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Diurnal cortisol after early institutional care—Age matters

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ABSTRACT

Several studies have shown that young children who have experienced early caregiving adversity (e.g. previously institutionalization (PI)) exhibit flattened diurnal cortisol slopes; however, less is known about how these patterns might differ between children and adolescents, since the transition between childhood and adolescence is a time of purported plasticity in the hypothalamic-pituitary-adrenal (HPA) axis. PI youth experience a massive improvement in caregiving environment once adopted into families; therefore we anticipated that a developmental increase in HPA axis plasticity during adolescence might additionally allow for an enhanced enrichment effect by the adoptive family. In a cross-sectional sample of 197 youths (PI and Comparison; 4–15 years old) we observed age-related group differences in diurnal slope. First replicating previous findings, PI children exhibited flattened diurnal slope. This group difference, however, was not observed in adolescents. Moderation analyses showed that pubertal development, increased time with family, and early adoption contributed to the steeper diurnal cortisol slope in PI adolescents. These findings add support to existing theories positing that the transition between middle childhood and adolescence may mark an additional sensitive period for diurnal cortisol patterning, allowing PI youth to benefit from the enriched environment provided by adoptive parents during this period of development.

1. Introduction

Early rearing environments play an important role in the development of the hypothalamic-pituitary-adrenal (HPA) axis, a central system in the body's ability to appropriately respond and adapt to stress (Gunnar et al., 2009). Across several species, early adverse caregiving is followed by alterations to diurnal cortisol activity, such as flattened diurnal slopes with blunted morning and elevated evening levels (Gunnar and Vazquez, 2001; Sánchez et al., 2005). These early alterations in cortisol activity have been correlated with long-term future physiological and psychological outcomes, such as inflammation and increased rates of psychiatric disorders (e.g. anxiety and depression; Loman and Gunnar, 2010). Children with a history of early parental deprivation as a result of institutional (i.e., "orphanage") caregiving are at significantly elevated risk for long-term alterations to stress physiology and socio-emotional functioning (Loman and Gunnar, 2010). Nonetheless, many previously-institutionalized (PI) children that have been adopted, exhibit tremendous rebound in a number of developmental domains (Loman and Gunnar, 2010; Nelson et al., 2007; Tottenham, 2012), raising the possibility that the HPA axis may also exhibit change in the post-adoption home. Though much research has demonstrated flattened diurnal cortisol profiles for younger PI children, some work has shown that there is also dynamic change in the HPA axis observed into early adolescence (Kertes et al., 2008; Quevedo et al., 2012), which is suggested to be another sensitive period for HPA axis programming (Hostinar and Gunnar, 2013).

1.1. International adoption as end of early life adversity

Examining the sequelae of early adversity is particularly difficult in

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humans because adverse caregiving contexts often do not have a discrete end point. Moreover, children who experience early adversity may continue to be living under conditions of adversity at the time of testing. It is therefore difficult to disentangle the effects of adversity during an early sensitive period of development from the chronic effects of adversity. Individuals with a history of previous institutional care and subsequent adoption by families, however, provide a rare chance to examine the sequelae of a discrete and early exposure to adverse caregiving, which ends upon adoption by families. Institutional rearing, even under the best conditions is a species atypical experience (Tottenham, 2012). However, the majority of parents who adopt internationally tend to have a higher income, increased education, and two-parent homes (Hellerstedt et al., 2008), and importantly they tend to exhibit an extraordinary degree of parental investment (Hamilton et al., 2007) and involvement (Levy-Shiff et al., 1997; McGuinness et al., 2000); therefore, PI children and adolescents are likely to be adopted into highly enriched family environments (Hamilton et al., 2007). This transition into adoptive homes provides the rare opportunity to examine how HPA axis activity can change with an enriched home environment.

1.2. Adolescence as another sensitive period in HPA programming

Strong evidence suggests that early postnatal development is a sensitive period in the HPA axis. However, mounting evidence from both rodent and human models suggests that the transition from childhood to adolescence may represent a second period of heightened HPA axis plasticity (Gunnar et al., 2009; Romeo, 2010), when the HPA axis can be "reorganized" by positive social environments (Francis et al., 2002; Morley-Fletcher et al., 2003). This period of potential reorganization could provide another opportunity to influence the development of the HPA axis, which is particularly important for individuals with a history of early adversity. For example, evidence from rodent studies demonstrates that HPA axis dysregulation from early maternal deprivation can be reversed by enriched environments in the juvenile-to-adolescent period (Francis et al., 2002; Morley-Fletcher et al., 2003).

There are many changes occurring around this transition into adolescence that could increase the malleability of the HPA axis (Lupien et al., 2009). One proposed mechanism of this increase in HPA axis activity is pubertal maturation that typically begins in late childhood/early adolescence and extends into late adolescence. Although pubertal effects are often difficult to separate from age effects (Gunnar et al., 2009), Quevedo et al., 2012 demonstrated that puberty is a time of HPA axis recalibration. Specifically, between ages 12–14 years old, PI adolescents who were in pre/early pubertal development displayed blunted morning cortisol levels (cortisol awakening response, specifically), which was not observed in PI adolescents in post/late pubertal development. This "pubertal recalibration" hypothesis would suggest that puberty instantiates another sensitive period of HPA axis programming, providing an opportunity for PI youth to take advantage of their post-adoptive home environments in late childhood/early adolescence. Here, we extended these findings to assess diurnal cortisol production across the day (i.e., diurnal slope) as it relates to puberty and time with adoptive family across a broader age range.

1.3. Current study

The current study aimed to characterize age-related patterns of diurnal cortisol slope in a cross-sectional sample of both PI and never-institutionalized (Comparison) youth (4–15 years old) and to further examine the moderating effects of adoption-related variables and pubertal development on age-related changes in diurnal cortisol slope. First, we hypothesized that at younger ages (i.e., childhood), the PI group would exhibit a flattened diurnal cortisol slope, characterized by lower morning values (i.e., shallower slope) than the Comparison group. Secondly, we hypothesized that group differences would be less apparent between PI and Comparisons groups as age increased (i.e., in adolescence), resulting from steeper age-related change in diurnal cortisol slope in the PI group relative to the Comparison group. Lastly, we hypothesized that these age-related changes in the PI group's diurnal cortisol slope would be associated with pubertal development and moderated by time with adoptive family, such that increased pubertal development and time with adoptive family would be associated with a steeper diurnal slope.

2. Methods and materials

2.1. Participants

A total of 197 youths (79 PI and 118 Comparison) participated in the study. A wide age range (4–15 years old) was studied to examine cross-sectional age-related differences in diurnal cortisol. Participants were recruited as part of a larger longitudinal study examining the neural correlates of emotional development. The larger study included participants, ages 3–17 years old; however, due to the relatively smaller diurnal cortisol sample size for the PI group at either tail of the study (mean < 3 participants per year), we restricted the range to 4–15 years old (see Table 1). PI participants (defined as previously institutionalized in an "orphanage" abroad and subsequently adopted to the United States) were recruited via local international adoption agencies, adoption family networks, posted flyers, and friend referral. Healthy comparison participants (defined as raised by biological parents in the United States and never adopted) were recruited via birth records, posted flyers, and friend referral. Comparison participants were pre-screened for prior diagnoses of any behavioral/psychological concerns or learning disabilities, and confirmed by in-lab assessments (e.g., CBCL internalizing problems mean(SD) = 46.90(10.82); CBCL externalizing problems mean(SD) = 44.99(9.60)). The protocol was approved by the Institutional Review Board at the University of California, Los Angeles. Participants and their parents provided both informed assent and consent, respectively.

2.2. Inclusion criteria

Early life adversity is associated with a number of health and behavioral outcomes, including increased allergies, and psychotropic medication use for mental health related problems (Kozyrskyj et al., 2011; Tottenham, 2012). Therefore, we did not exclude based on psychotropic (PI: 13, C: 0) or steroid (PI: 14, C: 3) medication. However, to properly control for the associations of these medications

Table 1
Demographics Between Groups. PI = previously institutionalized. Comparison = never institutionalized. Peterson's Pubertal Development Scale (PPDS; 1 (*not begun*) − 4 (*fully developed*)). Age and time variables all represented in years. Income ranges were between 1 and 10. Income range of 7 = $100,001-150,000; income range of 6 = $70,001–85,000 *above the US national average(~$52,250; DeNavas-Walt et al., 2015). Parent education ranges were between 1 and 10. Parent education range of 6 = Some Graduate; parent education range of 5 = 4 Year Degree.

	PI mean(SD)	Comparison mean (SD)	Significance
Sex	M:26 F:50	M:59 F:59	$\chi 2 = 4.73$, $p = 0.04$
Puberty	2.13 (0.77)	2.14 (0.91)	$t(87) = 0.04$, $p = 0.97$
Age	9.50 (3.11)	8.79 (3.53)	$t(192) = -1.42$, $p = .16$
Estimated IQ	103.21 (15.01)	111.61 (17.52)	$t(152) = 3.14$, $p < 0.003$
Parent Income	7.59*(2.08)	6.29*(2.94)	$t(185) = -3.29$, $p < 0.002$
Parent Education	6.25(1.43)	5.44(1.91)	$t(188) = -3.11$, $p < 0.003$