenerational concordance of cortisol production, it is not yet clear whether the concordance between mother and child cortisol production is equivalent in mothers with and without a history of depression. It is possible that mothers' history of depression will decrease maternal sensitivity and responsiveness, which has been shown to attenuate dyadic concordance of cortisol production (Gunnar, Brodersen, Nachmias, Buss, & Rigatuso, 1996; Tu et al., 2007). Alternatively, higher levels of maternal negative affect have been reported to increase concordance (Papp et al., 2009). Elucidating the nature of concordance between depressed mothers' and

their children's diurnal cortisol production is a critical next step toward understanding mechanisms underlying both hypercortisolemia in children of depressed parents and the intergenerational transmission of risk for depression. Importantly, no study has yet examined the concordance in diurnal cortisol production between formerly depressed mothers and their never-depressed adolescent offspring.

The current study was designed to examine the concordance in diurnal cortisol production between mothers with a history of depression and their never-depressed, but high-risk, children. Given the high rates of depression in daughters of depressed mothers (Gotlib & Colich, 2014; Hops, 1996), we recruited a sample of adolescent daughters at high or low risk for depression based on whether their mothers did or did not experience recurrent episodes of depression during the daughter's lifetime. We first examined whether our sample of high-risk daughters and their mothers exhibited elevated diurnal cortisol production compared to their low-risk counterparts by assessing risk-group differences in CAR, peak morning cortisol, and daytime cortisol production. We then examined the concordance between mother and daughter diurnal cortisol production, and tested whether maternal history of depression moderated the strength of this association. We expected that mothers with a history of recurrent MDD would exhibit greater overall cortisol production than would mothers with no current or past Axis I disorder. Similarly, we expected that daughters who were at high risk for depression based on their mothers' history of the disorder would exhibit greater overall cortisol production than would low-risk daughters. Finally, we expected to find significant intergenerational concordance in cortisol production in both the high- and low-risk groups, a pattern that could contribute to hypercortisolemia in high-risk daughters and, in turn, increase our understanding of the intergenerational transmission of risk for depression.

## 1. Materials and methods

### 1.1. Participants

The current sample consisted of 112 mother–daughter dyads. All dyads included daughters who were between the ages of 9 and 15 years and who had no current or past Axis I disorder. Fifty-three daughters had mothers without a current or past Axis I disorder (low-risk daughters; CTL), and 59 daughters had mothers who had a history of recurrent episodes of MDD but whose depression was in full remission, defined as not meeting criteria for depression for the past two months (high-risk daughters; RSK). Mother–daughter dyads were recruited through advertisements posted throughout the community. A telephone screen was used to assess initial inclusion/exclusion criteria; these dyads were invited to the laboratory for a more extensive interview. No participant had any major neurological or metabolic conditions, significant head trauma, or clinically significant learning disorder, and all were fluent in English.

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