Cortisol Production Patterns in Young Children Living With Birth Parents vs Children Placed in Foster Care Following Involvement of Child Protective Services

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Objective: To examine differences in waking to bedtime cortisol production between children who remained with birth parents vs children placed in foster care following involvement of Child Protective Services (CPS).

Design: Between-subject comparison of cortisol patterns among 2 groups of children.

Setting: Children referred from the child welfare system.

Participants: Three hundred thirty-nine children aged 2.9 to 31.4 months who were living with birth parents (n=155) or placed in foster care (n=184) following CPS involvement as well as 96 unmatched children from low-risk environments.

Main Exposures: Involvement by CPS and foster care.

Main Outcome Measure: Salivary cortisol samples obtained at waking and bedtime for children on 2 days.

Results: Child Protective Services–involved children who continued to live with birth parents and CPS-involved children placed in foster care differed in cortisol production, with children living with their birth parents showing flatter slopes in waking to bedtime values.

Conclusions: Continuing to live with birth parents following involvement of CPS is associated with greater perturbation to the diurnal pattern of cortisol production than living with foster parents. Foster care may have a regulating influence on children's cortisol among children who have experienced maltreatment.


The functioning of the hypothalamus-pituitary-adrenal (HPA) axis is vulnerable to the effects of early adversity. Experimental studies with rodent and nonhuman primate young as well as correlational studies (or natural experiments) with young children have shown that neglect and separation from caregivers are associated with perturbations to the functioning of the HPA axis.1-6 In particular, experiences of neglect and separation from caregivers affect the production of glucocorticoids (cortisol among humans), an end product of the HPA axis. Alterations to the diurnal pattern of cortisol production have been seen among children living with their birth parents following maltreatment and among neglected children placed in foster care.1-6 In previous studies, it has not been possible to discern whether children who continue to live with their birth parents or those placed in foster care have shown greater perturbations in HPA functioning following involvement of Child Protective Services (CPS). Our study addresses this question.

A typical daytime cortisol pattern is characterized by a high waking value (peaking about 30 minutes after waking), followed by a rapid decline and then a slow drop-off across the day, reaching a nadir at bedtime. This pattern begins to emerge in the first 2 months of life, with mature functioning emerging by 5 to 6 years of age.7,8 Young children who have experienced neglect often differ from children from low-risk environments in showing a more blunted pattern of cortisol production across the day.3-5 Morning levels of cortisol have been shown to be lower with a flatter waking to bedtime slope than for other children.

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These findings have emerged for neglected children living with their birth parents and for neglected children placed in foster care.3-5 In the studies conducted to date, high-risk children (neglected children living with birth parents or with
foster parents) have been compared with children with no known risk factors. To our knowledge, no study has contrasted HPA functioning of children living with birth parents vs HPA functioning of children living with foster parents following involvement of CPS.

The primary aim of this study was to examine daily cortisol production patterns among maltreated children following involvement of CPS. Specifically, we were interested in whether there were differences in daily cortisol production between CPS-involved children who continued to live with their birth parents and children who were placed into foster care. We included data from a third group of unmatched children from low-risk conditions to provide an estimate of typical levels of cortisol among children of this age. We hypothesized that, relative to children living with foster parents following involvement of CPS, 155 of the children continued to live with their birth parents and 184 of the children were placed in foster care. For those placed in foster care, it was the first placement for 138 children (75%), the second placement for 42 (23%), the third placement for 2 (1%), and the fourth placement for 2 (1%). The duration with the current foster parent at the time of sampling until the children were healthy again.

Participants

Primary participants included 339 children, ranging in age from 2.9 to 31.4 months (mean [SD], 12.9 [6.9] months). All children were involved with CPS and referred for participation in ongoing longitudinal studies assessing the effectiveness of an attachment-based parenting intervention; only children’s pre-intervention data were included in this study. Following involvement of CPS, 155 of the children continued to live with their birth parents and 184 of the children were placed in foster care. For those placed in foster care, it was the first placement for 138 children (75%), the second placement for 42 (23%), the third placement for 2 (1%), and the fourth placement for 2 (1%). The duration with the current foster parent at the time of enrollment in our study ranged from 0.1 to 18.1 months (mean [SD], 3.6 [3.6] months). Secondarily, 96 children from low-risk environments were included. Participants in the low-risk group were recruited from a university-based child care center.

Table 1 shows demographic characteristics of each group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Male</th>
<th>Female</th>
<th>White</th>
<th>African American</th>
<th>Hispanic</th>
<th>Biracial</th>
<th>Age, Mean (SD), mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPS-involved, stayed with birth parents (n=155)</td>
<td>38 (54)</td>
<td>33 (46)</td>
<td>8 (11)</td>
<td>44 (62)</td>
<td>13 (18)</td>
<td>6 (9)</td>
<td>12.7 (6.6)</td>
</tr>
<tr>
<td>CPS-involved, placed in foster care (n=184)</td>
<td>69 (57)</td>
<td>52 (43)</td>
<td>32 (27)</td>
<td>77 (64)</td>
<td>7 (6)</td>
<td>4 (3)</td>
<td>11.2 (6.5)</td>
</tr>
<tr>
<td>Low-risk environment (n=96)</td>
<td>46 (54)</td>
<td>39 (46)</td>
<td>49 (58)</td>
<td>21 (25)</td>
<td>8 (9)</td>
<td>7 (8)</td>
<td>16.1 (6.6)</td>
</tr>
</tbody>
</table>

Abbreviation: CPS, Child Protective Services.

Cortisol Data Preparation

Following procedures commonly used in previous studies, cortisol values 3 SDs above the mean were considered outliers and excluded from analyses. Each child could have up to 4 cortisol values (ie, 2 waking and 2 bedtime samples). Of 1740 possible samples, 61 outliers were removed and 126 samples were missing due to an inadequate volume of saliva or because no sample was taken, representing approximately 11% of the data. Missing data patterns were comparable across groups, with children living with birth parents missing approximately 9%, children living with foster parents missing 13%, and children from low-risk environments missing 10% (Table 2). Log10 transformation was used to normalize the distribution of cortisol values owing to a positive skew.

Preliminary Analyses

Demographic variables were examined to determine whether child characteristics were associated with log-transformed cortisol values. Child age, sex, and minority status were not associated with cortisol values at any of the time points (P > .05).

Time of sample collection was also not associated with cortisol values at any of the time points (P > .05). Despite these findings, child age and sampling time were included in primary
analyses as both have been significantly related to cortisol levels in previous studies.\(^7\),\(^8\),\(^11\)

**DATA ANALYTIC STRATEGY**

Group differences in cortisol levels at waking and bedtime as well as change in cortisol levels across the day were analyzed using hierarchical linear modeling.\(^12\) Hierarchical linear modeling treats repeated observations as nested within individuals, allowing for separate estimates of within-subject (level 1) and between-subject (level 2) variation. This nesting accounted for the nonindependence of multiple samples from the same child. Rather than aggregating across days to create an average waking cortisol level and an average bedtime cortisol level for each child (resulting in only 2 data points per child), all samples were used as level 1 data (resulting in up to 4 data points per child). This approach is more appropriate than averaging across samples because it accounts for measurement error associated with each sample.\(^13\) Data were analyzed in 2 steps. First, CPS-involved children living with birth parents were compared with CPS-involved children living in foster care. Then, children from low-risk environments were included as a reference group to provide an estimate of typical cortisol levels.

The dependent variable was the log-transformed cortisol value, measured in micrograms per deciliter. Cortisol sample collection time (in hours since the average waking sample time) was included as a time-varying covariate. The following level 1 within-individual model was specified:

\[
\log\text{cortisol}_i = \pi_0 + \pi_1(\text{sample}) + \pi_2(\text{time}) + \epsilon_i
\]

where log cortisol\(_i\) represents the log-transformed cortisol value for child \(i\) at time \(t\); \(\pi_0\) represents child \(i\)'s estimated log cortisol value at waking when controlling sampling time; \(\pi_1\) is the estimated slope of cortisol change from waking to bedtime; \(\pi_2\) is the regression coefficient representing the effect of the time-varying covariate (ie, sampling time); sample represents the time of day of the sample (with 0 representing waking and 1 representing bedtime); \(\epsilon_i\) is the within-individual error in child \(i\)'s log cortisol value.

Level 2 variables were included to examine whether group status (ie, CPS-involved children living with birth parents or CPS-involved children living with foster parents) predicted individual differences in cortisol levels at waking or bedtime and in change across the day. Group status was dummy coded (0 for children living with foster parents, 1 for children living with birth parents) to allow for comparisons among individuals between the 2 groups. Child age was included as a control variable given that previous studies have found changes in cortisol production across development.\(^8\) The resulting level 2 model can be represented as follows:

\[
\pi_0 = \beta_{00} + \beta_{01}(\text{CPS-birth}) + \beta_{02}(<\text{child's age}) + \epsilon_0
\]

\[
\pi_1 = \beta_{10} + \beta_{11}(\text{CPS-birth}) + \beta_{12}(<\text{child's age}) + \epsilon_1
\]

\[
\pi_2 = \beta_{20}
\]

where \(\pi_0\) represents the waking log cortisol value for an individual and \(\pi_1\) represents the linear change (slope) in log cortisol across the day for an individual; the term \(\beta_{01}\) represents the average estimated log cortisol level at waking for CPS-involved children living with foster parents, controlling for child's age; \(\beta_{02}\) is the difference in the waking log cortisol value between the CPS-involved children living with foster parents and the CPS-involved children living with birth parents (ie, the group
To examine group-related differences in the diurnal pattern of cortisol production, we examined whether group status predicted the waking level of cortisol (intercept) and the change in cortisol level from waking to bedtime (slope). Results of the first model are summarized in Table 3. When controlling for sample collection time (at level 1) and child’s age (at level 2), the log cortisol waking level differed significantly between CPS-involved children placed in foster care and CPS-involved children who continued to live with their birth parents, with children living with birth parents showing a lower waking level of cortisol (Table 3).

The model was rerun with the bedtime sample as the intercept, indicating that CPS-involved children living with their birth parents had significantly higher cortisol levels at bedtime than children living with foster parents (β11 = .20; P = .001). Furthermore, the change in cortisol level across the day differed significantly between the groups, with CPS-involved children living with their birth parents showing a more blunted pattern (i.e., flatter slope) than children living with foster parents (Table 3).

The secondary analysis including the low-risk children as the reference group indicated that both CPS-involved children living with their birth parents and those living with foster parents differed significantly from the low-risk children in terms of their waking cortisol levels and slope across the day (Table 4). Whereas CPS-involved children living with birth parents also differed from low-risk children in their bedtime cortisol levels (β20 = .26; P < .001), children placed in foster care did not (β21 = .05; P = .46). Comparison of the magnitude of differences between low-risk children and CPS-involved children indicates that CPS-involved children living with their birth parents showed the most blunted pattern of diurnal cortisol production. The Figure presents the estimates of the waking and bedtime values for each group.

### Table 3. Multilevel Modeling Coefficients of Group Effects on Diurnal Cortisol Production

<table>
<thead>
<tr>
<th>Effect</th>
<th>β Coefficient (SE)</th>
<th>t Statistic</th>
<th>df</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, β00</td>
<td>−.65 (.03)</td>
<td>−19.97</td>
<td>326</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>CPS-birth, β01</td>
<td>−.09 (.05)</td>
<td>−1.94</td>
<td>326</td>
<td>.05</td>
</tr>
<tr>
<td>Child’s age, β02</td>
<td>−.00 (.00)</td>
<td>−.71</td>
<td>326</td>
<td>.48</td>
</tr>
<tr>
<td>Sample slope, β10</td>
<td>−.45 (.04)</td>
<td>−11.82</td>
<td>326</td>
<td>.002</td>
</tr>
<tr>
<td>CPS-birth, β11</td>
<td>.30 (.06)</td>
<td>5.21</td>
<td>326</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Child’s age, β12</td>
<td>−.00 (.00)</td>
<td>−.77</td>
<td>326</td>
<td>.51</td>
</tr>
<tr>
<td>Time slope, β20</td>
<td>−.00 (.01)</td>
<td>−.21</td>
<td>1067</td>
<td>.84</td>
</tr>
</tbody>
</table>

Abbreviation: CPS, Child Protective Services.

β01 and β02 represent the waking level of cortisol and the slope of cortisol production across the day, respectively, for children living with foster parents. β11 and β12 represent the difference in the waking level of cortisol and the slope of cortisol production across the day, respectively, between CPS-involved children living with foster parents and CPS-involved children living with their birth parents.

Consistent with previous studies,13 our results indicate that CPS-involved children, who have typically experienced maltreatment, differ from low-risk children in showing lower waking cortisol values and flatter patterns of cortisol production from waking to bedtime. The findings go beyond prior studies to show that CPS-involved children who continue to live with their birth parents appear to have the greatest perturbation to their systems. Children living with their birth parents have lower waking cortisol values and flatter patterns of cortisol values than both CPS-involved children living with foster parents and children from low-risk environments, and they have flatter slopes from waking to bedtime than other children.

Although foster care involves disruptions in children’s relationships with parents, children are better able to regulate their neuroendocrine systems when living with foster parents than when they continue to live with ne-
The greatest limitation of this study is that it did not randomly assign children to conditions of neglect or foster care, and therefore a third variable (or variables) could account for the findings. Indeed, we expect that the 2 groups of children who experienced maltreatment differ from the comparison children perhaps in ways that are important to HPA regulation. Nonetheless, the 2 groups of CPS-involved children (those who continued to live with birth parents and those placed in foster care) provide reasonable comparisons for one another. Differences in prenatal histories would likely be expected to favor children living with birth parents, making it unlikely that obtained differences between these 2 groups are attributable to prenatal factors.

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Author Contributions: Study concept and design: Bernard and Dozier. Acquisition of data: Bernard, Butzin-Dozier, and Rittenhouse. Analysis and interpretation of data: Bernard, Butzin-Dozier, Rittenhouse, and Dozier. Drafting of the manuscript: Bernard, Butzin-Dozier, Rittenhouse, and Dozier.

Table 4. Multilevel Modeling Coefficients of Group Effects on Diurnal Cortisol Production With Low-Risk Children as Reference Group

<table>
<thead>
<tr>
<th>Effecta</th>
<th>β Coefficient (SE)</th>
<th>t Statistic</th>
<th>df</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, β₀₀</td>
<td>-0.49 (0.04)</td>
<td>-11.12</td>
<td>411</td>
<td>&lt;.001</td>
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<tr>
<td>CPS-foster, β₁₁</td>
<td>-0.18 (0.05)</td>
<td>-3.27</td>
<td>411</td>
<td>.002</td>
</tr>
<tr>
<td>CPS-birth, β₀₂</td>
<td>-0.26 (0.06)</td>
<td>-4.71</td>
<td>411</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Child’s age, β₀₃</td>
<td>-0.00 (0.00)</td>
<td>-0.84</td>
<td>411</td>
<td>.40</td>
</tr>
<tr>
<td>Sample slope, β₁₀</td>
<td>-0.67 (0.14)</td>
<td>-4.72</td>
<td>411</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>CPS-foster, β₁₁</td>
<td>0.22 (0.07)</td>
<td>3.41</td>
<td>411</td>
<td>.001</td>
</tr>
<tr>
<td>CPS-birth, β₀₂</td>
<td>0.52 (0.07)</td>
<td>7.76</td>
<td>411</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Child’s age, β₀₃</td>
<td>0.00 (0.01)</td>
<td>0.60</td>
<td>411</td>
<td>.55</td>
</tr>
<tr>
<td>Time slope, β₀₃</td>
<td>-0.00 (0.00)</td>
<td>-0.18</td>
<td>1345</td>
<td>.86</td>
</tr>
</tbody>
</table>

Abbreviation: CPS, Child Protective Services.

aβ₀₀ and β₁₀ represent the waking level of cortisol and the slope of cortisol production across the day, respectively, for low-risk children. β₀₁ and β₁₁ represent the difference in the waking level of cortisol and the slope of cortisol production across the day, respectively, between low-risk children and CPS-involved children living with their birth parents. β₀₂ and β₁₂ represent the difference in the waking level of cortisol and the slope of cortisol production across the day, respectively, between low-risk children and CPS-involved children living with their birth parents.

Figure. Cortisol patterns for Child Protective Services (CPS)–involved children who stayed with birth parents, CPS-involved children placed in foster care, and low-risk children. Cortisol levels were measured as micrograms per deciliter (to convert to nanomoles per liter, multiply by 27.588). Error bars indicate SE.

Table 4. Multilevel Modeling Coefficients of Group Effects on Diurnal Cortisol Production With Low-Risk Children as Reference Group

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REFERENCES


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