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Differential Sensitization of Parenting on Early Adolescent Cortisol: Moderation by Profiles of Maternal Stress

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Abstract

The hypothalamic-pituitary-adrenal (HPA) axis is a critical component of the body's stress-response neurobiological system, and its development and functioning are shaped by the social environment. Much of our understanding of the effects of the caregiving environment on the HPA axis is based on a) parenting in young children and b) individual maternal stressors, such as depression. Yet, less is known about how parenting behaviors and maternal stressors interact to influence child cortisol regulation, particularly in older children. With an ethnically diverse sample of 199 mothers and their early adolescent children ($M = 11.00$ years; 54% female), a profile analytic approach was used to investigate how multiple phenotypes of maternal stress co-occur and moderate the relation between parenting behaviors and youths' diurnal cortisol rhythms. Latent profile analysis yielded 4 profiles: current parenting stress, concurrent parenting and childhood stress, childhood stress, and low stress. For mothers with the concurrent parenting and childhood stress profile, inconsistent discipline, poor parental supervision, and harsh caregiving behaviors each were related to flattened diurnal cortisol rhythms in their adolescents. For mothers with the current parenting stress and childhood stress profiles, their use of inconsistent discipline was associated with flattened diurnal cortisol rhythms in their adolescents. For mothers with the low stress profile, none of the parenting behaviors was related to their adolescents' cortisol regulation.

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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. Hyoun 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.

Findings suggest that based on mothers' stress profile, parenting behaviors are differentially related to youths' diurnal cortisol rhythms. Implications for parenting interventions are discussed.

Keywords

cortisol; maternal stress; parenting; differential sensitization; latent profile analysis

1. Introduction

The hypothalamic-pituitary-adrenal (HPA) axis is a critical component of the stress-response neurobiological system that responds to physical and psychological stressors via a cascade of neuroendocrine hormones, ending with cortisol. Although genetic and prenatal programming effects are linked to neurobiological development and functioning (Bartels et al., 2003; Belsky & Pluess, 2009), the development of the HPA axis is also shaped by environmental experiences (Del Giudice et al., 2011); this is especially true of early caregiving experiences, as evidenced in both nonhuman primates (Sánchez, 2006) and children (Hostinar et al., 2014; McEwen, 2012). Considerable work in this area has centered around infants and young children, thus, much of our understanding of how parenting practices influence the developing HPA axis is based on sensitive, responsive, and consistent parenting (Hostinar et al., 2014), the fundamental caregiving behaviors for infants and young children (Ainsworth et al., 1974). However, little is known about the effects of parenting practices on the HPA axis in early adolescence, a developmental period associated with heightened stress and emotional responsiveness to the social environment (Steinberg & Morris, 2001), as well as increased conflict with parents (Marceau et al., 2015). Accumulating evidence suggests that the HPA axis becomes more reactive to stress during adolescence (Gunnar et al., 2009; Klein & Romeo, 2013; Lupien et al., 2009). Thus, a better understanding of how key parenting behaviors are related to HPA functioning in early adolescence is needed and may have important clinical implications for designing effective parenting interventions aimed at improving stress reactivity and regulation.

Extensive research has identified inconsistent discipline, poor parental supervision, and harsh parenting as salient parenting behaviors linked to adolescents' poor emotion regulation, externalizing behavior problems, and substance use (Duncombe et al., 2012; Luyckx et al., 2011; MacKenzie et al., 2013). Albeit limited, evidence suggests that as with neglectful early care (Bruce et al., 2009; Johnson et al., 2011), poor parental supervision (Martin et al., 2014) has been linked to flatter slope in morning-to-evening cortisol in older children. In contrast, inconsistent discipline and harsh parenting have not been found to affect diurnal cortisol rhythms in early adolescence (Martin et al., 2012; 2014). It may be that in comparison to inconsistent discipline and harsh parenting, parental supervision is a better predictor of cortisol regulation in older children. Alternatively, because parenting does not occur in isolation, parents' experiences of stress may differentially affect the influence of parenting behaviors on HPA axis functioning.

Numerous studies have linked environmental stressors, particularly in mothers, to their children's dysregulated HPA functioning. Parental stress (Fisher & Stoolmiller, 2008; Koch et al., 2010), interparental aggression (Sturge-Apple et al., 2012), parental substance use

while controlling for the number of adverse life events experienced by their children (Evans et al., 2013), maternal depression (Lupien et al., 2000), and socioeconomic disadvantage (Lupien et al., 2000; Zalewski et al., 2012) have all been associated with dysregulated child cortisol. Experiences of childhood abuse have likewise been associated with dampened cortisol reactivity in adulthood (Carpenter et al., 2007). In contrast, less is known about how maternal childhood abuse impacts her child's cortisol regulation. This body of research highlights the link between maternal stress and youths' cortisol reactivity and regulation, yet the manner in which such stressors influence the relationship between parenting behaviors and child cortisol is not well understood. Moreover, a limitation of the aforementioned research is that most studies examined individual stressors in isolation (Sturge-Apple et al., 2012) or combined the stressors into a composite (Martin et al., 2012) or cumulative risk index (Zalewski et al., 2012). These methods lack specificity, as such stressors often co-occur in meaningful ways. A more ecologically valid way to examine the effects of maternal stress involves assessing multiple indicators of stress to determine distinct patterns of co-occurrence, in tandem with examining the more proximal role of parenting behaviors.

Our study used a latent profile analytic approach to investigate how phenotypes of maternal stress moderate the relationship between inconsistent discipline, poor parental supervision, and harsh parenting behaviors and early adolescent diurnal cortisol rhythms in 9- to 12-year-olds (Figure 1). We examined multiple indicators of mothers' current as well as childhood stress due to exposure to child abuse. Based on findings that childhood abuse history alone may be insufficient but when combined with ongoing stress in the form of depression or other psychological stressors, is related to neurobiological dysregulation (Heim et al., 2004; Kaufman et al., 1997; Rinne et al., 2002), we expected at least 4 groups with distinctive stress profiles: a low stress group, a group with current high levels of stress, a group with high levels of childhood but not current stress, and a group with high levels of current and childhood stress. Further, based on prior findings on the association between parenting behaviors and diurnal cortisol rhythms in early adolescence (e.g., Martin et al., 2014) we hypothesized that there would be a direct link between parenting behaviors and diurnal cortisol rhythms in early adolescence. We further hypothesized that the associations between parenting behaviors and youths' diurnal cortisol rhythms would be stronger in the presence of maternal stress, particularly for combined childhood and current stress (e.g., Heim et al., 2004).

2. Material and Methods

2.1 Participants

The present data were collected as part of a follow-up assessment from youths and families who had participated in the Healthy Families America (HFA) San Diego clinical trial from child birth to age 3 (Landsverk et al., 2002). For detailed information about the original study and sample see Martin et al. (2014). For our study, a total of 239 families, of the original 488, were recruited. Families were excluded if the participating caregiver was not the youth's biological mother ($n = 33$), if the youth was taking medication containing corticosteroids ($n = 5$), if the mother did not complete a questionnaire recording her youth's eating and sleeping behaviors on cortisol sampling days ($n = 1$), or if the youth ate full meals

30 min prior to each cortisol collection ($n = 1$). As such, 199 mother–adolescent dyads were included in our study.

The youths were 9–12 years old ($M = 11.00$, $SD = 0.74$; 54% female), and were racially and ethnically diverse, including 54% ($n = 108$) Latino or of Hispanic descent, 19% ($n = 38$) multiracial, 14% ($n = 27$) African American, and 13% ($n = 26$) Caucasian. Mothers were on average approximately 35 years old ($SD = 6.23$). Most mothers (48%, $n = 95$) identified as Latina or of Hispanic descent, 24% ($n = 47$) identified as Caucasian, 19% ($n = 37$) as African American, and 10% ($n = 20$) as multiracial or another minority. A quarter of the mothers were single parents ($n = 51$), and the average annual, after-tax family income was approximately \$30,000 ($SD = \$15,000$). The level of mothers' education varied; 22% ($n = 43$) had not graduated from high school or obtained a GED, 23% ($n = 46$) had a high school diploma or GED, 40% ($n = 80$) had some college, 11% ($n = 21$) had obtained an associate's degree, and another 4% ($n = 9$) had obtained a bachelor's or graduate-level degree. Compared with the mothers in the original study, mothers in the follow-up study had a higher annual family income, $t(416) = -3.44$, $P = 0.001$, and were more likely to have a high school diploma, $\chi^2(1, N = 488) = 23.23$, $p < 0.001$, at the baseline interview.

The original clinical trial did not evidence significant intervention effects on the targeted outcomes, including reducing child maltreatment. For the present study, preliminary analyses further indicated that there were no significant group differences in any of the study variables between the intervention ($n = 92$) and control ($n = 107$) groups, including the maternal stress indicators, parenting practices, or salivary cortisol variables. Thus, intervention group status was not included as a covariate in the current analyses.

2.2 Procedure

All study procedures were approved by the institutional review boards for San Diego State University, Children's Hospital of San Diego, and Oregon Social Learning Center. Parent consent/permission and youth assent were obtained prior to participation. Assessments were completed in the family's homes ($n = 164$) or over the phone for families who had moved from the area ($n = 35$). Assessments were conducted in English ($n = 173$) or in Spanish ($n = 26$) on the basis of family preference. The youths and parents separately completed assessments, each of which lasted approximately 2.5 h. At the end of the assessments, the assessors demonstrated the salivary cortisol collection procedures and provided instructions for in-home cortisol collection. Assessors telephoned families in the evening prior to each day of salivary collection to remind them of the procedures and to interview mothers about their stress in managing child problem behavior for the current day.

2.3 Measures

Indicators of maternal stress include parenting stress, intimate partner aggression, depression, physical health, substance use, socioeconomic disadvantage, and mothers' past exposure to abuse in childhood. Of the 7 maternal stress indicators, 6 were assessed when the youths were between ages 9 and 12. Maternal history of child abuse was assessed in the original HFA study when the child was age 36 months. Each indicator of maternal stress, except socioeconomic disadvantage, was log transformed due to positive skew.

2.3.1 Indicators of maternal stress

Parenting stress: Parenting stress was measured with the Parent Daily Report (PDR; Chamberlain & Reid, 1987), a 40-item checklist of daily child problem behaviors and the parenting stress associated with them. Trained assessors called families at the end of the day for 3 consecutive days. During each 5-to 10-min telephone call, assessors asked mothers whether each of the youth problem behaviors had occurred during the past 24 hours. Mothers responded using a *yes/no* format, and for any endorsed behavior, mothers were asked if the behavior was stressful or not. Consistent with procedures in prior research (Fisher & Stoolmiller, 2008), the proportion of youth behavior problems endorsed and rated as stressful was computed to determine the conditional probability of parenting stress, given child problem behavior. The conditional probability of parenting stress was significantly correlated across the 3 assessment days and thus averaged ($r = 0.28\text{--}0.48$, $p = 0.01\text{--}<0.001$). At least 1 problem behavior from the child was reported by 86% of mothers, with an average of 8.35 ($SD = 8.65$) problem behaviors reported across the 3 assessment days. Of all study mothers, 46% reported that experiencing youth problem behaviors had been stressful. The PDR has been shown to have acceptable interrater reliability and validity (Weinrott et al., 1979), and internal reliabilities for youth behavior problems and associated parental stress in this sample were 0.91 and 0.87, respectively.

Intimate partner aggression: Partner psychological and physical aggression was assessed using the Revised Conflict Tactics Scale (CTS2; Straus et al., 1996). Mothers reported the frequency of their own and their partners' use of aggressive tactics during the past year on a scale ranging from 0 (*never*) to 6 (*more than 20 times*), and responses were recoded to the midpoint (e.g., 8 [*6–10 times*] and 15 [*11–20 times*], and response 6 was recoded to 25) based on Straus et al.'s (1996) suggestion. We used the 8-item Psychological Aggression scale to assess the frequency of verbal acts intended to hurt the partner and the 12-item Physical Assault scale to assess the frequency of physical force used in the relationship. Maternal aggression and partner aggression correlated significantly, $r = .84$, $p < 0.001$ (psychological aggression), and $r = .67$, $p < 0.001$ (physical assault), and thus were averaged together to create composites of dyadic psychological aggression and physical assault within the couple. Consistent with prior research that has suggested that psychological aggression and physical assault represent a single latent construct of partner aggression (El-Sheikh et al., 2008), these variables were correlated in this sample, $r = .52$, $p < 0.001$, and averaged to create 1 indicator of partner aggression. The prevalence of any reported intimate partner aggression was 84.5% and the mean was 0.85 ($SD = 1.04$). Cronbach's alpha for partner aggression in this sample was 0.82.

Maternal depression: Maternal depression was assessed with the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), a 20-item self-report checklist of depressive symptoms. Mothers were asked to consider their experiences during the past week and rate the frequency with which they had experienced each item on a scale ranging from 0 (*rarely or none of the time*) to 3 (*most or all of the time*). The mean CES-D score for mothers in this study was 8.53 ($SD = 8.89$). Cronbach's alpha was 0.90.

Maternal physical health: Mothers were asked if they currently experienced any of 20 physical health problems, such as asthma, diabetes, heart disease, or high blood pressure. Mothers responded using a *yes/no* format. Endorsed health problems were summed to create an index of physical health stress. The mean number of physical health problems endorsed was 2.61 ($SD = 2.34$). Cronbach's alpha was 0.69.

Maternal substance use: Mothers were asked about the frequency with which they currently used tobacco, alcohol, marijuana, and other substances, including uppers, downers, opiates, and tranquilizers on a scale ranging from 0 (*never*) to 8 (*2–3 times a day [or more]*). Approximately 63% of mothers reported currently using at least 1 substance. Mean frequency was 1.60 ($SD = 3.08$) for tobacco, 1.63 ($SD = 1.99$) for alcohol, 1.40 ($SD = 2.07$) for marijuana, and 0.17 ($SD = 1.08$) for other substances. Volume was assessed by asking about the number of cigarettes smoked per day for tobacco use, the number of drinks consumed at 1 time for alcohol, and the amount of marijuana used at 1 time, ranging from 1 (*a joint*) to 5 (*ounces*). Volume was not assessed for the other substances. A frequency by volume score was calculated for tobacco, alcohol, and marijuana use and each score was standardized by calculating a z-score for each variable and summing all variables. The frequency scores for each of the other substances were likewise standardized by calculating z-scores and summing them with the tobacco, alcohol, and marijuana use scores to create a composite substance use score.

Maternal childhood history of abuse: Mothers used an adapted version of the Conflict Tactics Scales Parent-Child (CTSPC; Straus et al., 1998) to self-report the frequency with which their parent or another caregiver engaged in emotionally (5 items), physically (13 items), and sexually (2 items) abusive behaviors before they were age 18. Responses for questions about emotional and physical abuse were on a scale ranging from 0 (*never*) to 6 (*more than 20 times*), and responses were recoded in the same manner as for the intimate partner aggression measure. Responses for the sexual abuse questions were coded as 0 (*No, it did not happen*), 1 (*Yes, it happened just once*), or 2 (*Yes, it happened more than once*). Prior studies assessing maternal abuse history retrospectively with a modified version of the CTSPC have reported good internal reliability of the measure (Mah et al., 2013). The prevalence of any emotional or physical abuse in this sample was approximately 70% and the prevalence for any sexual abuse was approximately 20%. The mean frequency was 5.08 ($SD = 6.63$; range = 0–25) for emotional abuse, 3.24 ($SD = 1.85$; range = 0–16.54) for physical abuse, and 0.13 ($SD = 0.28$; range = 0–1) for sexual abuse. Each of the 3 abuse types was significantly correlated ($r = 0.47$ – 0.75 , $p < 0.001$) and thus the abuse types were standardized by calculating a z-score for each abuse type and summing them together to create a composite score of maternal childhood history of abuse. Cronbach's alpha was 0.89.

Socioeconomic disadvantage: Mothers self-reported about their annual, after-tax family income ($M = \$30,000$, $SD = \$15,000$), level of education, and the number of 22 types of social assistance benefits, including food stamps, housing assistance, disability benefits, and Social Security their family currently received ($M = 2.26$, $SD = 2.12$). Annual income, maternal education, and social service use were standardized by calculating a z-score for each indicator and summing them to create a composite index of socioeconomic

disadvantage. Income and maternal education scores were recoded prior to standardization so that higher scores were indicative of greater socioeconomic disadvantage.

2.3.2 Maternal Parenting

Inconsistent discipline: Use of inconsistent discipline was assessed using a modified version of the Poor Discipline Implementation subscale from the Discipline Questionnaire (Capaldi, 1995). Parents were asked to rate the frequency of 5 discipline practices by using a 5-point scale ranging 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 mean frequency was 2.12 ($SD = 0.66$). Cronbach’s alpha was 0.60.

Parental supervision: Parental supervision was assessed with the Monitor and Parent–Child Relationship Questionnaire (Capaldi, 1998). Parents were asked to rate the frequency of 6 supervision experiences during the previous 6 months (e.g., “How often has your child played out of adult eyesight and hearing by themselves?”) on a scale ranging from 1 (*never*) to 5 (*very often*). Responses were summed so that higher scores indicated lower levels of supervision. The mean frequency of parental supervision was 9.32 ($SD = 3.62$). Scores were log transformed due to positive skew. Cronbach’s alpha was 0.72.

Harsh parenting: Mothers self-reported their harsh parenting practices by using a modified version of the Parent–Child Conflict Tactics Scales (Straus et al., 1998). Our study used the 5-item Psychological Aggression scale and 5 items from the Physical Assault scale that represent minor physical assault. Mothers reported the frequency with which they had engaged in harsh parenting tactics in the previous year on a scale ranging from 0 (*never*) to 6 (*more than 20 times*), and responses were recoded in the same manner as for the intimate partner aggression measure. Maternal report of psychological and physical aggression were significantly correlated, $r = 0.48$, $p < 0.001$, and averaged together to create a composite of harsh parenting practices. The prevalence of any harsh parenting in this sample was 95%. The mean frequency was 26.49 ($SD = 25.51$). Cronbach’s alpha was 0.74.

2.3.3 Salivary Cortisol—Salivary cortisol samples were collected 3 times per day for 3 consecutive days in the youths’ homes. Saliva collection occurred 30 min after waking (morning), between 1600 h and 1700 h (afternoon), and 30 min prior to bedtime (evening), consistent with the collection procedures used in previous research (Johnson et al., 2011). See Martin et al. (2014) for detailed information regarding the cortisol collection and assay procedures. Cortisol values at each sampling time were significantly correlated at the $p < 0.001$ level across the 3 sampling days ($r = 0.40$ – 0.53 , 0.31 – 0.62 , and 0.37 – 0.43 , respectively), and results from repeated-measures ANOVA indicated that cortisol values did not differ significantly by day. Thus, as with previous research (Adam & Gunnar, 2001), the cortisol values were averaged across days. The average cortisol values by sampling time are presented in Table 1.

2.3.4 Covariates—Child gender, pubertal development (the Pubertal Development Scale; Petersen et al., 1998), and wake time on cortisol sampling days have been associated with diurnal cortisol slope (Edwards et al., 2001; Gunnar et al., 2009; Jessop & Turner-Cobb, 2008) and thus were included as covariates for this study. Wake time was significantly correlated across the 3 sampling days, $r = 0.48$ – 0.72 , $p < 0.001$, and was averaged across days.

2.4 Analytic Strategy

The primary analyses were conducted using Mplus version 7 (Muthén & Muthén, 1998–2012) using the full sample of 199 mothers. A Latent Profile Analysis (LPA) was conducted using the 3-step method (Asparouhov & Muthén, 2014) to examine how maternal parenting is related to adolescent diurnal cortisol slope under distinct profiles of maternal stress. In the first step, an LPA was estimated only with the 7 indicators of maternal stress. We used a stepwise procedure to test the profiles (Muthén, 2001) by running 2 through 5 profile models. The optimal number of profiles was selected using various model fit indicators and identifying the interpretability of each profile on the basis of mean indicator scores. The Bayesian information criterion (BIC), the sample size-adjusted BIC, and the Akaike information criteria are based on the log likelihood function and balance goodness of fit with parsimony. Lesser values or the smallest decrease in value between successive models indicate the best fit. The Lo-Mendell-Rubin Adjusted Likelihood Ratio Test and the bootstrap likelihood ratio test (BLRT) compare the fit of the current, more complex model to that of the prior, less complex model. A significant value indicates that the current model has a better fit. Entropy indicates the accuracy of profile assignment, with values greater than 80% considered acceptable. The BIC and BLRT have been found to be the best model fit indicators for determining the optimal number of profiles (Nylund et al., 2007) and were thus relied upon more heavily while selecting the best-fitting model. After the initial model selection, the latent class posterior probabilities for each observation that were obtained during step 1 were used in step 2 to create a nominal variable indicating the maternal stress profile to which each mother most likely belonged. The interpretability of each profile was then examined based on mean stress scores, and the selected model was confirmed. Finally, in step 3 of the LPA, the most likely profile was used as a latent class indicator variable. The parameters of the conditional distribution of the log ratios computed in step 2 were fixed to account for measurement error (Asparouhov & Muthén, 2014). A linear regression auxiliary model was then computed in which the effect of maternal parenting on adolescent diurnal cortisol slope was examined for each maternal stress profile. Adolescent gender, pubertal development, and average wake time were also added into the model in step 3. The effects of these covariates on adolescent diurnal cortisol slope were held constant across the maternal stress profiles.

Diurnal cortisol slope was estimated using latent growth curve modeling. We used 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 (Graham et al., 2012). An unconditional model without any predictors was fitted to examine the diurnal cortisol slope across the day. 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 loadings were fixed at 1. The slope factor loading for morning and evening cortisol was fixed at 0 and 1, respectively. The slope factor loading for afternoon cortisol was freely estimated. This model showed good fit, $X^2(4) = 1.16$, $P = 0.88$, CFI = 1.00, TLI = 1.00, and RMSEA = 0.00, and the slope factor was saved and used as an indicator of the estimated direction and magnitude of change in cortisol levels from morning to evening (see Martin et al., 2014, for additional information about the latent growth curve modeling).

3. Results

3.1 Latent Profile Analysis of Maternal Stress

Table 2 shows the model fit statistics from step 1 of the 3-step LPA from models with 2 to 5 profiles. Although the BLRT indicated that each model had a significantly better fit than did the prior model, the information criteria indicators, in general, indicated that the 4-profile model had the best fit. Additionally, the fit indices of the 5-profile model increased from those of the 4-profile model, which had the lowest values. Entropy was also the highest for the 4-profile model and in the acceptable range.

In step 2, the posterior probabilities obtained in step 1 were used to create nominal variables for the 4 profiles. After the 4-profile solution was reviewed for substantive meaning, it was selected as the best-fitting model. The first profile, which comprised 19% of the sample, was labeled *current parenting stress*. The mothers in this profile endorsed high levels of parenting stress in response to their adolescents' behavior problems. These mothers also endorsed some exposure to intimate partner aggression, depression, and physical health problems, but low levels of socioeconomic disadvantage or childhood abuse. The second profile comprised 9% of the sample and was labeled *concurrent parenting and childhood stress* because the mothers in this profile endorsed high levels of current parenting stress and a history of childhood abuse. The mothers in this profile also reported exposure to all the other current stressors, particularly physical health problems, depression, and substance abuse. Another 20% of the sample was grouped into the third profile, labeled *childhood stress*. These mothers reported high rates of abuse during childhood, with low levels of stress on all the other current indicators of stress except socioeconomic disadvantage. The final profile, labeled *low stress*, comprised 53% of the sample, and these mothers endorsed low levels of stress across all the indicators. Figure 2 illustrates levels of maternal stress indicators by latent profile membership.

We sought to confirm and compare the patterns of maternal stress across the 4 identified profiles. A 1-way ANOVA with Bonferroni comparisons was performed using PASW Statistics 17 to examine profile differences across the 7 indicators (Figure 2). The sample size for these analyses ranged from 148 to 197 resulting from missing data on each of the indicators. There were significant differences across the maternal stress profiles for parenting stress, $F(3, 172) = 187.85$, $P < 0.001$; depression, $F(3, 191) = 6.05$, $P = 0.001$; physical health, $F(3, 192) = 9.47$, $P < 0.001$; history of child abuse, $F(3, 178) = 140.19$, $p < 0.001$; and socioeconomic disadvantage, $F(3, 193) = 6.70$, $p < 0.001$. As expected, mothers with the current parenting stress profile reported significantly more parenting stress than did the mothers in the other 3 profiles. Mothers with the concurrent parenting and childhood

stress profile reported having significantly more parenting stress and depression than did the mothers with the childhood stress and low stress profiles. They also endorsed significantly more physical health stress and child abuse compared with the mothers in the other 3 profiles. Mothers with the childhood stress profile endorsed significantly more child abuse than did mothers with the current parenting stress only or the low stress profiles. They also endorsed significantly greater socioeconomic disadvantage compared with the mothers in the low stress profile. Thus, mothers in the concurrent parenting and childhood stress profile endorsed experiencing more stressors overall and a greater frequency of abuse as children than did mothers in the other profiles, suggesting that these mothers may be at greatest risk.

In step 3 of the LPA, a linear regression auxiliary model (Asparouhov & Muthén, 2014) was tested to examine the effect of parenting on adolescent diurnal cortisol slope, given mother's stress profiles (Table 3). The effects of adolescent wake time on cortisol levels were controlled. Adolescent gender and pubertal development were not significantly associated with diurnal cortisol slope within any of the maternal stress profiles, and were removed from the model. For mothers with the concurrent parenting and childhood stress profile, inconsistent discipline, poor parental supervision, and harsh parenting were all significantly related to flattened diurnal cortisol slopes in their children. For mothers with current parenting stress and childhood stress profiles, their use of inconsistent discipline, but not poor parental supervision or harsh parenting, was significantly associated with flattened diurnal cortisol slopes in their children. None of the parenting behaviors were associated with children's diurnal cortisol slopes for mothers with the low stress profiles. Average wake time was significantly related to child diurnal cortisol slope (0.003 , $SE = 0.001$, $p < 0.001$), where later wake times were associated with flattened diurnal cortisol slopes. This was true regardless of mother's stress profile.

4. Discussion

The purpose of the present study was to examine whether the association between parenting behaviors and youth's HPA axis functioning would vary depending on parental stress in early adolescence. The findings indicated that when multiple potential stressors are considered, the mothers in this study experienced distinctive patterns of stress, with three stress profiles—current parenting stress, concurrent parenting and childhood stress, and childhood stress—and one low stress profile. Consistent with stress proliferation and stress sensitization models, the emergence of the concurrent parenting and childhood stress profile represents mothers whose experiences of childhood adversity may have increased their likelihood of experiencing subsequent stressful experiences (Turner & Schieman, 2008) or sensitized them to later stressors (Hammen et al., 2000). Mothers in this profile were not only more likely to experience parenting stress, but they were also more likely to experience depression, physical health problems, and socioeconomic disadvantage. Likewise, the emergence of the childhood stress profile fits with research finding that childhood abuse is not always associated with additional negative outcomes or stressors in adulthood, especially when resources for resiliency are available (Nurius et al., 2015). Finally, parenting can be a highly stressful endeavor (Dix, 1991), even in the absence of other stressors, fitting with the emergence of the current parenting stress profile.

Our findings also indicated that as expected, a mother's parenting behaviors were differentially related to her adolescent's diurnal cortisol rhythms on the basis of her stress profile. For the mothers in the low stress profile, who had had little to no exposure to childhood abuse or other current stressors, their use of inconsistent discipline, poor parental supervision, and harsh parenting behaviors in and of themselves were not linked to their adolescents' diurnal cortisol rhythms. In contrast, for mothers in the most at-risk profile, that is, the concurrent parenting and childhood stress profile, who were managing several stressors in addition to a history of childhood abuse, nonoptimal use of each of the parenting practices was directly related to blunted diurnal patterns of cortisol in their early adolescent children. Finally, for mothers in the childhood stress and the current parenting stress profiles, their use of erratic and inconsistent discipline practices were significantly associated with flattened diurnal cortisol rhythms in early adolescence. However, their use of poor supervision and harsh parenting was not significantly related to their adolescents' diurnal cortisol rhythms.

The finding that mothers' use of inconsistent discipline, poor parental supervision, and harsh parenting each was associated with flattened diurnal cortisol rhythms for children whose mothers have the concurrent parenting and childhood stress profile suggests that maternal history of child abuse with continued exposure to adverse experiences in adulthood seems to be an important determinant of risk for child cortisol regulation. Similar research that has examined cortisol regulation in children of Holocaust survivors suggests that blunted cortisol levels are more prevalent when the mother has a concurrent diagnosis of posttraumatic stress disorder (Yehuda et al., 2007). Our finding is likewise consistent with findings from studies that have examined the neurobiological effects of childhood abuse in adults (Heim et al., 2004; Rinne et al., 2002) and in children (Kaufman et al., 1997), that is, a childhood history of abuse alone is typically insufficient but when combined with ongoing stress in the form of depression or other psychological stressors, is related to neurobiological dysregulation. These results suggest that there may be intergenerational effects of maternal stress on children's HPA axis regulation and that these effects tend to emerge when mothers' discipline practices are inconsistent, supervision is lacking, and harsh parenting practices are implemented.

Inconsistent discipline may be a particularly salient predictor of adolescent diurnal cortisol dysregulation, as adolescents whose mothers in all 3 stress profiles evidenced flattened diurnal cortisol rhythms in association with its use. Inconsistent application and enforcement of rules and inconsistent use of specific discipline strategies portray a parenting environment that is unpredictable and lacks structure or routine in the adolescent's daily life. Whereas lack of control during acute psychological stressors is known to elicit a cortisol response (Dickerson & Kemeny, 2004), chronic exposure to uncontrollable stress is associated with flattened diurnal cortisol slopes (Miller et al., 2007). Inconsistent discipline among parents appears to be more persistent across childhood than are other problematic parenting behaviors, such as lack of parental supervision (Luyckx et al., 2011), and thus may be more likely to affect children's behavior and stress-response neurobiological systems throughout development. Research examining the negative psychological and behavioral outcomes of poor parenting practices has also shown differential results, in which inconsistent use of discipline, not harsh parenting practices, drives these relationships (Duncombe et al., 2012).

Our findings further support the particularly problematic role of inconsistent discipline and expand this finding to cortisol dysregulation in early adolescence.

Our finding of differential sensitization of the HPA axis based upon mother's parenting behaviors and their past and current stress profiles has important implications for parenting interventions. Inconsistent discipline, poor parental supervision, and harsh parenting have consistently been associated with externalizing behavior in children (Duncombe et al., 2012; Luyckx et al., 2011; MacKenzie et al., 2013), and interventions based on parent management training models aimed at increasing parental supervision and consistent parental use of nonharsh discipline strategies have largely been established as effective, evidence-based treatments (Kazdin, 1997). However, such evidence-based parenting interventions have not been found to be effective for all families, and in particular, they have been found to be less effective when mothers are dealing with their own stressors, including maternal depression and poor psychological health (Maliken & Katz, 2013; McMahon et al., 2006). Thus, for mothers in the current parenting stress profile who find it particularly stressful to manage their children's problematic behaviors and for mothers in the childhood stress profile who are not struggling with any current stressors, participation in a parenting intervention designed to help them become more consistent in their application of rules and discipline may likely be an effective approach toward mitigating the neurobiological effects of unpredictable parenting environments (Fisher & Stoolmiller, 2008). Empirical research is needed to determine whether parenting interventions for mothers with current and childhood stressors might benefit from integrating psychological interventions aimed at helping mothers regulate their own emotions in response to the various ongoing adversities they are managing and whether such an intervention would, in turn, mitigate adolescent cortisol dysregulation. Findings from this study suggest that in addition to considering specific parenting practices and youth behaviors in assessment and treatment planning, clinicians and interventionists should also assess and consider mothers' exposure to current and childhood stressors, provided that parenting practices do not occur in isolation from mothers' own stressful life experiences.

4.1 Limitations

The data for this study are cross-sectional, so causal inferences cannot be confirmed. Moreover, it could be that maternal stressors experienced pre- or postnatally or that early-childhood adversities were largely responsible for programming effects of the adolescents' stress response neurobiological systems (Lupien et al., 2009). Longitudinal research is sorely needed to fully understand the development of the HPA axis throughout childhood. Because mothers retrospectively reported their maltreatment histories, some abuse may have been forgotten or occurred too early in childhood to have been remembered. Moreover, we relied on maternal-report for our measures of maternal stress and parenting practices and future research would benefit from a multimethod assessment. Finally, although Tein and colleagues' (2013) simulation study indicated that sample size is not consistently related to the power to detect the correct number of profiles in a LPA, our analyses were likely to be underpowered. Therefore, it is possible that we incorrectly identified the number of maternal stress profiles, making it all the more important that these findings be interpreted with caution and replicated.

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 (CAR). Moreover, although we employed sampling procedures consistent with prior studies (e.g., Adam & Kumari, 2009; Fisher et al., 2011; Johnson et al., 2011; Koss et al., 2014; Kroupina et al., 2012; Russ et al., 2012), assessing diurnal cortisol slope using the peak morning value confounds slope with the CAR. Future research should examine the CAR and diurnal cortisol slope outside of the CAR. Likewise, other indices of HPA axis regulation, such as cortisol reactivity, have been shown to change during early adolescence (Gunnar et al., 2009), and future research should also include such indices when examining the relationships between maternal stress, parenting, and child HPA axis regulation. Finally, although mothers reported saliva collection times, we did not monitor them electronically and cannot confirm their accuracy.

4.2 Conclusions

Despite its limitations, our study contributes to the literature in numerous ways. Our study supports a model of differential sensitization of the HPA axis based upon maternal parenting practices. The relationship of the specific parenting behaviors examined—inconsistent discipline, parental supervision, and harsh parenting—with adolescent diurnal cortisol profiles depended on mothers' experience of current and ongoing stress. This finding suggests that the widely accepted one-size-fits-all approach to parent management interventions may not be appropriate for all mothers, especially those with childhood and ongoing stressors. The present findings also suggest that maternal stress and parenting behaviors on HPA axis functioning continue to be significant beyond childhood and into early adolescence. These findings highlight how mothers' stress profiles interact in distinct ways with their parenting behaviors and how these dynamic environmental mechanisms drive their children's stress regulation and in particular, their HPA axis functioning.

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Highlights

- Profile analytic approach to examine how phenotypes of maternal stress co-occur.
- Mothers with concurrent parenting and childhood stress appear to be most at-risk.
- The effects of parenting on child diurnal cortisol slope depend on maternal stress.
- One-size-fits-all approach to parent training interventions may need re-evaluation.

Figure 1.

Conceptual model for dimensions of maternal stress as a moderator between distinct parenting behaviors and early adolescent diurnal cortisol rhythms.

Figure 2.
Maternal stress indicators by latent profile membership.

Table 1

Average cortisol values in micrograms per deciliter (ug/dl) by time of sampling, maternal stress profile, and parenting behaviors

	Current Parenting Stress	Concurrent and Childhood Stress	Parenting Childhood Stress	Low Stress
Inconsistent discipline				
Morning	0.395	0.365	0.383	0.425
Afternoon	0.129	0.129	0.136	0.131
Evening	0.069	0.055	0.099	0.071
Poor supervision				
Morning	0.399	0.376	0.383	0.421
Afternoon	0.130	0.127	0.136	0.131
Evening	0.069	0.051	0.100	0.071
Harsh parenting				
Morning	0.400	0.363	0.389	0.413
Afternoon	0.125	0.126	0.136	0.134
Evening	0.074	0.054	0.104	0.071

Note. Means are adjusted by average wake time.

Table 2

Model fit statistics for LPA for maternal stress

No. of profiles	LL	AIC	BIC	adj BIC	LMR	<i>p</i>	BLRT	<i>p</i>	Entropy
2	-1242.88	2529.76	2602.22	2532.52	58.33	< .001	-1272.74	< .001	0.66
3	-1210.78	2481.55	2580.35	3485.31	27.97	0.28	-1225.09	< .001	0.68
4	-1164.52	2405.04	2530.18	2409.80	46.87	0.33	-1188.51	< .001	0.84
5	-1197.13	2486.25	2637.75	4492.02	8.31	0.65	-1201.38	< .001	0.75

Note. LPA = latent profile analysis; LL = log likelihood; AIC = Akaike information criterion; adj BIC = sample size-adjusted Bayesian information criterion; LMR = Lo-Mendell-Rubin; BLRT = bootstrap likelihood ratio test; *p* = *p*-value.

Table 3

Parameter estimates for early adolescent diurnal cortisol slope.

Parameter	Estimate	SE
Current parenting stress		
Inconsistent discipline	0.005 *	0.003
Poor parental supervision	0.008	0.005
Harsh parenting	0.002	0.002
Concurrent parenting and childhood stress		
Inconsistent discipline	0.005 *	0.002
Poor parental supervision	0.022 ***	0.004
Harsh parenting	0.004 ***	0.001
Childhood stress		
Inconsistent discipline	0.029 *	0.014
Poor parental supervision	0.002	0.016
Harsh parenting	-0.004	0.007
Low stress		
Inconsistent discipline	-0.003	0.002
Poor parental supervision	0.004	0.005
Harsh parenting	0.000	0.001

Note. Parameter estimates are unstandardized.

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$.