



Short Communication

Effects of institutional rearing on children's diurnal cortisol production

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ABSTRACT

Young children living in institutional settings often show a range of deficits in social, physical, and cognitive functioning. Whereas the diurnal production of cortisol has been examined among post-institutionalized children in a number of investigations, studies of children continuing to live in institutions are limited. In this study, we assessed wake-up and bedtime cortisol among 73 children living in Russia, with 52 institutionally-reared ($n = 31$ at time 2), and 21 family-reared ($n = 18$ at time 2). Institutionally-reared children showed a blunter wake-up to bedtime slope than family-reared children at both time 1 and time 2, with significantly higher cortisol levels at bedtime. These findings highlight the deleterious effects of institutional care on children's developing neuroendocrine regulation.

1. Introduction

UNICEF estimates that at least 2.7 million children live in orphanage or institutional care worldwide (UNICEF, 2017). Institutions are typically characterized by low staff to child ratio, a lack of individualized care, and little opportunity for caregiver/child social interactions. Because young children are biologically prepared to expect input from interactive partners, the lack of such input impedes behavioral and biological development (Dozier et al., 2014). Institutional care has pervasive problematic effects on young children's development, including effects on diurnal production of cortisol (e.g., McLaughlin et al., 2015; Zeanah et al., 2017). A blunted pattern of cortisol production has been seen among post-institutionalized children in most studies, although elevated levels of cortisol production have been seen in some studies (e.g., Fries et al., 2008; Gunnar et al., 2001; Van der Vegt et al., 2009). Adversity has been associated with blunted patterns of diurnal cortisol production in other populations as well (e.g., Bernard et al., 2010). Meta-analytic evidence suggests that blunted cortisol rhythms are associated with poor mental and physical health outcomes (Adam et al., 2017).

Attempts have been made to enhance orphanage care through improving the structure of orphanage care and increasing caregiver training, yielding some positive effects on children's outcomes, although effects on cortisol regulation have not been reported (McCall et al., 2016; St. Petersburg-USA Orphanage Research Team, 2008).

Given that orphanage care is used widely in most parts of the world, it is important to ascertain whether enhanced orphanage care adversely affects children's functioning, specifically with regard to cortisol regulation.

Most of the research on cortisol production has been conducted among children following rather than during institutional care, with several notable exceptions. Carlson and Earls (1997) found a blunted slope among 40 children in a Romanian institutional setting relative to family-reared children. The study was conducted in the early highly depriving years post-Ceasescu. Also, cortisol was sampled at 8 a.m. and late afternoon rather than wake-up and bedtime. In a study conducted prior to improvements in institutional environments in the Russian Federation, Kroupina et al. (1997) found a blunter slope among a small sample ($n = 10$) of institutionally-reared children than among family-reared children. Dobrova-Krol et al. (2008) found evidence of an interaction of stunting with institutional rearing in predicting diurnal production of cortisol, but no main effects of institutional rearing among a small sample ($n = 16$) of institutionally-reared children in Ukraine. Similarly, Dobrova-Krol et al. (2010) found that HIV status interacted with institutional rearing in predicting diurnal cortisol but a main effect of institutional rearing did not emerge. As with the Dobrova-Krol et al. (2008) study, the sample was very small ($n = 24$ in institutionalized group), with limited power to detect effects. These studies, while important, are limited in their relatively small sample size. Further, children in these settings were living in moderately to

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extremely depriving settings.

2. Current study

Given that many children continue to live in institutional care rather than move into adoptive care, it is important to examine effects of orphanage care while children are in institutions. Examining effects on children living in orphanages with enhanced conditions is particularly important because different perspectives have been taken regarding the effects of such conditions on children's functioning (e.g., Dozier et al., 2014; St. Petersburg-USA Orphanage Research Team, 2008).

The current study examined differences in diurnal cortisol production between institutionally-reared and family-reared children in the Russian Federation at two time-points. Children were recruited from institutions with enhanced conditions (e.g., reduced caregiver/child ratio and training in responsiveness for caregivers). We hypothesized that institutionally-reared children would have flatter wake-up to bedtime slopes than family-reared children, given the non-optimal caregiving experiences associated with institutional care. We examined effects of duration in orphanage care, but our measure was limited because we lacked information about previous orphanages. We also examined change over time, but did not have specific hypotheses because children had resided in orphanages for variable lengths of time and the interval between assessments was short.

3. Methods

3.1. Participants

Participants included 73 children living in the Russian Federation. Of these, 52 (27 male) were living in institutions, and 21 (14 male) were family reared. For the institutionally-reared group, the average time in the current orphanage was 6.1 months (SD = 6.5) at the first assessment. Family-reared children had not experienced significant separations from their parents. For both groups, children were excluded if they had significant neurological impairments, such as Cerebral Palsy or Down Syndrome. Institutionally-reared children were 21.3 months old (SD = 9.2) at the time of the first assessment and family-reared children were 20.1 months old (SD = 9.9). At the second assessment, 31 institutionally-reared and 17 family-reared were included. Most children were lost to follow-up from the institutionally-reared group because they moved into foster or adoptive care. The time from initial assessment to follow-up averaged 3.5 and 4.2 months for institutionally-reared and family-reared groups, respectively. Family-reared children were recruited through ads placed on social media platforms used by families in St. Petersburg. The median monthly income was about 95,000 rubles (~1436 USD), with most families above the reported mean monthly income of 59,604 rubles for the city of St. Petersburg (2018 State Statistics, <http://www.gks.ru>). The study was approved by the Institutional Review Board of St. Petersburg State University. Children's guardians or parents consented to their participation.

3.2. Procedure

3.2.1. Saliva sampling

The procedures used for collecting and assaying cortisol followed established protocols (e.g., Bernard et al., 2010). Caregivers collected saliva samples from children twice daily (within 30 min of waking and immediately before bedtime) during a 3-day period. Time since waking was not significantly correlated with any of the morning cortisol values, whereas time of sampling was significantly correlated with cortisol values for several samples; thus, time of sampling was included as a covariate in analyses. The saliva samples were stored in a freezer at -20 °C prior to assay procedures. Samples were assayed using a high sensitivity salivary cortisol enzyme immunoassay kit (Salimetrics, LLC). All

samples from a child were assayed in duplicate on the same plate to minimize variability. All intra- and inter-assay coefficients of variation fell below 10%. Biologically implausible cortisol values (> 2.0 ug/dL) were deleted; cortisol values greater than 3 SD above the mean were considered outliers and excluded from analyses. Cortisol values were log-transformed due to positive skew.

3.3. Data analytic plan

Group differences (institutional-reared vs. family-reared) in cortisol levels and cortisol slope were examined using hierarchical linear modeling (HLM; Raudenbush and Bryk, 2002). HLM treats repeated measurements at level 1 as nested within individuals at level 2, thus accounting for the nonindependence of data points and modeling error at both the within-subject and between-subject levels.

The data were analyzed using a multivariate statistical model. Log-transformed cortisol values measured at wake-up and bedtime at the initial timepoint (T1) and the follow-up timepoint (T2) were stacked to create the dependent variable. The following level 1 within-individual model was specified:

$$\text{Log cort}_{ti} = (T1)_{ti}[\pi T1_{0i} + \pi T1_{1i}(\text{Sample}) + \pi T1_{2i}(\text{Sampling_Time})] + (T2)_{ti}[\pi T2_{0i} + \pi T2_{1i}(\text{Sample}) + \pi T2_{2i}(\text{Sampling_Time})] + \epsilon_{ti}$$

where Log cort_{ti} is the log-transformed cortisol value for child i at time t ; $(T1)_{ti}$ and $(T2)_{ti}$ are dummy-coded indicators for time point; Sample represents whether the cortisol sample was collected at wake-up or bedtime (0 = wake-up, 1 = bedtime); $\pi T1_{0i}$ and $\pi T2_{0i}$ represent child i 's estimated log-transformed cortisol value at wake-up at T1 and T2, respectively; $\pi T1_{1i}$ and $\pi T2_{1i}$ are the estimated slopes of cortisol change from wake-up to bedtime at T1 and T2, respectively; and ϵ_{ti} is the within-individual error in child i 's log-transformed cortisol value. Time of sampling (mean-centered) was included as a time-varying covariate.

At level 2, between-subject predictors were included to examine whether there were group differences in cortisol levels at wake-up or bedtime and cortisol change across the day at each time-point. We provide the level 2 between-subjects equations for the intercept and slope at T1 as examples:

$$\pi T1_{0i} = \beta T1_{00} + \beta T1_{01}(\text{Institutionally-reared}) + \beta T1_{02}(\text{Male}) + \beta T1_{03}(\text{Age}) + r T1_{0i}$$

$$\pi T1_{1i} = \beta T1_{10} + \beta T1_{11}(\text{Institutionally-reared}) + \beta T1_{12}(\text{Male}) + \beta T1_{13}(\text{Age}) + r T1_{1i}$$

where $\pi T1_{0i}$ represents the wake-up log-transformed cortisol value (intercept) for an individual at T1; $\pi T1_{1i}$ represents the linear change (slope) in log-transformed cortisol across the day for an individual at T1. Similar equations were included for the intercept and slope at T2, as well as for the time-varying covariate of sampling time. Rearing group was included as a level 2 predictor, and child gender and age were included as covariates (See Table 1 note for interpretation of all β coefficients).

Planned contrasts were tested using the hypothesis testing function in HLM to explore whether there were differences in cortisol levels or diurnal slopes across time points. In order to compare wake-up levels, bedtime levels, and slopes between T1 and T2 within each group, separate models were estimated with variables re-centered for each comparison of interest.

Exploratory analyses were conducted using only data from institutionally-reared children to examine the effect of total months in institutional care (available for 38 children) and months in current institution (available for all 52 children) on cortisol. These analyses paralleled those described above, with duration in care variables added as level 2 predictors; additionally, a third level was added to account for children being nested within institutions. Only T1 data were explored

Table 1
Multilevel modeling coefficients of effect of rearing group on diurnal cortisol production.

Fixed Effect	Log-transformed Cortisol				
	Coefficient	SE	t	df	p
T1 Intercept, $\beta_{T1,00}$	-0.65	0.07	-8.80	69	0.000
Institutionally-reared, $\beta_{T1,01}$	-0.03	0.08	-0.34	69	0.736
Male, $\beta_{T1,02}$	0.02	0.05	0.41	69	0.684
Age, $\beta_{T1,03}$	-0.004	0.002	-1.61	69	0.112
T1 Slope, $\beta_{T1,10}$	-1.25	0.09	-13.29	69	0.000
Institutionally-reared, $\beta_{T1,11}$	0.24	0.09	2.68	69	0.010
Male, $\beta_{T1,12}$	0.06	0.08	0.72	69	0.476
Age, $\beta_{T1,13}$	-0.003	0.004	-0.65	69	0.521
T1 Covariate [Sampling time], $\beta_{T1,20}$	-0.02	0.05	-0.47	69	0.641
Institutionally-reared, $\beta_{T1,21}$	0.02	0.06	0.31	69	0.758
Male, $\beta_{T1,22}$	-0.05	0.04	-1.27	69	0.210
Age, $\beta_{T1,23}$	-0.001	0.002	-0.57	69	0.569
T2 Intercept, $\beta_{T2,00}$	-0.67	0.08	-8.02	69	0.000
Institutionally-reared, $\beta_{T2,01}$	-0.06	0.09	-0.63	69	0.531
Male, $\beta_{T2,02}$	-0.03	0.06	-0.49	69	0.625
Age, $\beta_{T2,03}$	-0.005	0.003	-1.64	69	0.106
T2 Slope, $\beta_{T2,10}$	-1.26	0.10	-12.45	69	0.000
Institutionally-reared, $\beta_{T2,11}$	0.28	0.10	2.88	69	0.006
Male, $\beta_{T2,12}$	-0.01	0.10	-0.07	69	0.945
Age, $\beta_{T2,13}$	-0.01	0.005	-1.59	69	0.116
T2 Covariate [Sampling time], $\beta_{T2,20}$	-0.01	0.06	-0.15	69	0.881
Institutionally-reared, $\beta_{T2,21}$	-0.15	0.08	-1.88	69	0.063
Male, $\beta_{T2,22}$	-0.04	0.05	-0.87	69	0.390
Age, $\beta_{T2,23}$	-0.001	0.003	-0.20	69	0.843

Note. $\beta_{T1,00}$ and $\beta_{T2,00}$ are the wake-up levels of log-transformed cortisol for family-reared children at T1 and T2, respectively, controlling for child gender and age; $\beta_{T1,10}$ and $\beta_{T2,10}$ are the cortisol slopes for family-reared children at T1 and T2, respectively; $\beta_{T1,01}$ ($\beta_{T1,11}$) and $\beta_{T2,01}$ ($\beta_{T2,11}$) reflect the difference in wake-up cortisol (slope of cortisol) between family-reared and institutionally-reared children at T1 and T2, respectively. $\beta_{T1,02}$ and $\beta_{T2,02}$ are the regression coefficients representing the effect of child gender at T1 and T2, respectively; $\beta_{T1,03}$ and $\beta_{T2,03}$ are the regression coefficients representing the effect of child age (grand-centered at the mean) at T1 and T2, respectively. Institutionally-reared represents the rearing group (with 0 = family-reared and 1 = institutionally-reared); Male represents the child's gender (with 0 = female and 1 = male); Age represents the child's age in months. We only present full model results with intercept centered at wake-up; see text for rearing group effect when intercept was re-centered at bedtime.

due to the reduced sample size available for T2.

4. Results

At the initial time point (T1), log-transformed cortisol at wake-up did not differ significantly between family-reared children and institutionally-reared children. There was a significant group effect on the slope of cortisol, with children in the institutionally-reared group showing a more blunted (i.e., less negative) change in cortisol across the day than children in the family-reared group, $\beta_{T1,11} = 0.24, p = 0.010$. In analyses with bedtime sample re-centered as the intercept, there was a significant group effect on bedtime cortisol levels, with institutionally-reared children showing significantly higher bedtime cortisol than family-reared children, $\beta_{T1,01b} = 0.22, p = 0.027$.

Results were similar at the follow-up time-point (T2). Log-transformed cortisol at wake-up did not differ significantly between family-reared children and institutionally-reared children. Children in the institutionally-reared group had a more blunted slope, $\beta_{T2,11} = 0.28, p = 0.006$, and significantly higher bedtime cortisol than family-reared children, $\beta_{T2,01b} = 0.23, p = 0.05$. See Table 1 for full model output and Fig. 1 for model-estimated cortisol levels for each group at T1 and T2.

With regard to changes over time, wake-up cortisol, bedtime cortisol, and cortisol slope for children did not differ significantly between T1 and T2 assessments for either group, all p values > .50.

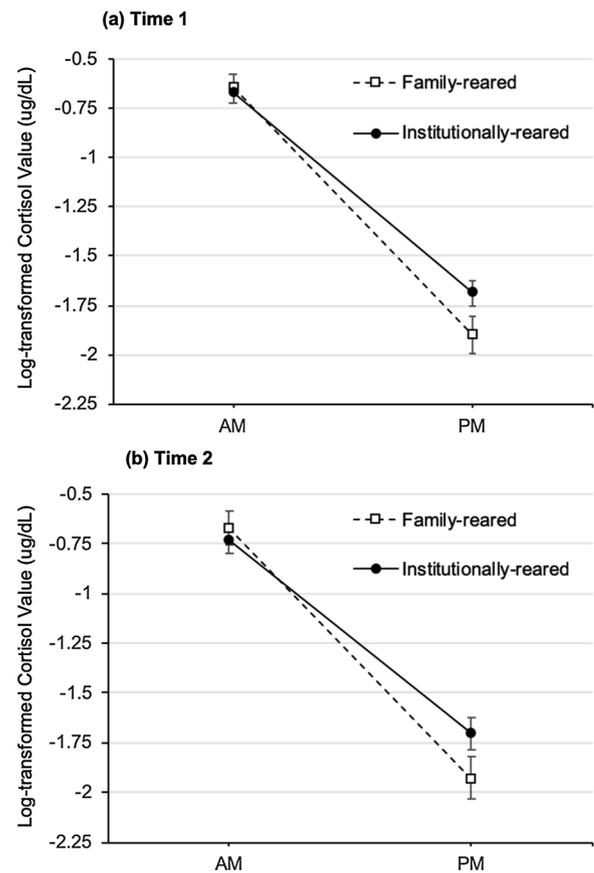


Fig. 1. Model-estimated wake-up to bedtime diurnal cortisol slopes for family-reared and institutionally-reared children at (a) Time 1 and (b) Time 2.

In exploratory analyses, total duration in institutional care and duration in the current institution did not significantly predict wake-up cortisol, bedtime cortisol, or cortisol slope. See Supplementary Table A.

5. Discussion

The present study examined diurnal cortisol production among institutionally-reared children and family-reared children in the Russian Federation. Institutionally-reared children showed blunter patterns of cortisol production than family-reared children, with higher evening levels of cortisol. Similar to the findings of others who have studied children while they lived in institutional settings (Carlson and Earls, 1997; Kroupina et al., 1997), these findings suggest that the institutional environment fails to fully support children's regulation of the production of hormones. Although between-group differences are often seen in wake-up values, differences emerged here in evening levels.

Previous investigations have studied children in highly depriving institutions. The present study assessed children in institutions that had modified the structure to increase caregiver opportunities for sensitive care, and had provided caregivers with training in sensitive care. However, even under these relatively more favorable conditions, children were nonetheless living in institutional settings that are not well suited to developmental needs (Dozier et al., 2014).

Study limitations include a small sample and the loss of some children at the second assessment. Further, given that this is not a randomized clinical trial, we cannot rule out the possibility that other factors affected cortisol production, such as prenatal and postnatal environment unrelated to the institutional environment. Beyond current exclusions for steroid and psychotropic usage, larger future studies should include all medication usage as a potential covariate in cortisol analyses. A lack of detailed records for all children prior to entering the

current institutions limits interpretation of null findings for duration of institutionalization. Nonetheless, the study is important in adding to the scant literature regarding effects of institutional rearing on diurnal production of cortisol.

Conflict of interest

The authors have no conflicts of interest to report.

Author note

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.psyneuen.2019.04.010>.

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