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Child Diurnal Cortisol Rhythms, Parenting Quality, and Externalizing Behaviors in Preadolescence

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Abstract

This study examined a neurobiologically-informed model of the emergence of child externalizing behaviors in an ethnically diverse community sample of 232 9–12 year old children. Replicating extensive prior research, our analyses revealed that parents' inconsistent discipline and poor quality monitoring were predictive of child externalizing behavior. In addition, poor parental monitoring, but not inconsistent discipline, was associated with children having a significantly flatter morning-to-evening cortisol slope, which was in turn, related to higher levels of externalizing behaviors. An indirect effect of parental monitoring on externalizing behaviors, through child diurnal cortisol rhythms, was also supported. These findings highlight the role of the hypothalamic-pituitary-adrenal (HPA) axis and its hormonal end product, cortisol, in the relationship between the caregiving environment and the development of externalizing behaviors.

Keywords

cortisol; parenting; parental monitoring; inconsistent discipline; externalizing behaviors

Externalizing behaviors, characterized by aggression and defiance are associated with poor academic performance, substance abuse, and criminal activities (Brook et al., 2011; Moilanen et al., 2010). Parenting practices such as inconsistent discipline and poor monitoring are recognized as robust predictors of child externalizing behaviors (Capaldi et al., 1997; Lahey et al., 2008). The hypothalamic-pituitary-adrenal axis (HPA)—a

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Contributors

Phil Fisher designed the original study and wrote the protocol. All of the authors made contributions to the conceptualization of the study. Christina Gamache Martin conducted the literature review and statistical analyses. Hyouun Kim assisted in and reviewed the analyses. Christina Gamache Martin wrote the first draft of the manuscript. All authors contributed to and approved of the final manuscript.

Conflict of Interest

The authors have no conflicts of interest to disclose.

neurobiological system involved in stress reactivity and regulation—is postulated to play a role in the association between parenting and the development of externalizing behaviors (Susman, 2006; van Goozen et al., 2007). Although pathways between parenting practices, the HPA axis, and child externalizing behaviors have been individually tested and supported (Lahey et al., 2008; Pendry and Adam, 2007; Ruttle et al., 2011), they have not been tested in a model simultaneously. The current study sought to fill this gap by examining the role of diurnal cortisol slope in linking parenting practices to externalizing behaviors.

HPA Axis and Cortisol

The HPA axis is a critical component of the body's stress reactivity and regulation system and is involved in maintaining homeostasis in the face of dynamic environmental change. It responds to physical and psychological stressors via a cascade of neuroendocrine hormones, ending with cortisol, and activates systems involved in modulating immune function, learning, memory, and emotion and behavior regulation (Sapolsky et al., 2000; McEwen, 2008). In addition to its role in the stress response system, cortisol exhibits a diurnal pattern of activity in humans, with levels typically peaking 30–45min after waking and declining gradually throughout the remainder of the day (Stone et al., 2001). Dysregulated diurnal cortisol patterns (e.g. lower morning and higher evening cortisol levels, resulting in a flatter diurnal cortisol slope, or rhythm, across the day) are associated with decreased physical and psychological health (Chrousos, 2009; Heim et al., 2000). Flatter diurnal cortisol rhythms have been observed among children, adults, and nonhuman primates exposed to chronic stress (Bruce et al., 2009; Heim et al., 2000; Fries et al., 2005; Gunnar and Vazquez, 2001; Sánchez et al., 2005).

Behavioral and Neurobiological Consequences of Poor Quality Parenting

Inconsistent discipline and poor parental monitoring are two salient parenting practices associated with the development of externalizing behaviors, especially during preadolescence (Capaldi et al., 1997; Lahey et al., 2008). Coercion Theory (Patterson, 1982) explicates a pattern of interactions in which aggressive behaviors lead to desired outcomes within the parent–child dynamic, resulting in mutual escalation of inconsistent discipline and aversive child behavior. Parental monitoring, which involves attending to and tracking the child's whereabouts and activities, also becomes particularly important during preadolescence, as youth begin to spend more time away from home (Beyers et al., 2003).

Research on the neurobiological effects of childhood adversity has also supported the relationship between parenting practices and dysregulation of the HPA axis (see Lucas–Thompson and Goldberg, 2011 for a review). Lower maternal parenting quality, responsiveness, and scaffolding and greater negativity have been significantly related to flatter diurnal cortisol rhythms in young children (Pendry and Adam, 2007; Zalewski et al., 2012). Notably, parental responsiveness, monitoring, and consistency have been found to mitigate the negative neurobiological effects of being raised in stressful environments (Evans et al., 2007; Fisher et al., 2007). These results suggest that poor quality parenting negatively impacts HPA axis activity.

Diurnal Cortisol Rhythms and Externalizing Behaviors

In addition to the link between parenting quality and externalizing behaviors, low morning cortisol levels and flatter morning–to–evening diurnal cortisol rhythms have been associated with child externalizing behaviors (Shirtcliff et al., 2005; Poustka et al., 2010; Ruttle et al., 2011). Flatter diurnal cortisol rhythms in middle childhood have been shown to predict more severe externalizing behaviors in adolescence (Shoal et al., 2003; Shirtcliff and Essex, 2008). However, the findings examining this association are not entirely consistent. In their

meta-analysis, Alink et al. (2008) found that the association between diurnal cortisol levels and externalizing disorders was moderated by age, with a positive relation for preschool-aged children and a negative relation for school-aged children. Other studies have found higher evening cortisol levels associated with externalizing behaviors (Marsman et al., 2008; Sondejker et al., 2007). However, these studies examined morning and evening values individually. Thus, it is unclear whether the evening cortisol levels in these studies contributed to flatter morning-to-evening cortisol slopes associated with externalizing behaviors.

Cortisol has been theorized as an important link in the association between poor quality caregiving and externalizing behaviors in youth (Susman, 2006; van Goozen et al., 2007). Exposure to chronic low quality caregiving, and in particular inconsistent and unresponsive parenting, appears to contribute to the down-regulation of the HPA axis and flatter diurnal cortisol rhythms, which subsequently contribute to later child externalizing behaviors (Gunnar and Vazquez, 2006; Pendry and Adam, 2007). Thus, it is plausible that diurnal cortisol rhythms may partially explain the association between poor parenting practices and child externalizing behaviors.

The aim of the current study was to empirically examine a neurobiological model of externalizing behaviors in 9–12 year old children (Figure 1). We hypothesized that poor quality parenting would be associated with increased externalizing behaviors and that effects of poor quality parenting practices on externalizing behaviors would be partially explained by flatter diurnal cortisol rhythms. This study extends prior research in multiple ways. First, no studies to date have simultaneously investigated the pathways between poor quality parenting practices, diurnal cortisol slope, and child externalizing behaviors. Second, little is known regarding the effect of specific parenting practices on cortisol in preadolescence. We examined inconsistent discipline and poor parental monitoring to investigate whether these practices would differentially impact diurnal cortisol rhythms in preadolescence. Third, repeated cortisol collections throughout the day and across days were used to characterize more robust diurnal cortisol rhythms (Rotenburg et al., 2012). Finally, this study was conducted with an ethnically diverse sample of children identified as being at risk for child maltreatment at birth.

Methods

Participants

The data for the present study were collected from a follow-up subsample from the Healthy Families America (HFA) San Diego clinical trial (Landsverk et al., 2002). The HFA intervention is a widely implemented home visitation program for high-risk families aimed at improving parenting, preventing child maltreatment, and promoting healthy child development. The original study recruited 488 mothers who were identified as at risk for child maltreatment at the time of their children's birth. Mothers who gave birth in San Diego between February 1996 and March 1997 and met eligibility criteria (i.e., residing in the target area, nonmilitary, and English- or Spanish-speaking) were initially selected and underwent a two-stage screening process. First, the mothers' medical charts were reviewed for 15 risk factors with the Hawaii Risk Indicators checklist (Hawaii Family Stress Center, 1994). Second, mothers with 2 or more risk factors (e.g. not married or received inadequate prenatal care) were further assessed using the 10-item Family Stress Checklist (Kempe and Kempe, 1976) to identify risk for child maltreatment. Mothers who scored 25 or greater and did not have an open case with child protective services were invited to participate in the study. Each mother completed a home interview within 2 weeks of childbirth and an annual assessment when her child was 12, 24, and 36 months of age. Additional information on the recruitment process can be found in Landsverk et al. (2002).

The follow-up study was conducted when the children were 9–12 years old ($M = 11.02$, $SD = 0.72$; 53% female). Of the 239 families who completed the follow-up study, 232 families were included in the present study. Seven children were excluded because they were taking medications containing corticosteroids ($n = 5$), did not provide a completed questionnaire recording eating and sleeping behaviors on sampling days ($n = 1$), or ate full meals 30min prior to each cortisol collection ($n = 1$). Siblings were not included in the current analyses. The children were racially and ethnically diverse including 52% ($n = 121$) Latino or of Hispanic descent, 16% ($n = 36$) multiracial, 15% ($n = 34$) Caucasian, 14% ($n = 33$) African American, and 3% ($n = 8$) Asian American or Pacific Islander. The participating parents were primarily female (92%) and biological parents (91%) or biological relatives (7%). Average annual, after-tax family income was approximately \$31,000 ($SD = \$15,000$). The highest level of parent education varied, as 15% ($n = 35$) did not graduate from high school or obtain a GED, 22% ($n = 51$) had a high school diploma or GED, 43% ($n = 100$) had some college, 10% ($n = 23$) obtained an associate's degree, and another 10% ($n = 23$) obtained a bachelor's or graduate level degree. Compared to the parents in the original study, parents in the follow-up study had a higher annual family income, $t(451) = -2.55$, $p < .001$, and were more likely to have a high school diploma, $X^2(1, N = 488) = 17.49$, $p < .001$, at the baseline interview.

The original clinical trial did not evidence significant intervention effects on the targeted outcomes, including reducing child maltreatment (Landsverk et al., 2002). Nonetheless, we examined potential intervention effects on parenting practices, child diurnal cortisol rhythms, and child externalizing behaviors during preadolescence. The follow-up assessment included an equal number of participants in the intervention ($n = 116$) and control ($n = 116$) groups, and there were no significant group differences in any of the study variables. Thus, intervention group status was not included as a covariate in the current analyses.

Procedure

All study procedures were approved by the IRBs for San Diego State University, Children's Hospital of San Diego, and Oregon Social Learning Center. Parent consent/permission and child assent were obtained prior to participation. Assessments were completed in the family's homes ($n = 187$) or over the phone for families who had moved from the area ($n = 45$). Assessments were conducted in English ($n = 204$) or Spanish ($n = 28$) based on family preference. The children and parents separately completed assessments that each lasted approximately 2.5h. At the end of the assessments, the assessors demonstrated the salivary cortisol collection procedures and provided instructions for in-home cortisol collection.

Measures

Parenting Practices

Inconsistent Discipline: Inconsistent discipline was assessed using a modified version of the Poor Discipline Implementation subscale from the Discipline Questionnaire (Capaldi, 1995), a parent-report measure of typical discipline practices frequently used in other studies (e.g., Pears et al., 2013). Parents were asked to rate the frequency of five discipline practices using a 5-point scale from 1 (*never or almost never*) to 5 (*always or almost always*) with higher scores indicative of greater inconsistency of discipline. Example items include: "How often do you let your child get out of a punishment when s/he really sets his/her mind to it?" and "How often do you let your child get away with things that you feel should have been punished?" The coefficient alpha reliability for internal consistency was .62.

Poor Parental Monitoring: Parental monitoring was assessed with the Monitor and Parent–Child Relationship Questionnaire (Capaldi and Wilson, 1998). Parents were asked to rate the frequency of six parental monitoring experiences over the prior six months (e.g. “How often has your child played out of adult eyesight and hearing by themselves”): 1 (*never*) to 5 (*very often*). Higher scores indicate lower levels of parental monitoring. The coefficient alpha reliability for internal consistency was .71.

Salivary Cortisol—Salivary cortisol samples were collected 3 times per day for 3 consecutive days in the children’s home. Participants were instructed to sample on a typical weekday, and a majority of the sample complied with this instruction (93%). There were no significant differences in the cortisol values depending on whether samples were collected on a weekday or a weekend day. Saliva collection occurred 30min after waking (morning), between 1600h and 1700h (afternoon), and 30min prior to bedtime (evening), consistent with the collection procedures used in previous research (e.g., Fisher et al., 2011; Johnson et al., 2011; Kroupina et al., 2012; Russ et al., 2012). Children were instructed not to eat, drink, or brush their teeth prior to collections; deviations from these guidelines were recorded. Parents also recorded their children’s general health, medication use, wake and bed times, and saliva collection times on a brief questionnaire each day. Conforming to the collection procedures used at the time of the study (Schwartz et al., 1998), the children chewed Trident® Original Flavor sugarless gum for 1min to stimulate salivation and then used a straw to expel saliva into a prelabeled vial. The vials were then labeled with the date and time of collection, refrigerated, and mailed to the laboratory after all of the samples had been collected. In the laboratory, the samples were stored at –20° C until they were mailed to the Biochemical Laboratory at the University of Trier for analysis. The samples were assayed in duplicate using a competitive solid phase time–resolved fluorescence immunoassay with fluoromeric end point detection (Dressendörfer et al., 1992). The lower sensitivity limit of this assay is 0.006 µg/dl. The samples from each child were included in the same assay batch to minimize within–participant variability. Duplicates varying by more than 15% were reassayed. The intraassay coefficients of variance ranged 4.44–5.00%, and the interassay coefficients of variance ranged 6.61–8.31%.

Cortisol values at each sampling time (i.e., morning, afternoon, and evening) were significantly correlated at the $p < .001$ level across the 3 sampling days ($r = .36-.46, .33-.55$, and $.36-.38$, respectively) and results from repeated measures ANOVA indicated that cortisol values did not differ significantly by day. Thus, consistent with previous research (e.g., Adam and Gunnar, 2001), the cortisol values were averaged across days.

Externalizing Behaviors—Preadolescent externalizing behaviors were assessed by parent reports on the Child Behavior Checklist/4–18 (CBCL; Achenbach, 1991) and teacher reports on the Teacher Observation of Child Adaptation–Revised (TOCA–R; Rains, 2003). The CBCL Externalizing Behavior scale is comprised of the Aggressive (18 items) and Rule–Breaking (17 items) Behavior subscales. Responses ranged from 0 (*not true*) to 2 (*very true or often true*). The coefficient alpha reliability for internal consistency for the externalizing scale was .92. The TOCA–R Authority Rejection subscale was used to assess the frequency of 12 externalizing behaviors using a 6–point scale from 1 (*never*) to 6 (*almost always*). The coefficient alpha reliability for internal consistency was .92. Parent– and teacher–reported externalizing behaviors were significantly correlated ($r = .34, p < .001$), and thus, were standardized and averaged to create a composite score of preadolescent externalizing behaviors.

Covariates

Demographics: Child ethnicity, age, and gender have been associated with parenting practices, diurnal cortisol rhythms, and externalizing behaviors (Beyers et al., 2003; Jessop and Turner-Cobb, 2008; Aalsma et al., 2011; Martin et al., 2012), thus, they were included as control variables in the present study. Due to the large number of Latino children and the small number of children from other racial/ethnic groups, a dichotomous ethnicity variable was created with non-Latino coded as 0 ($n = 111$) and Latino coded as 1 ($n = 121$).

Wake and Morning Latency Time: Both wake time and the latency between waking and morning collection time have been associated with morning cortisol values (Edwards et al., 2001; Dockray et al., 2008), and thus, were included in the model as covariates. Parents recorded the children's wake time along with each collection time for the three cortisol sampling days on a brief questionnaire. Wake time and morning latency times were significantly correlated at the $p < .001$ level across the 3 sampling days ($r = .50-.73$ and $r = .29-.41$, respectively) and were averaged across days.

Early Externalizing Behaviors: To take the effects of children's early externalizing behaviors into account, externalizing behaviors assessed at the 36 month assessment in the original HFA study were included in the present analysis. Parents rated their children on 100 behavior problems using the Child Behavior Checklist/2–3 (CBCL, Achenbach, 1992). Responses ranged from 0 (*not true*) to 2 (*very true or often true*). The Externalizing scale included the Aggressive (15 items) and Destructive (11 items) Behavior subscales. The coefficient alpha reliability for internal consistency was .88.

Pubertal Development: Pubertal development has also been associated with diurnal cortisol levels (Gunnar and Vazquez, 2006); however, recent longitudinal research suggests that the flattening of the diurnal cortisol rhythm during adolescence may result more from age than pubertal development (Shirtcliff et al., 2012). When evaluated using the Pubertal Development Scale (Petersen et al., 1988), the majority of the boys in the present sample were in the pre- or early pubertal stage (93%). In contrast, the majority of the girls were in the mid- to late pubertal development stage (61%), with those who had started menstruation classified in the post- pubertal stage (25%). Preliminary analysis indicated that pubertal development was not associated with any of the variables in the model, including diurnal cortisol rhythm, and thus, was not included in subsequent analyses as a covariate.

Analytic Strategy

Preliminary analyses were conducted to examine patterns of normality and missing data. Bivariate Pearson correlation coefficients were then computed to examine the relationships between the study variables, including the covariates. To evaluate the hypothesized model, a path analysis testing the association between parenting practices and externalizing behaviors in preadolescence was conducted. Then, to assess diurnal cortisol rhythms across the day and evaluate the full model incorporating parenting practices and preadolescent externalizing behaviors, latent growth curve modeling was conducted. The average morning, afternoon, and evening cortisol values across the 3 sampling days were used to estimate 2 latent factors (intercept and slope) of diurnal cortisol rhythms. The intercept factor was centered at Time 1 to indicate the estimated morning cortisol value. The slope factor indicated the estimated direction and magnitude of change in cortisol levels from morning to evening. First, an unconditional model without any predictors was fitted to examine the cortisol rhythm across the day. Then, to test for the direct and indirect effects of inconsistent discipline and poor parental monitoring through diurnal cortisol rhythms on preadolescent externalizing behaviors, the hypothesized predictors, covariates, and outcome variable were added to the unconditional model. We also tested significance of the indirect path using the

RMediation package (Tofighi and MacKinnon, 2011), which provides a more accurate method for testing an indirect effect (MacKinnon et al., 2004). All other analyses were conducted using Mplus (Version 6.12; Muthén and Muthén, 1998–2012).

Results

Preliminary Analyses

Prior to analyses, all variables were examined for missing data, outliers, and significant deviations from normality. The average morning, afternoon, and evening cortisol values, as well as early childhood and preadolescent externalizing behaviors were log transformed due to positive skew. Full information maximum likelihood was used to take full advantage of the available data using Mplus (Schafer and Graham, 2002). The amount of missing values was relatively small considering the longitudinal nature of the study; the covariance coverage ranged from .74 to .98. The descriptive statistics and bivariate correlations among the study variables are presented in Table 1.

Direct Effects of Parenting Practices on Preadolescent Externalizing Behaviors

The path model was designed to examine the relationship between the parenting behaviors and preadolescent externalizing behaviors, while controlling for the effects of the child's ethnicity, age, gender, and externalizing behaviors at 36 months. The path model showed a reasonably good fit, $X^2(3) = 4.63$, $p = .20$, CFI = 0.99, TLI = 0.94, and RMSEA = 0.05. We removed paths that were not significant with a probability level of .10 to develop a more parsimonious model (i.e., paths from gender and age to inconsistent discipline, paths between age and ethnicity to preadolescent externalizing behaviors, and a covariance between externalizing behaviors at 36 months and parental monitoring). The trimmed model was not significantly different from the full model, nested $X^2(5) = 5.08$, $p = .41$, and the patterns of significance in the trimmed model remained the same as in the full model. The trimmed model (shown in Model 1 in Table 2) showed a good fit, $X^2(8) = 9.71$, $p = .29$, CFI = 0.99, TLI = 0.98, and RMSEA = .03. Ethnicity, age, and gender were significantly associated with the variables of interest. Latino parents monitored their children more closely and were more consistent in their discipline practices than non-Latino parents. Older children were monitored less by their parents. Additionally, boys experienced poorer parental monitoring and displayed more externalizing behaviors than did girls. As hypothesized, inconsistent discipline and poor parental monitoring were predictive of greater preadolescent externalizing behaviors, even when controlling for externalizing behaviors at 36 months. The model accounted for a significant amount of the variance in preadolescent externalizing behaviors, $R^2 = .19$, $p < .001$.

Diurnal Cortisol Rhythms

Prior research suggests that diurnal cortisol rhythms better fit cubic or quadratic growth curves compared to linear growth models (e.g., Hauner et al., 2008; Van Ryzin et al., 2009). Because we had only 3 cortisol samples across the day, we tested a linear spline growth model (Stoolmiller, 1995), which has been shown to be an effective approach to modeling nonlinearity in longitudinal data with 3 or 4 time points (Kim et al., 2010; Graham et al., 2012). In the model, the intercept factor loadings were fixed at 1. The slope factor loading for morning cortisol was fixed at 0, and the slope factor loading for evening cortisol was fixed at 1. The slope factor loading for afternoon cortisol was freely estimated. This model showed good fit, $X^2(4) = 1.38$, $p = .85$, CFI = 1.00, TLI = 1.00, and RMSEA = 0.00.

As displayed in Model 2 in Table 2, the means of the intercept and slope factor in the unconditional linear spline model differed significantly from 0, at .33, $p < .001$ and $-.26$, $p < .001$, respectively. These values represented the average initial levels and change rates

across individuals (i.e., group means). The negative slope factor mean indicated that, on average, there were significant decreases in cortisol across the day as expected. The variances of the intercept and slope factor were not significant in the unconditional model, suggesting a lack of individual differences in the morning cortisol values and in the changes in cortisol across the day. The covariance between the intercept and slope factor was not statistically significant.

Parenting Practices, Diurnal Cortisol Rhythms, and Preadolescent Externalizing Behaviors

The hypothesized model, as shown in Figure 2, included direct and indirect paths from inconsistent parenting and poor parental monitoring to externalizing behaviors in preadolescence via diurnal cortisol rhythms (i.e., the intercept and slope factors of cortisol). The covariance between the parenting predictors and the covariates that predicted these parenting practices in the path model were included. In addition, gender and average wake time were included as predictors of the intercept and slope factor. Average morning latency time and a dummy-coded variable indicating whether cortisol was collected on a weekday or a weekend day were not significantly related to the intercept or slope factor, and thus these paths were not included in the model. The model fit the data relatively well, $X^2(39) = 33.53$, $p = .72$, CFI = 1.00, TLI = 1.00, and RMSEA = 0.00. As shown in Model 3 in Table 2, the means of the intercept and slope factor in this conditional linear spline model remained significant (.51, $p < .001$ and $-.53$, $p < .001$, respectively). With the inclusion of the hypothesized predictors and covariates, the intercept and slope factor variances became significant and marginally significant, respectively (.004, $p = .03$ and .003, $p = .08$, respectively).

There was a significant positive effect of poor parental monitoring on the slope factor, indicating that poorer parental monitoring was related to a flatter diurnal cortisol slope. In contrast, the direct path from parental monitoring to the intercept factor was not significant, indicating that parental monitoring was not associated with the morning cortisol value. The direct paths from inconsistent discipline to the intercept and slope factor were not significant, suggesting that inconsistent discipline was not associated with cortisol in preadolescents. Average wake time was negatively associated with the intercept factor and positively associated with the slope factor, suggesting that later wake times were associated with lower morning cortisol values and flatter diurnal rhythms across the day. Gender was positively associated with the intercept factor and negatively associated with the slope factor, indicating that boys had lower morning cortisol values and flatter diurnal cortisol patterns compared to girls. Ethnicity, age, and gender remained significant predictors of parental monitoring. Parental monitoring was negatively associated with morning latency time, indicating that poorer parental monitoring was related to waiting less time after waking to collect the morning cortisol sample. However, poorer parental monitoring was not related to greater compliance with the saliva collection protocol, in general, as parental monitoring was not associated with the collection day (i.e., weekday or weekend day) or the discrepancy between the instructed collection time and the actual collection time for the afternoon or evening cortisol samples.

The slope factor of cortisol was significantly and positively associated with preadolescent externalizing behaviors, indicating that flatter diurnal cortisol rhythms were associated with greater externalizing behaviors in preadolescence. In contrast, the intercept factor of cortisol was not significantly associated with externalizing behaviors. Additionally, the significant direct effects of inconsistent discipline and poor parental monitoring on externalizing behaviors in preadolescence were no longer significant in the presence of the intercept and slope factor of cortisol. Early externalizing behaviors continued to be significantly associated with preadolescent externalizing behaviors. The model accounted for 39% of the

variance in the intercept factor, $p = .002$, 45% of the variance in the slope factor, $p = .003$, and 27% of the variance in preadolescent externalizing behaviors, $p < .001$.

The indirect path from poor parental monitoring to preadolescent externalizing behaviors through the slope factor of cortisol did not reach statistical significance (unstandardized $b = .007$, 95% CI = $-0.001, 0.025$). However, the direct path between parental monitoring and preadolescent externalizing behaviors became nonsignificant when the intercept and slope factor of cortisol were entered into the model, thus, the nonsignificant indirect effect may have resulted from limited power (Fritz and MacKinnon, 2007). Hence, we tested the indirect path after removing the nonsignificant paths from inconsistent discipline. This model fit the data well, $X^2(31) = 20.83$, $p = .92$, CFI = 1.00, TLI = 1.00, and RMSEA = 0.00, and the indirect effect of poor parental monitoring on preadolescent externalizing behaviors through the diurnal cortisol rhythm was significant (unstandardized $b = .009$, 95% CI = $0.001, 0.034$).

Multigroup Gender Analyses

Because gender was a significant covariate in prior models, we conducted post-hoc, multigroup analyses to test for potential gender differences in the path between the slope factor of cortisol and preadolescent externalizing behaviors (e.g., Shirtcliff et al., 2005) and the indirect path from poor parental monitoring to preadolescent externalizing behaviors through the slope factor of cortisol. We first tested a model where all the paths were free to vary and then a model where the paths were constrained to be equal for boys and girls. For the path from the slope factor of cortisol to preadolescent externalizing behaviors, the constrained model did not differ significantly from the model in which the path was free to vary, nested $X^2(1) = 3.21$, $p = .07$. Similarly, for the indirect path from poor parental monitoring to preadolescent externalizing behaviors through the slope factor of cortisol, the constrained model was not significantly different from the model in which the indirect path was free to vary, nested $X^2(1) = 0.02$, $p = .90$. These results suggest that the pattern of findings did not differ by gender.

Discussion

The goal of the current study was to examine a neurobiologically-informed model of the emergence of externalizing behaviors in an ethnically diverse sample of at-risk preadolescent children. Within this model, the relationship between two distinct parenting practices and child externalizing behavior problems was hypothesized to be partially accounted for by a pattern of dysregulated HPA axis activity. Although neurobiologically-informed models of externalizing behaviors have been proposed (e.g., Susman, 2006; van Goozen et al., 2007), there is a paucity of empirical work testing such models. As hypothesized, we found that inconsistent discipline practices and poor parental monitoring uniquely predicted externalizing behavior problems in preadolescence. Furthermore, poor parental monitoring, but not inconsistent discipline, predicted flatter diurnal cortisol slopes in children, which were in turn related to higher levels of externalizing behaviors. The association between diurnal cortisol slope and externalizing behaviors remained significant even after controlling for child ethnicity, age, gender, and early externalizing behaviors assessed at 36 months. Importantly, we found an indirect effect of poor parental monitoring to externalizing behaviors via diurnal cortisol slopes, suggesting that poor parental monitoring influences externalizing behaviors through flatter diurnal cortisol slopes.

Consistent with findings linking a lack of parental warmth, responsiveness, and sensitivity to flatter diurnal cortisol rhythms in young children (Zalewski et al., 2012), preadolescent youth who experienced poor parental monitoring in the current study showed flatter diurnal cortisol slopes, which are suggestive of a dysregulated HPA system (Fries et al., 2005). It

may be that children equate their parents' lack of monitoring to less responsive and supportive parenting (Vieno et al., 2009). Parents who exhibit poor monitoring may also be less capable of anticipating and preventing problem behaviors, such as engagement in delinquent or risky behaviors (Dishion et al., 2003). Thus, poor parental monitoring may serve as a developmental equivalent in adolescence of unresponsive parenting in early childhood and act as a chronic stressor in the caregiving environment. It is interesting to note that the relation between inconsistent discipline and diurnal cortisol rhythms was not significant in the present study. It might be that during preadolescence, parental monitoring is a more developmentally salient predictor of diurnal cortisol rhythms than inconsistent discipline. Alternatively, other forms of inconsistent caregiving environments such as repeated caregiver transitions might be stronger predictors of diurnal cortisol rhythms (e.g., Fisher et al., 2011).

As predicted by neurobiologically-informed models of externalizing behaviors, children with flatter diurnal cortisol rhythms displayed higher levels of aggressive, defiant, and delinquent behaviors than children with steeper diurnal rhythms. This finding is consistent with Raine's (2002) hypothesis that children with low levels of arousal are more willing to engage in negative behaviors because they lack a fear of punishment. Because parental monitoring is lower for these children, they might also have more opportunities to engage in these types of activities without negative consequences. The finding that diurnal cortisol slope may serve as a mechanism through which poor parental monitoring leads to problematic externalizing behaviors is promising. Research has long supported that when parents are less aware of how and with whom their children spend their time, their children are more likely to engage in problematic behaviors (e.g., Lahey et al., 2008). The results from this study suggest that a lack of parental monitoring in preadolescence is distressing at a neurobiological level, leading to a dysregulated diurnal cortisol slope. Thus, a lack of parental monitoring might not only provide the opportunity for children to misbehave, it might also precipitate a neurobiological profile that increases the likelihood for children to engage in externalizing behaviors.

Additional research is needed to better understand how the relations between poor parental monitoring, diurnal cortisol slope, and externalizing behaviors can inform prevention and intervention efforts aimed at decreasing externalizing behavior problems in children and adolescents. Prior research with young children in foster care has shown that therapeutic interventions that promote parental responsiveness, monitoring, and consistency may attenuate negative neurobiological effects (Fisher et al., 2007). Importantly, a reduction in caregiver stress appears to be an important component in altering dysregulated cortisol rhythms for young children in foster care (Fisher and Stoolmiller, 2008). Decreasing parent stress may also allow parents to monitor their children more closely. Although numerous studies have already demonstrated the positive effect of parental monitoring on externalizing behaviors in youth (e.g., Eddy and Chamberlain, 2000), additional studies are necessary to determine whether increases in parental monitoring during preadolescence could likewise modify diurnal cortisol rhythms.

Notably, ethnicity, age, and gender were significant predictors of parenting behaviors in the model. Specifically, compared to non-Latino parents, Latino parents monitored their children more closely and their discipline practices tended to be more consistent. Thus, it may be important to examine differences in cultural and parenting values in future studies investigating the association between parenting behaviors and child externalizing behaviors in Latino and non-Latino families. Furthermore, consistent with findings from other studies (Beyers et al., 2003; Aalsma et al., 2011; Brook et al., 2011), parents monitored older children less than younger children and their sons less than their daughters. Parents' increased monitoring for their daughters may be advantageous, as prior research suggests

that girls have a higher likelihood of risky behaviors compared to boys when parental monitoring is poor (Svennsson, 2003). In the current study, boys also had significantly flatter diurnal cortisol rhythms and higher levels of externalizing behaviors compared to girls. However, gender did not moderate the association between flatter diurnal cortisol rhythms and higher levels of externalizing behaviors. Prior findings regarding gender differences in diurnal cortisol rhythms among children lack a clear consensus (Jessop and Turner-Cobb, 2008), suggesting that gender differences warrant further research.

Limitations

There were several limitations of this study. First, data were cross-sectional, and thus, causal inferences cannot be made. Although some studies suggested that externalizing behaviors might lead to altered diurnal cortisol rhythms, other longitudinal research suggests that diurnal cortisol rhythms are likely to precede externalizing behaviors (Shoal et al., 2003; Shirtcliff and Essex, 2008). Moreover, parenting practices and child externalizing behaviors are likely reciprocal in nature (e.g., Patterson, 1982). We were not able to assess these bidirectional relationships in this study; however, we did take into account children's externalizing behaviors at 36 months in the present analyses as a way to control for potential effects of early externalizing behaviors on parenting practices and diurnal cortisol rhythms in preadolescence. In addition, although we were able to incorporate parent- and teacher-report of child externalizing behaviors, we relied on parent-report for our measures of parenting practices. Future research would benefit from including a multi-method assessment of parenting practices.

There are also a few limitations related directly to the salivary cortisol sampling procedures. First, saliva collection was limited to 3 times across the day, which precluded an examination of the cortisol awakening response. Second, although the salivary cortisol samples were collected using a protocol that was widely accepted at the time of the current study (e.g., Schwartz et al., 1998; Gunnar et al., 2009; Cicchetti et al., 2010; Johnson et al., 2011), more recent evidence suggests that some sugarless gums may affect cortisol levels (Schultheiss, 2013). Thus, it is important to test the effect of any stimulant on cortisol levels using the intended assay prior to data collection. Third, although the parents reported child wake time and saliva collection times, we did not monitor these times electronically. It is possible that parents who monitored their children less closely were also less compliant with the saliva collection protocol; thus, their children might have had flatter profiles compared to children with better parental monitoring (Kudielka et al., 2003). However, we included parental monitoring, wake time, and the length of time between wake time and the morning sampling time as covariates in the model. Both wake time and parental monitoring were associated with the cortisol intercept and slope factors. In contrast, the morning latency time was not, suggesting that our findings are not merely a lack of compliance.

Despite these limitations, our study contributes to the literature by empirically examining a neurobiological model of externalizing behaviors using two different aspects of parenting practices—inconsistent discipline and poor parental monitoring—and a parent- and teacher-report of child externalizing behaviors in preadolescence controlling for externalizing behaviors assessed at 36 months. We found preliminary support for a neurobiologically-informed model of externalizing behaviors in an ethnically diverse sample of at-risk children. Poor parental monitoring, but not inconsistent discipline practices, predicted flatter diurnal cortisol profiles, which in turn were associated with more problematic behaviors in preadolescence. The indirect effect between parental monitoring and externalizing behaviors through diurnal cortisol rhythms was also significant. These findings highlight the role of stress reactivity and regulation in the relationship between parenting behavior and the development of externalizing behaviors in youth.

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Figure 1.

Conceptual model of the associations between parenting practices and child diurnal cortisol slope and externalizing behaviors in late childhood.

Figure 2. Significant associations between parenting practices, diurnal cortisol slope, and externalizing behaviors in preadolescents. Only significant associations are shown; nonsignificant pathways were deleted for clarity. Ave is Average; Ext is Externalizing.

Table 1

Descriptive Statistics and Correlations Between Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Gender (male)	–											
2. Ethnicity (non-Latino)	0.01	–										
3. Age	–0.00	–0.18**	–									
4. Early ext behaviors	–0.05	–0.14*	0.04	–								
5. Inconsistent discipline	0.00	–0.13*	–0.00	0.19**	–							
6. Poor parental monitor	–0.18**	–0.47***	0.22**	0.18*	0.22**	–						
7. Ave wake time	–0.12	–0.06	0.01	0.07	0.03	0.12	–					
8. Ave morning lat (min)	0.04	0.15*	0.03	–0.11	0.08	–0.17*	–0.02	–				
9. Ave morning cort	0.25***	0.05	0.07	–0.04	–0.06**	–0.17*	–0.29***	0.02	–			
10. Ave afternoon cort	0.12	–0.14	0.00	0.06	0.07	0.07	–0.02	0.08	0.23**	–		
11. Ave evening cort	0.12	–0.20**	0.02	0.07	0.13	0.12	0.02	0.08	0.20**	0.63***	–	
12. Ext behaviors	–0.20**	–0.19**	0.13*	0.32***	0.26***	0.28***	0.19**	–0.13	–0.20**	0.05	0.08	–
Percentage/Mean	47%	48%	11.02	12.84	2.10	9.39	7:04	21.41	0.40	0.13	0.08	0.00
Standard Deviation			0.72	7.56	0.66	3.58	1:01	15.63	0.20	0.10	0.11	0.89

* Note. Gender: 0 (male), 1 (female); Ethnicity: 0 (Non-Latino), 1 (Latino). Ext is externalizing; monitor is monitoring; ave is average; lat is latency; cort is cortisol; $p < .05$.

** $p < .01$.

*** $p < .001$.

Log transformed variables for early ext behaviors, ave morning cort, ave afternoon cort, ave evening cort, and ext behaviors used for the intercorrelations; raw variables used for the descriptive statistics.

Table 2

Parameter Estimates for Path Model (Model 1), Unconditional Linear Spline Model (Model 2) and Conditional Linear Spline Model (Model 3)

Parameter	Model 1		Model 2		Model 3	
	Estimate	SE	Estimate	SE	Estimate	SE
Cortisol intercept mean	0.527***	0.079	0.505***	0.073		
Cortisol intercept variance	0.002	0.003	0.004*	0.002		
Intercept covariance with slope	0.000	0.003	-0.001	0.002		
Predictors of cortisol intercept						
Gender			0.059***	0.016		
Inconsistent discipline			-0.009	0.014		
Poor parental monitoring			-0.004	0.003		
Average wake time			-0.030**	0.009		
Cortisol slope mean			-0.554***	0.086	-0.530***	0.080
Cortisol slope variance			0.002	0.004	0.003	0.002
Predictors of cortisol slope						
Gender			-0.042*	0.018		
Inconsistent discipline			0.020	0.015		
Poor parental monitoring			0.006*	0.003		
Average wake time			0.033**	0.01		
Predictors of externalizing behaviors						
Early externalizing behavior	0.343***	0.087			0.325***	0.086
Gender	-0.128*	0.051			-	-
Inconsistent discipline	0.112**	0.040			0.083	0.049
Poor parental monitoring	0.022**	0.007			0.008	0.010
Cortisol intercept					-0.639	0.622
Cortisol slope					1.503*	0.727
Predictor of inconsistent discipline						
Ethnicity	-0.149	0.087			-0.149	0.086
Predictors of poor parental monitoring						

Parameter	Model 1		Model 2		Model 3	
	Estimate	SE	Estimate	SE	Estimate	SE
Ethnicity	−3.149***	0.413			−3.147***	0.413
Age	0.707*	0.283			0.707*	0.283
Gender	−1.356**	0.400			−1.354**	0.400
Early externalizing beh covariance with						
Inconsistent discipline	0.030*	0.014			0.030*	0.014
Inconsistent discipline covariance with						
Poor parental monitoring	0.333*	0.136			0.332*	0.136
Predictor of average wake time						
Poor parental monitoring					0.035	0.020
Predictor of average morning latency						
Poor parental monitoring					−0.072*	0.031

Note. Parameter estimates are unstandardized. Gender: 0 (male), 1 (female), Ethnicity: 0 (Non-Latino), 1 (Latino). Beh is behavior;

*
p < .05.
**
p < .01.

p < .001.