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ARTICLE

Attachment dimensions and cortisol responses during the strange situation among young children adopted internationally

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ABSTRACT

Children's attachments to their parents may help regulate their hypothalamic-pituitary-adrenal (HPA) axes. Prior research has largely focused on children with relatively consistent and low-risk caregiving histories, resulting in limited knowledge about the associations between attachment quality and HPA axis reactivity among children who have experienced early adversity. This study investigated whether dimensional measures of attachment quality were associated with HPA responses to the Strange Situation Procedure (SSP) among 64 children ages 11–33 months adopted internationally from institutional or foster care. Children who showed high levels of attachment avoidance exhibited a blunted cortisol response during the SSP. Conversely, children who sought proximity and contact with their adoptive parents exhibited an increase in cortisol reactivity during the SSP, followed by a return to baseline levels after the completion of the procedure. This association was independent of the previously reported association between parental insensitivity and blunted cortisol responses in this sample.

KEYWORDS

Attachment; HPA axis; Strange Situation; International adoption

Children's attachments with their parents play a central role in regulating the early development of hypothalamic-pituitary-adrenal (HPA) axis, including HPA axis responses to psychosocial stressors (Groh & Narayan, 2019). However, the majority of the research on this topic has focused on children from normative-risk backgrounds, and few studies have examined the associations between attachment quality and HPA axis reactivity among at-risk young children who experienced adversity early in life. In the present study, we focused on children adopted internationally. These children are at risk for blunted HPA reactivity due to their experiences of institutionalization and unstable caregiving (Gunnar & Reid, 2019). In this study, we tested the hypothesis that internationally adopted children who showed attachment behavior indicative of insecure attachments (avoidant or resistant/disorganized attachment behavior) would exhibit blunted HPA responses during the Strange Situation Procedure (SSP), but children who showed attachment behavior indicative of attachment security would exhibit a modest HPA response to the SSP followed by quick recovery.

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Supplemental data for this article can be accessed here.

HPA axis reactivity to stress

The HPA axis can become activated in response to a variety of physical and social challenges across development (Gunnar, Talge et al., 2009). In response to these challenges, cells in the paraventricular nucleus of the hypothalamus produce corticotropin-releasing factor, which stimulates the secretion of adrenocorticotropic hormone from the anterior pituitary gland. This, in turn, triggers the production of the glucocorticoid hormone cortisol from the adrenal cortex into the bloodstream (Gunnar et al., 2015). However, the HPA axis includes a negative feedback loop in which cortisol binds to receptors in the hypothalamus and suppresses further HPA axis activation.

The short-term activation of the HPA axis enhances the mobilization of physical resources in response to social and environmental challenges (Gunnar et al., 2015). However, the chronic activation of the HPA axis is expected to cause impairments in physical and mental health (McEwen & Stellar, 1993). Although individuals experiencing chronic stress may initially exhibit elevated levels of cortisol, repeated exposure to stressors can result in an attenuated cortisol response to stress (Gunnar & Vazquez, 2001; Miller et al., 2007). This blunted cortisol response is thought to be a biological adaptation that protects against the potentially deleterious effects of excessively high cortisol levels. Nonetheless, blunted cortisol reactivity may confer risks for psychopathology and physical health problems (Alink et al., 2008; Heim et al., 2000).

HPA axis reactivity among children adopted internationally

Although the HPA axis can become activated by physical stressors within moments of birth, the HPA axis becomes less readily activated during infancy and typically does not produce elevations in cortisol in response to challenges during early childhood (Gunnar, Talge et al., 2009; Jansen et al., 2010). During the first few years of life, children instead depend on their parents and other caregivers when responding to stressful situations (Gunnar et al., 2015). This is consistent with the ideas that young children form relationships with a small number of caregivers who are consistently available, and that these attachment relationships help regulate young children (Bowlby, 1969/1982; Sroufe, 1996).

Children who have been adopted internationally often have encountered pre-adoptive conditions that interfere with formation of effective attachment relationships. For example, many children are adopted from institutional environments that are structurally incompatible with young children's social and emotional needs (Dozier et al., 2012). Internationally adopted children also experience disruptions in their early caregiving relationships. These early adversities undermine children's regulatory capabilities, including their HPA axis responses to stressful conditions. Most studies of children who have been adopted internationally indicate that these children exhibit more blunted HPA axis responses to laboratory stressors than their non-adopted peers (Fries et al., 2008; Gunnar, Frenn et al., 2009; Hostinar et al., 2015; Koss et al., 2016; see also McLaughlin et al., 2015).

One question that remains unsettled within this area of research is whether internationally adopted children's experiences with their adoptive parents can promote recovery of the functioning of their HPA axis. In other words, can supportive experiences with adoptive parents remediate internationally adopted children's blunted HPA axis responses to stress? This question is related to longstanding debate about the special

significance of children's early experiences and their capacity for developmental plasticity (e.g. Marshall & Kenney, 2009).

DePasquale et al. (2018) provided initial data addressing this question. Using data from the same sample as the present study, DePasquale et al. (2018) reported that internationally adopted children who experienced sensitive caregiving in their adoptive families exhibited higher cortisol responses (i.e. less blunted HPA reactivity) to the SSP than internationally adopted children whose adoptive parents provided insensitive care. The present study built on these earlier findings by investigating whether the quality of internationally adopted children's attachments to their adoptive parents is also associated with their HPA axis responses. Although parental sensitivity is a key determinant of the quality of the child-parent attachment relationship, sensitivity and attachment quality are conceptually and empirically distinct constructs (De Wolff & Van Ijzendoorn, 1997). Parental sensitivity captures the extent to which a parent responds promptly and appropriately to a child's signals, whereas attachment quality represents the child's expectations of the parents' availability in the context of threat. Thus, the child-parent attachment relationship quality may be a unique predictor of individual differences in children's HPA responses beyond the contributions of parental sensitivity.

Child-parent attachment quality and HPA axis reactivity

Children who form secure and organized attachments to their parents are thought to experience their parents as a secure base or a source of comfort in times of distress (Ainsworth et al., 1978; Bowlby, 1969/1982). When confronted with threatening situations, children who have formed secure attachments seek out their parents and effectively use them to alleviate their distress. Thus, securely attached children are expected to show marked reductions in physiological arousal in the presence of their parents.

Groh and Narayan (2019) meta-analysis of the research on this topic indicated that securely attached children exhibit lower cortisol levels during the SSP than insecurely attached children. These findings suggest that securely attached children either experience: (a) less activation of the HPA axis during the SSP than insecurely attached children or (b) a modest HPA axis activation during separations followed by rapid deactivation of the HPA axis upon reunion with the parent. In contrast, children who had developed insecure attachments (e.g. avoiding interaction with the parent, resisting contact with the parent, or demonstrating a disorganized attachment strategy) tended to show a heightened cortisol response during the SSP. In other words, reunions with parents were less effective in deactivating the HPA axis for insecurely attached children than securely attached children.

Importantly, nearly all of the nine studies included in Groh and Narayan (2019) meta-analysis of the association between child-parent attachment quality and young children's cortisol reactivity during the SSP involved low- or normative-risk children. As a result, relatively little is known about the associations between child-parent attachment quality and HPA axis reactivity among children who have experienced early adversity (Hostinar et al., 2015). A rare exception is a longitudinal study of 232 children from a financially impoverished community in South Africa (Fearon et al., 2017). In contrast to the Groh and Narayan (2019), meta-analytic results and the findings of other longitudinal studies with normative-risk children (e.g. Spangler & Zimmermann, 2014), Fearon et al. (2017) reported

that children with histories of secure attachment during infancy exhibited a *higher* cortisol response to a psychosocial task during early adolescence than children who had been insecurely attached. Moreover, this association was more pronounced for children experiencing high contextual adversity. These findings raise the possibility that secure attachment relationships may buffer children who are experiencing chronic stress from exhibiting blunted HPA responsivity.

Dimensional measures of child-parent attachment quality

DePasquale et al. (2018) reported that the categorical indices of attachment disorganization or overall attachment security were not associated with children's cortisol responses during the SSP. However, those null findings may be related to the use of categorical measures of attachment quality. Fraley and Spieker (2003) suggested that dimensional measures of attachment may capture variation in young children's attachment patterns during the SSP more accurately than the traditional categorical measures. Specifically, exploratory factor analyses and taxometric analyses of the attachment behavioral ratings of over 1,000 infants enrolled in the Study of Early Child Care and Youth Development indicated that individual differences in infant attachment quality vary along two dimensions. The first dimension reflected the degree to which infants avoid versus seek proximity and contact with the attachment figure during reunion episodes of the SSP. The second dimension reflected the degree to which infants became emotionally dysregulated (i.e. demonstrated resistance with the parent or disorganized attachment behaviors). These factor analytic findings were recently replicated among a sample of normative-risk infants (Groh et al., 2019). One of the practical advantages of using dimensional measures is that they may maximize the statistical power of analyses, especially analyses examining the significance of the different forms of attachment insecurity (for simulation data, Fraley & Spieker, 2003). For these reasons, we focused on the two-dimensional measures of children's attachment behaviors in the current study.

The current study

The purpose of the present study was to examine the association between attachment quality and HPA axis reactivity among a sample of internationally adopted children. Because internationally adopted children are at risk for blunted HPA axis reactivity (Koss et al., 2016), we hypothesized that these children would exhibit blunted HPA responses during the SSP if they have formed insecure attachments to their adoptive parents. In contrast, we hypothesized that internationally adopted children who formed secure attachments would exhibit a moderate HPA response to the SSP. We explored whether attachment avoidance or attachment resistance were uniquely associated with children's HPA responses during the SSP by using both the traditional categorical measures and the related dimensional measures of child-parent attachment quality identified by Fraley and Spieker (2003). Lastly, we investigated whether the measures of child-parent attachment quality would predict HPA axis responses after accounting for the previously reported association between parental sensitivity and the HPA reactivity in this sample (i.e. DePasquale et al., 2018).

Methods

Participants

Families who completed an international adoption were recruited through partnerships with local international adoption agencies, an international adoption clinic at a local children's hospital, and international adoption parent support groups. Seventy-nine internationally adopted children (41 females) completed the original version of the SSP (Ainsworth et al., 1978). These children had been adopted between the ages of 5 and 28 months (M = 13.98, SD = 4.95) from China (38%), Ethiopia (19%), Russia (19%), South Korea (17%), Kazakhstan (3%), Armenia (2%), and Marshall Islands (2%). Children had lived in institutional care settings for an average of 9.00 months prior to adoption (SD = 6.58). The adoptive parent who served as the primary parent for the adopted child participated in the SSP. Ninety-six percent were mothers and 4% were fathers. Most adoptive parents were White/non-Hispanic (97%), whereas 1% were African-American and 1% were Asian-American. In addition, most (93%) of the adoptive parents were married, whereas 7% were single at the time of assessment. Three percent of parents had obtained a high school degree, 16% had attended the college but not obtained a degree, 38% had graduated college, and 43% had obtained a post-baccalaureate degree. Four percent of adoptive families had an annual income of 40,000 USD-$59,000, 36% had an annual income of 60,000 USD-$99,000, and 60% had an annual income of 100,000 USD or more.

Of the 79 children who completed the SSP, 15 children did not have valid cortisol values (details below). As a result, the analyses predicting children's cortisol responses included data for 64 children. This sample is identical to the sample used in DePasquale et al. (2018) except that two children were excluded from the present study because they did not have attachment classification data due to technical errors. Children with complete data did not differ from the remaining 15 in terms of their country of origins, age of adoption, duration of institutional care, parent's gender, parents' race/ethnicity, parents' marital status, parents' education, or family income.

Procedure

For the 64 participants included in the analyses, parent–child interactions were video-recorded in participants' homes when children were ranged in age from 7 to 26 months (M = 16.09, SD = 4.40) and had lived with their adoptive families between 1 and 12 months (M = 3.35, SD = 2.05). Shortly after the home research visit, families were randomly assigned to receive either an attachment-based intervention (Attachment and Biobehavioral Catch-up; ABC) or a control intervention (Developmental Education for Families; DEF). For this sample of participants, approximately 47% received the ABC intervention, and 54% received the control intervention. ABC was designed to enhance children's biological, behavioral and emotional regulatory capabilities by promoting sensitive and nurturing parenting behaviors. The control intervention was designed to enhance children's motor development, cognitive skills, and linguistic capabilities through the occupational therapy (see Dozier & Bernard, 2019 for detailed discussion of the two interventions). After completing the assigned intervention, children's attachment quality was assessed using the SSP. This assessment took place between 3 and 20 months

(M = 8.74, SD = 3.91) after the initial home research visit. At the time of the attachment assessment, children ranged in age from 21 to 33 months (M = 25.85, SD = 2.16) and had lived with their adoptive families between 5 and 21 months (M = 11.98, SD = 4.09).

Measures

Parental sensitivity

Parental sensitivity was assessed through home-based observations of parent–child interactions. For these assessments, the child was placed in a chair, and the parent was provided with developmentally appropriate toys. Parents were instructed to interact with their children as they normally would for 7 min and then to clean up the toys as they normally would for 3 min. Parents' overall sensitivity to children's non-distress cues was rated using a 5-point scale adapted from the NICHD Observational Record of the Caregiving Environment (NICHD Early Child Care Research Network, 1996). Parents who received the lowest score followed their own agendas and/or ignored their children's cues. Parents who received the highest score consistently responded in a timely and appropriate manner to their children's signals. All videos were double-coded and the intraclass correlation was 0.62. The average score for the two coders was used for the analyses.

Child-parent attachment quality

Ainsworth et al. (1978) laboratory-based procedure of infant attachment quality consists of eight 3-min episodes. Children's proximity seeking, contact maintenance, proximity avoidance, and contact resistance behaviors during the two reunion episodes were coded using a series of 7-point scales described by Ainsworth et al. (1978). In addition, children's attachment disorganization was rated using Main and Solomon (1990) 9-point scale. Based on the scores on these scales, children included in the analyses were classified as having formed a secure (n = 34, 53%), avoidant (n = 4, 6%), resistant (n = 5, 8%), or disorganized (n = 21, 33%) attachment. All cases were coded by an expert coder and trainer for coding infant attachment quality during the SSP, and these scores were used in the analyses. A second coder who past the official reliability test also coded approximately 25% of the sample. Intercoder agreement for the four attachment classifications was 71% (κ = .56, p < .001).

We conducted an exploratory factor analysis of the nine attachment behavioral ratings using the full sample who completed the SSP (n = 79). Factor loadings were estimated using principal axis factoring with an oblique rotation. Consistent with Fraley and Spieker (2003) results, the scree plot indicated that a two-factor solution best accounted for the data (see Table 1). The first factor reflected children's tendencies to avoid versus seek proximity and contact with their parents. The second factor reflected children's resistant and disorganized attachment behaviors. Based on these results, the ratings for proximity seeking and contact maintenance were reverse-scored and averaged with the ratings of proximity avoidance to form a dimensional measure of attachment avoidance (α = 0.85). Because the ratings for resistance and disorganization were on different scales, those

Table 1. Descriptive statistics, interrater reliability estimates, and factor loadings from two-factor solution of strange situation behavioral rating scales.

	M	*SD*	Min	Max	ICC	Factor 1	Factor 2
Proximity seeking, Episode 5	3.57	1.37	1	6	.70	**.68**	.20
Proximity seeking, Episode 8	3.70	1.51	1	6	.90	**.78**	.10
Contact maintenance, Episode 5	2.67	1.57	1	6	.88	**.57**	.40
Contact maintenance, Episode 8	3.31	1.77	1	6	.90	**.68**	.31
Proximity avoidance, Episode 5	2.36	1.47	1	6	.72	**−.74**	.36
Proximity avoidance, Episode 8	2.15	1.40	1	6	.87	**−.68**	.13
Contact resistance, Episode 5	1.70	1.31	1	5	.39	.28	**.62**
Contact resistance, Episode 8	2.06	1.66	1	7	.94	.22	**.59**
Attachment disorganization	3.53	1.99	1	7	.25	−.23	**.70**
Eigenvalue						3.67	1.89
Percentage of variance accounted for						44%	20%

Note. $N = 79$. Loadings > |.50| are shown in boldface. ICC = *Intraclass correlation coefficient.*

three ratings were standardized and then averaged to form a dimensional measure of attachment resistance/disorganization ($\alpha = 0.69$).

Salivary cortisol levels

Children's HPA axis activity was assessed by examining salivary cortisol concentration levels upon the child's arrival at the lab (average collection time = 11:18 AM, *SD* = 1.93, range = 9:27 AM to 5:40 PM), as well as 15 min and 30 min after completing the SSP. Salivary cortisol concentrations in μg/dL at the time of arrival were considered the baseline measure of HPA activity. Consistent with other research in this area (Spangler & Grossmann, 1993), the first cortisol level was collected immediately after mothers completed informed consent and before the child became familiar with the laboratory setting. Past research has demonstrated that there typically is a 20-min lag between the onset of a stressor and increases in salivary cortisol levels (Gunnar, Talge et al., 2009). Thus, cortisol levels collected at 15 min and 30 min after the SSP were assumed to reflect child's HPA during the most stressful episodes of the SSP (namely, last two separation episodes) and the 5 min immediately after the SSP, respectively. Children were not allowed to eat between collection of samples. Consistent with standard procedures (e.g. Koss et al., 2016), parents were instructed to place a dental cotton roll in the child's mouth for each sample until it was sufficiently wet with saliva. Samples were stored in the laboratory freezer at −20°C prior to being assayed in duplicate using the High Sensitivity Salivary Cortisol Enzyme Immunoassay Kit (Salimetrics, LLC, State College, PA). Of the 79 children who completed the SSP, seven children did not provide any cortisol samples, and one child did not provide a sufficient amount of saliva. Seven additional cases were excluded because of low intra-assay coefficients of variation, which resulted in an analytic sample size of 64. Among these cases, all inter- and intra-assay coefficients of variation were below 10%, and all cortisol samples were biologically plausible values (<2.0 μg/dL). Five children did not provide a saliva sample at one or two of the time points, and these missing data were estimated using the multiple imputation technique. Data were imputed 10 times, and the results of analyses of the 10 data sets were pooled.

Child cortisol concentrations at each time point (i.e. baseline, 15, and 30 min) were used to calculate the area under the curve with respect to increase (AUC_I), which is a commonly used

method for estimating changes in cortisol concentrations in response to a challenge (Pruessner et al., 2003). Thus, the AUC_I was used as a measure of child's overall cortisol response to the SSP.

Analysis plan

Two sets of hierarchical linear regression analyses were conducted to examine whether child attachment dimensions were associated with HPA activity at baseline and in response to the SSP. For each regression model, the initial step included the two attachment dimensions. In the second step, the covariates were included to evaluate the robustness of the associations. Standardized regression coefficients are reported as estimates of the effect sizes.

Consistent with the prior publication with this sample of children adopted internationally (DePasquale et al., 2018), duration of institutional care (a commonly used marker of pre-adoptive adversity), intervention condition (ABC vs. control), and parental sensitivity at pre-intervention were included as covariates in the regression models. Children's baseline cortisol levels were also included as a covariate in the model predicting cortisol responses to the SSP. Children's biological sex, age at the time of the SSP, the continuous measure of the time of day of the procedure, amount of time since adoption, family income, and parent educational attainment were not significantly associated with either baseline cortisol levels or cortisol responses to the SSP. Thus, these variables were not included in the analyses.

Results

Descriptive statistics and correlations among the variables used in the analyses are presented in Table 2.

Associations between child attachment dimensions and baseline cortisol levels

Results of the regression analyses for attachment dimensions are presented in Table 3. The first regression analysis predicted children's baseline cortisol levels. Neither the attachment avoidance nor the resistance/disorganization dimension was significantly associated with baseline HPA activity. Similarly, the type of intervention received by parents, duration of institutional care, and parental sensitivity did not significantly predict the baseline cortisol levels.

Associations between child attachment dimensions and cortisol responses

The second regression analysis predicted children's overall cortisol responses to the SSP. The attachment avoidance dimension was negatively associated with children's overall cortisol responses. In other words, children who exhibited avoidant attachment behavior had more blunted HPA responses during the SSP than children who sought contact with their parents during reunion episodes. This association remained statistically significant after controlling for intervention condition, time children spent in institutional care, parental sensitivity, and baseline cortisol levels. The attachment resistance/disorganization dimension, on the other hand, was not significantly associated with overall cortisol responses during the SSP.

Table 2. Descriptive statistics and correlations for variables.

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Intervention condition	–										
2. Parental sensitivity	0.22†	–									
3. Time in institutional care	0.27*	0.02	–								
4. Attachment avoidance dimension	0.18	−0.02	0.08	–							
5. Attachment resistance dimension	−0.19	−0.12	0.14	−0.28*	–						
6. Avoidant classification	−0.11	0.13	−0.08	0.49**	−0.19	–					
7. Resistant/disorganization classification	−0.01	−0.10	0.20	−0.06	0.72**	−0.21†	–				
8. Baseline cortisol levels	−0.27*	−0.23†	−0.30*	0.02	−0.04	−0.14	−0.10	–			
9. Cortisol levels during SSP	−0.20	0.01	−0.28*	−0.20	−0.07	−0.13	−0.12	0.64**	–		
10. Cortisol levels after SSP	−0.08	0.17	−0.23†	−0.03	−0.01	−0.12	−0.06	0.46**	0.53**	–	
11. Total cortisol response	0.09	0.32*	0.02	−0.25†	−0.01	−0.01	−0.02	−0.41**	0.42**	0.24†	–
Mean or %	47%	2.80	9.31	3.97	−0.05	6%	42%	0.14	0.15	0.12	0.00
SD	–	0.76	6.40	1.16	0.76	–	–	0.16	0.19	0.12	0.07

Note. $N = 64$. †$p < .10$. *$p < .05$, ** $p < .01$. For intervention condition, Attachment and Biobehavioral Catch-up = 1, control intervention = 0. Total cortisol response equals area under the curve calculation of overall cortisol production in response to the Strange Situation Procedure (SSP).

Table 3. Associations between child attachment dimensions and salivary cortisol levels at baseline and in response to the strange situation.

	Baseline cortisol levels			Total cortisol response to the SSP			Cortisol levels during the SSP			Cortisol levels after the SSP		
	β	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*
Step 1												
Avoidance dimension	0.01	0.13	0.94	−0.27	0.12	0.02	−0.25	0.10	0.01	−0.03	0.12	0.79
Resistance dimension	−0.04	0.14	0.76	−0.10	0.12	0.39	−0.11	0.10	0.26	0.01	0.12	0.94
Baseline cortisol levels	–	–	–	−0.41	0.11	<0.01	0.64	0.09	<0.01	0.46	0.12	<0.01
Step 2												
Avoidance dimension	0.06	0.13	0.66	−0.25	0.12	0.04	−0.23	0.10	0.02	−0.01	0.12	0.94
Resistance dimension	−0.05	0.13	0.68	−0.06	0.13	0.63	−0.09	0.11	0.41	0.07	0.12	0.54
Intervention condition	−0.18	0.13	0.17	−0.01	0.13	0.97	−0.02	0.11	0.84	0.03	0.13	0.81
Time in institutional care	−0.25	0.13	0.06	−0.07	0.13	0.57	−0.04	0.11	0.66	−0.10	0.12	0.44
Parental sensitivity	−0.20	0.12	0.11	0.22	0.12	0.07	0.15	0.10	0.13	0.30	0.12	0.01
Baseline cortisol levels	–	–	–	−0.38	0.12	<0.01	0.66	0.11	<0.01	0.52	0.12	<0.01

Note. N = 64. Total cortisol response equals area under the curve calculation of overall cortisol production in response to the Strange Situation Procedure (SSP). For intervention condition, Attachment and Biobehavioral Catch-up = 1, control intervention = 0.

We conducted follow-up regression analyses to determine if the associations between the attachment avoidance dimension and children's overall cortisol responses were specific to cortisol levels during or after the completion of the SSP. The use of an avoidant strategy was negatively associated with cortisol levels during, but not after, the SSP (see Table 3). As illustrated in Figure 1, the cortisol levels of children who sought proximity and contact with their parents during reunion episodes increased during the SSP and then returned to near baseline levels after the completion of the SSP. In contrast, children who exhibited avoidant attachment behavior did not exhibit a significant cortisol response

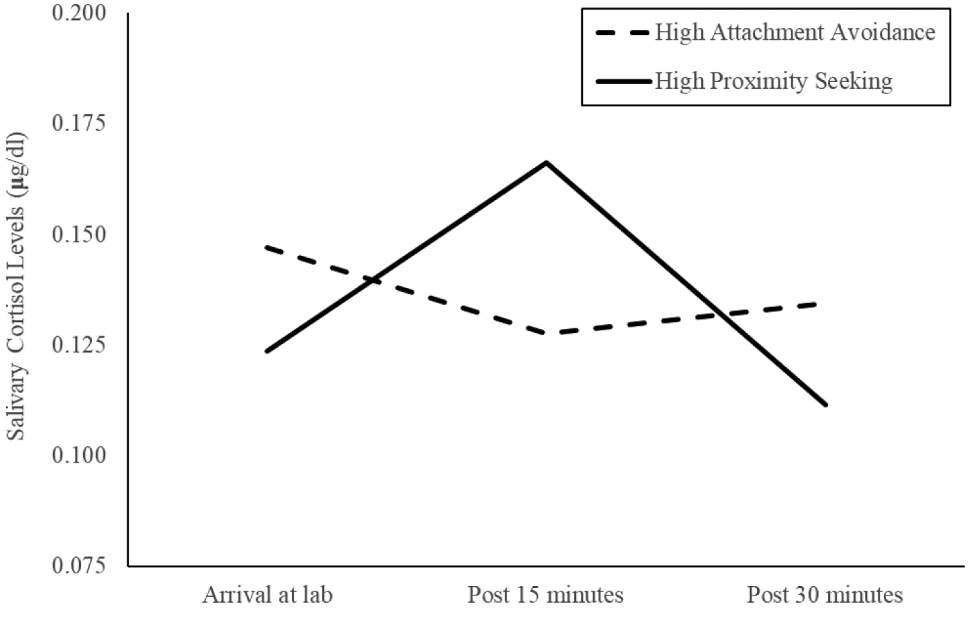

Figure 1. Internationally adopted children's cortisol responses to the Strange Situation as a function of scores on the attachment avoidance versus proximity seeking dimension. High attachment avoidance and high proximity seeking were calculated using a median split for visualization purposes.

throughout the laboratory procedure. Consistent with the findings reported by DePasquale et al. (2018), high parental sensitivity predicted high cortisol levels after the SSP (see Figure 2).

Associations between child attachment categories and cortisol variables

To compare the results involving the attachment dimensions to those using the attachment categories, two binary variables were created. The first variable reflected whether children were classified as avoidant or not, and the second variable reflected whether children were classified as resistant/disorganized. Neither the avoidant attachment classification nor the joint resistant/disorganized classification was significantly associated with baseline cortisol levels or cortisol responses to the SSP (see supplemental materials). All decisions about statistical significance did not change when the binary variables were created using the organized classification (i.e. secure, avoidant, or resistant) for infants classified as disorganized.

Discussion

Children who have experienced early deprivation in the form of institutional care are at risk for exhibiting blunted HPA axis responses to stressors even after they have been adopted internationally and placed in highly resourced families (Gunnar & Reid, 2019; Hostinar et al., 2015). The present study tested the hypothesis that forming high-quality attachments with adoptive parents promotes healthy functioning of the HPA axis functioning among this group of vulnerable children. We tested this hypothesis using the

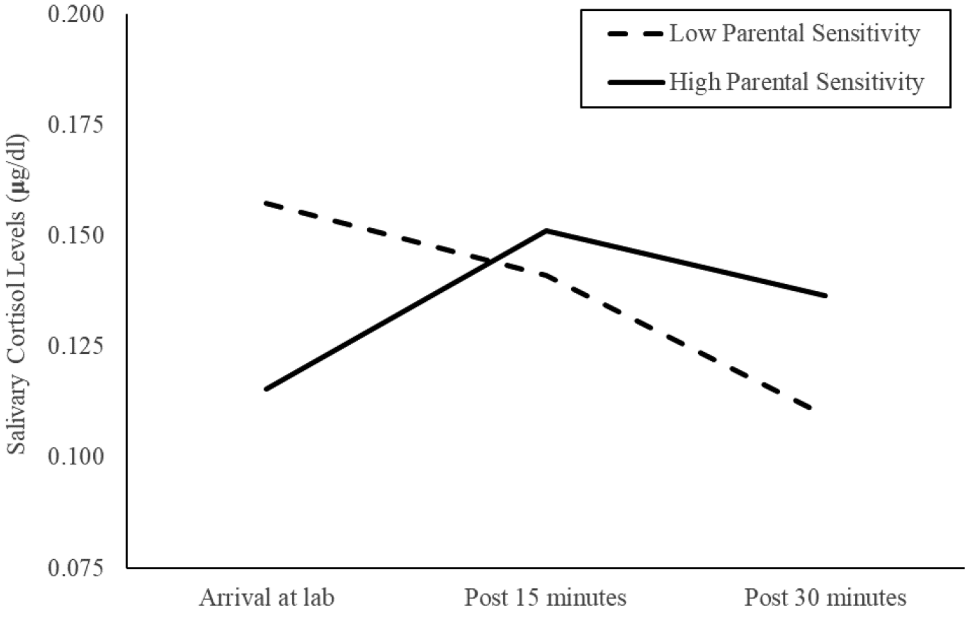

Figure 2. Internationally adopted children's cortisol responses to the Strange Situation as a function of parental sensitivity. High and low sensitivity were calculated using a median split for visualization purposes.

dimensional measures of child-parent attachment quality initially proposed by Fraley and Spieker (2003). Consistent with our hypothesis, the results indicated that internationally adopted children who exhibited attachment avoidance had more blunted cortisol responses during the reunion episodes of the SSP than children who sought proximity and contact with their parents. The attachment resistance/disorganization dimension, on the other hand, was not significantly associated with HPA axis responses to the SSP. Moreover, the association between attachment avoidance and blunted HPA axis responses was observed even after accounting for the previously reported association between parental insensitivity and blunted cortisol reactivity in this sample of internationally adopted children (DePasquale et al., 2018).

Consistent with DePasquale et al. (2018), there was no evidence that the ABC intervention had an effect on internationally adopted children's cortisol responses to the SSP, and the effect of the ABC intervention on children's baseline cortisol levels was not significant after including the other variables in the regression model. Other studies, however, have reported that the ABC intervention may alter children's HPA responses. For example, Berlin et al. (2019) reported that children of the financially impoverished families who received the ABC intervention exhibited marginally more recovery in cortisol levels after the SSP than children whose families received the control intervention. Thus, additional studies are needed to determine whether and under what conditions the ABC intervention may alter young children's HPA responses.

The evidence that children who exhibited attachment avoidance had blunted HPA axis responses to the SSP differs from many prior studies examining the association between attachment patterns and cortisol reactivity (Groh & Narayan, 2019; Spangler & Zimmermann, 2014). The differences in the nature of the samples may explain these divergent findings. Unlike most prior studies that have focused on low-risk children, the present study focused on internationally adopted children who are at higher risk for blunted HPA reactivity than nonadopted children because of their experiences of early deprivation (Koss et al., 2016). Thus, the combination of early adversity and the use of avoidant attachment behaviors with adoptive parents may have contributed to abnormally blunted HPA axis responsivity (see also Fearon et al., 2017). In contrast, seeking out proximity and contact with adoptive parents appeared to facilitate recovery of the HPA axis functioning (i.e. was associated with elevated levels of cortisol during but not after the SSP) among internationally adopted children. Based on the evidence that young children in foster care exhibited higher levels of proximity-seeking behavior than control children, Kungl et al. (2019) have speculated that children with histories of early adversity may need relatively high levels of proximity with attachment figures in order to achieve felt security. Therefore, it is likely that the internationally adopted children who exhibited avoidant attachment behavior (i.e. a lack of proximity seeking) toward their parents were not using their parents to help regulate their physiological responses at the time of stress.

Another possibility for these divergent findings is that the children who exhibited high avoidant attachment behavior and a lack of proximity seeking did not experience distress during the SSP and therefore did not mount an HPA axis response. Because information about children's distress levels during the SSP was not available for this sample of children, future research is needed to test this alternative explanation.

A limitation of the current study is the low interrater reliability for the contact resistance and attachment disorganization ratings. This may have contributed to the nonsignificant

associations between the attachment resistance/disorganization dimension and children's cortisol outcomes. Because interrater reliability was assessed using two reliable coders, the low reliability may reflect difficulties coding these attachment behaviors among children adopted internationally. Another limitation is the study's modest sample size. It may be challenging to replicate this study with a larger sample in the future because the number of international adoptions to the United States has dramatically dropped in the last decade, and most adoptions now involve older children with special needs (Jones & Placek, 2017). However, children who have experienced maltreatment are also at risk for blunted HPA responses to stress (Miller et al., 2007). Therefore, a valuable direction for future research would be to examine whether forming a high-quality attachment relationship with parents can promote more typical patterns of HPA axis reactivity among maltreated children, as well as other groups of children who have experienced early adversity.

The findings from this study provide additional support for the idea that children's attachment relationships with their parents assist with regulating HPA axis activity during the first few years of life. Another task for future is to examine the association between attachment quality and the HPA axis reactivity at later ages. The quality of children's attachments to their parents, including those of internationally adopted children, can change over time due to fluctuations in the level of sensitive caregiving children received (Beijersbergen et al., 2012). Moreover, the first few years of life are not the only times when the HPA axis can be regulated by the caregiving environment. Indeed, the early stages of puberty may be another sensitive period for recalibration of the HPA axis activity in individuals with early experiences of deprivation (Gunnar et al., 2019). Thus, it will be important to examine the association between child-parent attachment quality and the HPA axis functioning at these later ages for both low- and high-risk children.

In conclusion, findings from the current study indicate that features of post-adoption caregiving environment – namely, parental sensitivity and attachment quality with parents – help regulate the activity of HPA axis among internationally adopted children. Specifically, the results suggest that forming high-quality attachment relationships with adoptive parents serves as a protective factor that facilitate recovery of the HPA axis functioning among this group of vulnerable children.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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